19.

REPORT

OF THE

TWENTIETH MEETING

OF THE

BRITISH ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE;

HELD AT EDINBURGH IN JULY AND AUGUST 1850.

LONDON:

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OF

THE ASSOCIATION.

OBJECTS.

The Association contemplates no interference with the ground occupied by other Institutions. Its objects are,—To give a stronger impulse and a more systematic direction to scientific inquiry,—to promote the intercourse of those who cultivate Science in different parts of the British Empire, with one another, and with foreign philosophers,—to obtain a more general attention to the objects of Science, and a removal of any disadvantages of a public kind which impede its progress.

RULES.

ADMISSION OF MEMBERS AND ASSOCIATES.

All Persons who have attended the first Meeting shall be entitled to become Members of the Association, upon subscribing an obligation to conform to its Rules.

The Fellows and Members of Chartered Literary and Philosophical Societies publishing Transactions, in the British Empire, shall be entitled, in like manner, to become Members of the Association.

The Officers and Members of the Councils, or Managing Committees, of Philosophical Institutions, shall be entitled, in like manner, to become Members of the Association.

All Members of a Philosophical Institution recommended by its Council or Managing Committee, shall be entitled, in like manner, to become Members of the Association.

Persons not belonging to such Institutions shall be elected by the General Committee or Council, to become Life Members of the Association, Annual Subscribers, or Associates for the year, subject to the approval of a General Meeting.

COMPOSITIONS, SUBSCRIPTIONS, AND PRIVILEGES.

Life Members shall pay, on admission, the sum of Ten Pounds. They shall receive *gratuitously* the Reports of the Association which may be published after the date of such payment. They are eligible to all the offices of the Association.

Annual Subscribers shall pay, on admission, the sum of Two Pounds, and in each following year the sum of One Pound. They shall receive *gratuitously* the Reports of the Association for the year of their admission and for the years in which they continue to pay *without intermission* their Annual Subscription. By omitting to pay this Subscription in any particular year, Members of this class (Annual Subscribers) *lose for that and all future years* the privilege of receiving the volumes of the Association *gratis*: but they may resume their Membership and other privileges at any subsequent Meeting of the Association, paying on each such occasion the sum of One Pound. They are eligible to all the Offices of the Association.

Associates for the year shall pay on admission the sum of One Pound. They shall not receive *gratuitously* the Reports of the Association, nor be eligible to serve on Committees, or to hold any office.

The Association consists of the following classes :—

1. Life Members admitted from 1831 to 1845 inclusive, who have paid on admission Five Pounds as a composition.

2. Life Members who in 1846, or in subsequent years, have paid on admission Ten Pounds as a composition.

3. Annual Members admitted from 1831 to 1839 inclusive, subject to the payment of One Pound annually. [May resume their Membership after intermission of Annual Payment.]

4. Annual Members admitted in any year since 1839, subject to the payment of Two Pounds for the first year, and One Pound in each following year. [May resume their Membership after intermission of Annual Payment.]

5. Associates for the year, subject to the payment of One Pound.

6. Corresponding Members nominated by the Council.

And the Members and Associates will be entitled to receive the annual volume of Reports, *gratis*, or to *purchase* it at reduced (or Members') price, according to the following specification, viz. :—

1. *Gratis*.—Old Life Members who have paid Five Pounds as a composition for Annual Payments, and previous to 1845 a further sum of Two Pounds as a Book Subscription, or, since 1845 a further sum of Five Pounds.

   New Life Members who have paid Ten Pounds as a composition.

   Annual Members who have not intermitted their Annual Subscription.

2. *At reduced or Members' Prices*, viz. two-thirds of the Publication Price.—Old Life Members who have paid Five Pounds as a composition for Annual Payments, but no further sum as a Book Subscription.

   Annual Members, who have intermitted their Annual Subscription.

   Associates for the year. [Privilege confined to the volume for that year only.]

3. Members may purchase (for the purpose of completing their sets) any of the first seventeen volumes of Transactions of the Association, *and of which more than* 100 *copies remain*, at one-third of the Publication Price. Application to be made (by letter) to Mr. R. Taylor, Red Lion Court, Fleet Street, London.

Subscriptions shall be received by the Treasurer or Secretaries.

MEETINGS.

The Association shall meet annually, for one week, or longer. The place of each Meeting shall be appointed by the General Committee at the previous Meeting; and the Arrangements for it shall be entrusted to the Officers of the Association.

GENERAL COMMITTEE.

The General Committee shall sit during the week of the Meeting, or longer, to transact the business of the Association. It shall consist of the following persons :—

1. Presidents and Officers for the present and preceding years, with authors of Reports in the Transactions of the Association.

2. Members who have communicated any Paper to a Philosophical Society, which has been printed in its Transactions, and which relates to such subjects as are taken into consideration at the Sectional Meetings of the Association.

3. Office-bearers for the time being, or Delegates, altogether not exceeding three in number, from any Philosophical Society publishing Transactions.

4. Office-bearers for the time being, or Delegates, not exceeding three, from Philosophical Institutions established in the place of Meeting, or in any place where the Association has formerly met.

5. Foreigners and other individuals whose assistance is desired, and who are specially nominated in writing for the meeting of the year by the President and General Secretaries.

6. The Presidents, Vice-Presidents, and Secretaries of the Sections are *ex officio* members of the General Committee for the time being.

SECTIONAL COMMITTEES.

The General Committee shall appoint, at each Meeting, Committees, consisting severally of the Members most conversant with the several branches of Science, to advise together for the advancement thereof.

The Committees shall report what subjects of investigation they would particularly recommend to be prosecuted during the ensuing year, and brought under consideration at the next Meeting.

The Committees shall recommend Reports on the state and progress of particular Sciences, to be drawn up from time to time by competent persons, for the information of the Annual Meetings.

COMMITTEE OF RECOMMENDATIONS.

The General Committee shall appoint at each Meeting a Committee, which shall receive and consider the Recommendations of the Sectional Committees, and report to the General Committee the measures which they would advise to be adopted for the advancement of Science.

All Recommendations of Grants of Money, Requests for Special Researches, and Reports on Scientific Subjects, shall be submitted to the Committee of Recommendations, and not taken into consideration by the General Committee, unless previously recommended by the Committee of Recommendations.

LOCAL COMMITTEES.

Local Committees shall be formed by the Officers of the Association to assist in making arrangements for the Meetings.

Local Committees shall have the power of adding to their numbers those Members of the Association whose assistance they may desire.

OFFICERS.

A President, two or more Vice-Presidents, one or more Secretaries, and a Treasurer, shall be annually appointed by the General Committee.

COUNCIL.

In the intervals of the Meetings, the affairs of the Association shall be managed by a Council appointed by the General Committee. The Council may also assemble for the despatch of business during the week of the Meeting.

PAPERS AND COMMUNICATIONS.

The Author of any paper or communication shall be at liberty to reserve his right of property therein.

ACCOUNTS.

The Accounts of the Association shall be audited annually, by Auditors appointed by the Meeting.

I. Table showing the Places and Times of Meeting of the British Association, with Presidents, Vice-Presidents, and Local Secretaries, from its Commencement.

PRESIDENTS.	VICE-PRESIDENTS.	LOCAL SECRETARIES
The EARL FITZWILLIAM, D.C.L., F.R.S., F.G.S., &c. YORK, September 27, 1831.	Rev. W. Vernon Harcourt, M.A., F.R.S., F.G.S.	William Gray, jun., F.G.S. Professor Phillips, F.R.S., F.G.S.
The REV. W. BUCKLAND, D.D., F.R.S., F.G.S., &c. OXFORD, June 19, 1832.	Sir David Brewster, F.R.S.L. & E., &c. Rev. W. Whewell, F.R.S., Pres. Geol. Soc.	Professor Daubeny, M.D., F.R.S., &c. Rev. Professor Powell, M.A., F.R.S., &c.
The REV. ADAM SEDGWICK, M.A., V.P.R.S., V.P.G.S. CAMBRIDGE, June 25, 1833.	G. B. Airy, F.R.S., Astronomer Royal, &c. John Dalton, D.C.L., F.R.S.	Rev. Professor Henslow, M.A., F.L.S., F.G.S. Rev. W. Whewell, F.R.S.
Sir T. MAKDOUGALL BRISBANE, K.C.B., D.C.L., F.R.SS. L. & E. EDINBURGH, September 8, 1834.	Sir David Brewster, F.R.S., &c. Rev. T. R. Robinson, D.D.	Professor Forbes, F.R.S. L. & E., &c. Sir John Robison, Sec. R.S.E.
The REV. PROVOST LLOYD, LL.D. DUBLIN, August 10, 1835.	Viscount Oxmantown, F.R.S., F.R.A.S. Rev. W. Whewell, F.R.S., &c.	Sir W. R. Hamilton, Astron. Royal of Ireland, &c. Rev. Professor Lloyd, F.R.S.
The MARQUIS OF LANSDOWNE, D.C.L., F.R.S., &c. BRISTOL, August 22, 1836.	The Marquis of Northampton, F.R.S. Rev. W. D. Conybeare, F.R.S., F.G.S. J. C. Prichard, M.D., F.R.S.	Professor Daubeny, M.D., F.R.S., &c. V. F. Hovenden, Esq.
The EARL OF BURLINGTON, F.R.S., F.G.S., Chan. Univ. London LIVERPOOL, September 11, 1837.	The Bishop of Norwich, P.L.S., F.G.S. John Dalton, D.C.L., F.R.S. Sir Philip de Grey Egerton, Bart., F.R.S., F.G.S. Rev. W. Whewell, F.R.S.	Professor Traill, M.D. Wm. Wallace Currie, Esq. Joseph N. Walker, Pres. Royal Institution, Liverpool.
The DUKE OF NORTHUMBERLAND, F.R.S., F.G.S., &c. NEWCASTLE-ON-TYNE, August 20, 1838.	The Bishop of Durham, F.R.S., F.S.A. The Rev. W. Vernon Harcourt, F.R.S., &c. Prideaux John Selby, Esq., F.R.S.E.	John Adamson, F.L.S., &c. Wm. Hutton, F.G.S. Professor Johnston, M.A., F.R.S.
The REV. W. VERNON HARCOURT, M.A., F.R.S., &c. BIRMINGHAM, August 26, 1839.	Marquis of Northampton. Earl of Dartmouth. The Rev. T. R. Robinson, D.D. John Corrie, Esq., F.R.S. Very Rev. Principal Macfarlane	George Barker, Esq., F.R.S. Peyton Blakiston, M.D. Joseph Hodgson, Esq., F.R.S. Follett Osler, Esq.
The MARQUIS OF BREADALBANE, F.R.S. GLASGOW, September 17, 1840.	Major-General Lord Greenock, F.R.S.E. Sir David Brewster, F.R.S. Sir T. M. Brisbane, Bart., F.R.S. The Earl of Mount Edgecumbe	Andrew Liddell, Esq. Rev. J. P. Nicol, LL.D. John Strang, Esq.
The REV. PROFESSOR WHEWELL, F.R.S., &c. PLYMOUTH, July 29, 1841.	The Earl of Morley. Lord Eliot, M.P. Sir C. Lemon, Bart. Sir T. D. Acland, Bart.	W. Snow Harris, Esq., F.R.S. Col. Hamilton Smith, F.L.S. Robert Were Fox, Esq. Richard Taylor, jun., Esq.
The LORD FRANCIS EGERTON, F.G.S. MANCHESTER, June 23, 1842.	John Dalton, D.C.L., F.R.S. Hon. and Rev. W. Herbert, F.L.S., &c. Rev. A. Sedgwick, M.A., F.R.S. W. C. Henry, M.D., F.R.S. Sir Benjamin Heywood, Bart.	Peter Clare, Esq., F.R.A.S. W. Fleming, M.D. James Heywood, Esq., F.R.S.
The EARL OF ROSSE, F.R.S. CORK, August 17, 1843.	Earl of Listowel. Viscount Adare Sir W. R. Hamilton, Pres.R.I.A. Rev. T. R. Robinson, D.D.	Professor John Stevelly, M.A. Rev. Jos. Carson, F.T.C. Dublin. William Keleher, Esq. Wm. Clear, Esq.

The REV. G. PEACOCK, D.D. (Dean of Ely), F.R.S. ..... YORK, September 26, 1844.	Earl Fitzwilliam, F.R.S. Viscount Morpeth, F.G.S. .... The Hon. John Stuart Wortley, M.P. Sir David Brewster, K.H., F.R.S. Michael Faraday, Esq., D.C.L., F.R.S. .... Rev. W. V. Harcourt, F.R.S..	William Hatfeild, Esq., F.G.S. Thomas Meynell, Esq., F.L.S. Rev. W. Scoresby, LL.D., F.R.S. William West, Esq.
SIR JOHN F. W. HERSCHEL, Bart., F.R.S., &c. ...... CAMBRIDGE, June 19, 1845.	The Earl of Hardwicke. The Bishop of Norwich........................ Rev. J. Graham, D.D. Rev. G. Ainslie, D.D. .... G. B. Airy, Esq., M.A., D.C.L., F.R.S. .... The Rev. Professor Sedgwick, M.A., F.R.S.	William Hopkins, Esq., M.A., F.R.S. Professor Ansted, M.A., F.R.S.
SIR RODERICK IMPEY MURCHISON, G.C.S., F.R.S. SOUTHAMPTON, September 10, 1846.	The Marquis of Winchester. The Earl of Yarborough, D.C.L........... Lord Ashburton, D.C.L. Viscount Palmerston, M.P.................... Right Hon. Charles Shaw Lefevre, M.P. .... Sir George T. Staunton, Bart., M.P., D.C.L., F.R.S. .... The Lord Bishop of Oxford, F.R.S. .... Prof. Owen, M.D., F.R.S. Prof. Powell, F.R.S..........................	Henry Clark, M.D. T. H. C. Moody, Esq.
SIR ROBERT HARRY INGLIS, Bart., D.C.L., F.R.S., M.P. for the University of Oxford .... OXFORD, June 23, 1847.	The Earl of Rosse, F.R.S. The Lord Bishop of Oxford, F.R.S. .... The Vice-Chancellor of the University .... Thomas G. Bucknall Estcourt, Esq., D.C.L., M.P. for the University of Oxford. Very Rev. The Dean of Westminster, D.D., F.R.S. .... Professor Daubeny, M.D., F.R.S. The Rev. Prof. Powell, M.A., F.R.S.	Rev. Robert Walker, M.A., F.R.S. Henry Wentworth Acland, Esq., B.M.
The MARQUIS OF NORTHAMPTON, Pres. Royal Society, &c... SWANSEA, August 9, 1848.	The Marquis of Bute, K.T. Viscount Adare, F.R.S. .... Sir H. T. De la Beche, F.R.S., Pres. G.S. .... The Very Rev. the Dean of Llandaff, F.R.S. .... Lewis W. Dillwyn, Esq., F.R.S. W. R. Grove, Esq., F.R.S. .... J. H. Vivian, Esq., M.P., F.R.S. The Lord Bishop of St. David's......	Matthew Moggridge, Esq. D. Nicol, M.D.
The REV. T. R. ROBINSON, D.D., M.R.I.A., F.R.A.S. BIRMINGHAM, September 12, 1849.	The Earl of Harrowby. The Lord Wrottesley, F.R.S.................... Right Hon. Sir Robert Peel, M.P., D.C.L., F.R.S. .... Charles Darwin, Esq., M.A., F.R.S., Sec. G.S. .... Professor Faraday, D.C.L., F.R.S... Sir David Brewster, K.H., LL.D., F.R.S. .... Rev. Professor Willis, M.A., F.R.S.	Captain Tindal, R.N. William Wills, Esq. Bell Fletcher, Esq., M.D. James Chance, Esq.
SIR DAVID BREWSTER, K.H., LL.D., F.R.S. L. & E. EDINBURGH, July 31, 1850.	Right Hon. the Lord Provost of Edinburgh .... The Earl of Cathcart, K.C.B., F.R.S.E. .... The Earl of Rosebery, K.T., D.C.L., F.R.S. .... Right. Hon. David Boyle (Lord Justice-General), F.R.S.E. .... General Sir Thomas M. Brisbane, Bart., K.C.B., G.C.H., D.C.L., F.R.S., Pres. R.S.E... Very Rev. John Lee, D.D., V.P.R.S.E., Principal of the University of Edinburgh. Professor W. P. Alison, M.D., V.P.R.S.E............... Professor J. D. Forbes, F.R.S., Sec. R.S.E.	Rev. Professor Kelland, M.A., F.R.S.L. & E. Professor Balfour, M.D., F.R.S.E., F.L.S. James Tod, Esq., F.R.S.
GEORGE BIDDELL AIRY, Esq., D.C.L., F.R.S., Astronomer Royal. IPSWICH, July 2, 1851.	The Lord Rendlesham, M.P. The Lord Bishop of Norwich .... Rev. Professor Sedgwick, M.A., F.R.S. .... Rev. Professor Henslow, M.A., F.L.S................................... Sir John P. Boileau, Bart., F.R.S. Sir William F. F. Middleton, Bart. . J. C. Cobbold, Esq., M.P. T. B. Western, Esq.	Charles May, Esq. Dillwyn Sims, Esq. George Arthur Biddell, Esq. George Ransome, Esq.

II. Table showing the Names of Members of the British Association who have served on the Council in former years.

Acland, Sir Thomas D., Bart., M.P., F.R.S.
Acland, Professor H. W., B.M., F.R.S.
Adamson, John, Esq., F.L.S.
Adare, Edwin, Viscount, M.P., F.R.S.
Ainslie, Rev. Gilbert, D.D., Master of Pembroke Hall, Cambridge.
Airy, G. B., D.C.L., F.R.S., Astronomer Royal.
Alison, Professor W. P., M.D., F.R.S.E.
Ansted, Professor D. T., M.A., F.R.S.
Arnott, Neil, M.D., F.R.S.
Ashburton, William Bingham, Lord, D.C.L.
Babbage, Charles, Esq., F.R.S.
Babington, C. C., Esq., F.L.S.
Baily, Francis, Esq., F.R.S.
Balfour, Professor John H., M.D.
Barker, George, Esq., F.R.S.
Bengough, George, Esq.
Bentham, George, Esq., F.L.S.
Bigge, Charles, Esq.
Blakiston, Peyton, M.D., F.R.S.
Boyle, Right Hon. David, Lord Justice-General, F.R.S.E.
Brand, William, Esq.
Brewster, Sir David, K.H., D.C.L., LL.D., F.R.S.
Breadalbane, John, Marquis of, K.T., F.R.S.
Brisbane, General Sir Thomas M., Bart., K.C.B., G.C.H., D.C.L., F.R.S.
Brown, Robert, D.C.L., F.R.S., President of the Linnean Society.
Brunel, Sir M. I., F.R.S.
Buckland, Very Rev. William, D.D., Dean of Westminster, F.R.S.
Burlington, William, Earl of, M.A., F.R.S., Chancellor of the University of London.
Bute, John, Marquis of, K.T.
Carlisle, George William Frederick, Earl of, F.G.S.
Carson, Rev. Joseph.
Cathcart, Lieut.-General, Earl of, K.C.B., F.R.S.E.
Chalmers, Rev. T., D.D., late Professor of Divinity, Edinburgh.
Chance, James, Esq.
Chester, John Graham, D.D., Lord Bishop of.
Christie, Professor S. H., M.A., Sec. R.S.
Clare, Peter, Esq., F.R.A.S.
Clark, Rev. Professor, M.D., F.R.S. (Cambridge).
Clark, Henry, M.D.
Clark, G. T., Esq.
Clear, William, Esq.
Clerke, Major Shadwell, K.H., R.E., F.R.S.
Clift, William, Esq., F.R.S.
Colquhoun, J. C., Esq., M.P.
Conybeare, Very Rev. W.D., Dean of Llandaff, M.A., F.R.S.
Corrie, John, Esq., F.R.S.
Currie, William Wallace, Esq.
Dalton, John, D.C.L., F.R.S.
Daniell, Professor J. F., F.R.S.
Dartmouth, William, Earl of, D.C.L., F.R.S.
Darwin, Charles, Esq., F.R.S.
Daubeny, Professor Charles G. B., M.D., F.R.S.
De la Beche, Sir Henry T., F.R.S., Director-General of the Geological Survey of the United Kingdom.
Dillwyn, Lewis W., Esq., F.R.S.
Drinkwater, J. E., Esq.
Durham, Edward Maltby, D.D., Lord Bishop of, F.R.S.
Egerton, Sir Philip de M. Grey, Bart., F.R.S.
Eliot, Lord, M.P.
Ellesmere, Francis, Earl of, F.G.S.
Estcourt, T. G. B., D.C.L.
Faraday, Professor, D.C.L., F.R.S.
Fitzwilliam, Charles William, Earl, D.C.L., F.R.S.
Fleming, W., M.D.
Fletcher, Bell, M.D.
Forbes, Charles, Esq.
Forbes, Professor Edward, F.R.S.
Forbes, Professor J. D., F.R.S., Sec. R.S.E.
Fox, Robert Were, Esq., F.R.S.
Gassiot, J. P., Esq., F.R.S.
Gilbert, Davies, D.C.L., F.R.S.
Graham, Professor Thomas, M.A., F.R.S.
Gray, John E., Esq., F.R.S.
Gray, Jonathan, Esq.
Gray, William, jun., Esq., F.G.S.
Green, Professor Joseph Henry, F.R.S.
Greenough, G. B., Esq., F.R.S.
Grove, W. R., Esq., F.R.S.
Hallam, Henry, Esq., M.A., F.R.S.
Hamilton, W. J., Esq., Sec.G.S.
Hamilton, Sir William R., Astronomer Royal of Ireland, M.R.I.A.
Harcourt, Rev. William Vernon, M.A., F.R.S.
Hardwicke, Charles Philip, Earl of, F.R.S.
Harford, J. S., D.C.L., F.R.S.
Harris, Sir W. Snow, F.R.S.
Harrowby, The Earl of.
Hatfeild, William, Esq., F.G.S.
Henslow, Rev. Professor, M.A., F.L.S.
Henry, W. C., M.D., F.R.S.
Herbert, Hon. and Very Rev. William, late Dean of Manchester, LL.D., F.L.S.
Herschel, Sir John F. W., Bart., D.C.L., F.R.S.
Heywood, Sir Benjamin, Bart., F.R.S.
Heywood, James, Esq., M.P., F.R.S.
Hill, Rev. Edward, M.A., F.G.S.
Hodgkin, Thomas, M.D.
Hodgkinson, Professor Eaton, F.R.S.
Hodgson, Joseph, Esq., F.R.S.
Hooker, Sir William J., LL.D., F.R.S.
Hope, Rev. F. W., M.A., F.R.S.
Hopkins, William, Esq., M.A., F.R.S.
Horner, Leonard, Esq., F.R.S., F.G.S.
Hovenden, V. F., Esq., M.A.
Hutton, Robert, Esq., F.G.S.
Hutton, William, Esq., F.G.S.
Ibbetson, Capt. L. L. Boscawen, K.R.E., F.G.S.
Inglis, Sir Robert H., Bart., D.C.L., M.P., F.R.S.
Jameson, Professor R., F.R.S.
Jeffreys, John Gwyn Jeffreys, Esq.
Jenyns, Rev. Leonard, F.L.S.
Jerrard, H. B., Esq.
Johnston, Right Hon. William, Lord Provost of Edinburgh.

Johnston, Professor J. F. W., M.A., F.R.S.
Keleher, William, Esq.
Kelland, Rev. Professor P., M.A.
Lansdowne, Henry, Marquis of, D.C.L., F.R.S.
Lardner, Rev. Dr.
Latham, R. G., M.D., F.R.S.
Lee, Very Rev. John, D.D., F.R.S.E., Principal of the University of Edinburgh.
Lee, Robert, M.D., F.R.S.
Lefevre, Right Hon. Charles Shaw, Speaker of the House of Commons.
Lemon, Sir Charles, Bart., M.P., F.R.S.
Liddell, Andrew, Esq.
Lindley, Professor John, Ph.D., F.R.S.
Listowel, The Earl of.
Lloyd, Rev. Bartholomew, D.D., late Provost of Trinity College, Dublin.
Lloyd, Rev. Professor, D.D., Provost of Trinity College, Dublin, F.R.S.
Lubbock, Sir John W., Bart., M.A., F.R.S.
Luby, Rev. Thomas.
Lyell, Sir Charles, M.A , F.R.S.
MacCullagh, Professor, D.C.L., M.R.I.A.
Macfarlane, The Very Rev. Principal.
MacLeay, William Sharp, Esq., F.L.S.
MacNeill, Professor Sir John, F.R.S.
Malcolm, Vice Admiral Sir Charles, K.C.B.
Manchester, James Prince Lee, D.D., Lord Bishop of.
Meynell, Thomas, Jun., Esq., F.L.S.
Miller, Professor W. H., M.A., F.R.S.
Moillet, J. L., Esq.
Moggridge, Matthew, Esq.
Moody, J. Sadleir, Esq.
Moody, T. H. C., Esq.
Moody, T. F., Esq.
Morley, The Earl of.
Moseley, Rev. Henry, M.A., F.R.S.
Mount-Edgecumbe, Ernest Augustus, Earl of.
Murchison, Sir Roderick I., G.C.S., F.R.S.
Neill, Patrick, M.D., F.R.S.E.
Nicol, D., M.D.
Nicol, Rev. J. P., LL.D.
Northumberland, Hugh, Duke of, K.G., M.A., F.R.S.
Northampton, Spencer Joshua Alwyne, Marquis of, V.P.R.S.
Norwich, Edward Stanley, D.D., F.R.S., late Lord Bishop of.
Ormerod, G. W., Esq., F.G.S.
Orpen, Thomas Herbert, M.D.
Orpen, J. H., LL.D.
Owen, Professor Richard, M.D., F.R.S.
Oxford, Samuel Wilberforce, D.D., Lord Bishop of, F.R.S., F.G.S.
Osler, Follett, Esq.
Palmerston, Viscount, G.C.B., M.P.
Peacock, Very Rev. George, D.D., Dean of Ely, F.R.S.
Peel, Rt. Hon. Sir Robert, Bart., M.P., D.C.L., F.R.S.
Pendarves, E., Esq., F.R.S.
Phillips, Professor John, F.R.S.
Porter, G. R., Esq.
Powell, Rev. Professor, M.A., F.R.S.
Prichard, J. C., M.D., F.R.S.
Ramsay, Professor W., M.A.
Reid, Lieut.-Col. William, F.R.S.
Rennie, George, Esq., V.P.R.S.
Rennie, Sir John, F.R.S.
Richardson, Sir John, M.D., F.R.S.
Ritchie, Rev. Professor, LL.D., F.R.S.
Robinson, Rev. J., D.D.
Robinson, Rev. T. R., D.D., M.R.I.A.
Robison, Sir John, late Sec.R.S.Edin.
Roche, James, Esq.
Roget, Peter Mark, M.D., F.R.S.
Ronalds, Francis, F.R.S.
Rosebery, The Earl of, K.T., D.C.L., F.R.S.
Ross, Capt. Sir James C., R.N., F.R.S.
Rosse, William, Earl of, M.R.I.A., President of the Royal Society.
Royle, Professor John F., M.D., F.R.S.
Russell, James, Esq.
Russell, J. Scott, Esq.
Sabine, Lieut.-Colonel Edward, R.A., Treas. R.S.
Saunders, William, Esq., F.G.S.
Sandon, Lord.
Scoresby, Rev. W., D.D., F.R.S.
Sedgwick, Rev. Professor Adam, M.A., F.R.S.
Selby, Prideaux John, Esq., F.R.S.E.
Smith, Lieut.-Colonel C. Hamilton, F.R.S.
Spence, William, Esq., F.R.S.
Staunton, Sir George T., Bart., M.P., D.C.L., F.R.S.
St. David's, Connop Thirlwall, D.D., Lord Bishop of.
Stevelly, Professor John, LL.D.
Strang, John, Esq.
Strickland, H. E., Esq., F.G.S.
Sykes, Lieut.-Colonel W. H., F.R.S.
Symonds, B. P., D.D., late Vice-Chancellor of the University of Oxford.
Talbot, W. H. Fox, Esq., M.A., F.R.S.
Tayler, Rev. J. J.
Taylor, John, Esq., F.R.S.
Taylor, Richard, Jun., Esq., F.G.S.
Thompson, William, Esq., F.L.S.
Tindal, Captain, R.N.
Tod, James, Esq., F.R.S.E.
Traill, J. S., M.D.
Turner, Edward, M.D., F.R.S.
Turner, Samuel, Esq., F.R.S., F.G.S.
Turner, Rev. W.
Vigors, N. A., D.C.L., F.L.S.
Vivian, J. H., M.P., F.R.S.
Walker, James, Esq., F.R.S.
Walker, Joseph N., Esq., F.G.S.
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Washington, Captain, R.N.
West, William, Esq., F.R.S.
Wharncliffe, John Stuart, Lord, F.R.S.
Wheatstone, Professor Charles, F.R.S.
Whewell, Rev. William, D.D., F.R.S., Master of Trinity College, Cambridge.
Williams, Professor Charles J.B., M.D., F.R.S.
Willis, Rev. Professor Robert, M.A., F.R.S.
Wills, William.
Winchester, John, Marquis of.
Woollcombe, Henry, Esq., F.S.A.
Wrottesley, John, Lord, M.A., F.R.S.
Yarrell, William, Esq., F.L.S.
Yarborough, The Earl of, D.C.L.
Yates, James, Esq., M.A., F.R.S.

THE GENERAL TREASURER'S ACCOUNT from 13th of September

RECEIPTS.

	£	s.	d.	£	s.	d.
To balance brought on from last account				360	7	0
Life Compositions at Birmingham and since				130	0	0
Annual Subscriptions at Birmingham and since				206	1	0
Associates' at Birmingham				447	0	0
Ladies' Tickets at Birmingham				237	0	0
Book Compositions				25	0	0
Dividends on Stock (£3500 three per cent. Consols)				101	18	10
From Sale of Publications:—						
Of volume 1	0	8	1			
2	0	15	3			
3	1	17	0			
4	0	8	1			
5	1	9	7			
6	3	12	7			
7	1	7	0			
8	1	13	3			
9	2	16	0			
10	0	19	7			
11	1	14	10			
12	1	11	2			
13	1	17	0			
14	7	10	8			
15	5	12	9			
16	12	1	3			
17	47	11	0			
18	4	16	6			
British Association's Catalogue of Stars	84	17	5			
Lalande's Catalogue of Stars	7	13	11			
Lacaille's Catalogue of Stars	0	8	1			
Dove's Isothermal Lines	22	19	0			
Lithograph Signatures	0	6	0			
				214	6	0
				£1721	12	10

JAMES HEYWOOD,
J. W. GILBART,
C. MALCOLM.
} *Auditors.*

1849 (at Birmingham) to 31st of July 1850 (at Edinburgh).

PAYMENTS.

	£	s.	d.	£	s.	d.
For Sundry Printing, Advertising, Expenses of Meeting at Birmingham, and Sundry Disbursements made by the Treasurer and Local Treasurers				308	12	4
Printing, &c. the 17th vol.				290	11	10
Engraving for 18th vol.				22	1	11
Salaries, Assistant General Secretary and Accountant				350	0	0
Maintaining the Establishment at Kew Observatory:—						
Balance of Grant of 1848	44	13	2			
Part of Grant of 1849	211	4	10			
				255	18	0
Transit of Earthquake Waves				50	0	0
Periodical Phænomena of Animals and Vegetables:—						
Balance of Grant of 1848	5	0	0			
Grant of 1849	10	0	0			
				15	0	0
Meteorological Instruments for the Azore Islands				25	0	0
Balance in the Banker's hands	383	14	0			
Ditto in General Treasurer's and Local Treasurers' hands	20	14	9			
				404	8	9
				£1721	12	10

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M. Arago, Paris.
Dr. A. D. Bache, Philadelphia.
Professor H. von Boguslawski, Breslau.
Monsieur Boutigny (d'Evreux), Paris.
Professor Braschmann, Moscow.
Chevalier Bunsen.
Charles Buonaparte, Prince of Canino.
M. De la Rive, Geneva.
Professor Dovè, Berlin.
Professor Dumas, Paris.
Dr. J. Milne-Edwards, Paris.
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Dr. Eisenlohr, Carlsruhe.
Professor Encke, Berlin.
Dr. A. Erman, Berlin.
Professor Esmark, Christiania.
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M. Frisiani, Milan.
Professor Henry, Washington, United States.
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M. Jacobi, St. Petersburg.
Professor Jacobi, Königsberg.
Professor Kreil, Prague.
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Dr. Langberg, Christiania.
M. Leverrier, Paris.
Baron de Selys-Longchamps, Liège.
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Baron von Liebig, Giessen.
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Professor Plücker, Bonn.
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Professor H. Rose, Berlin.
Professor Schumacher, Altona.
Baron Senftenberg, Bohemia.
Dr. Siljestrom, Stockholm.
M. Struvè of St. Petersburg.
Dr. Svanberg, Stockholm.
Dr. Van der Höven, Leyden.
Baron Sartorius von Waltershausen, Gotha.
Professor Wartmann, Lausanne.

REPORT OF THE PROCEEDINGS OF THE COUNCIL IN 1849–50, AS PRESENTED TO THE GENERAL COMMITTEE AT EDINBURGH, WEDNESDAY, JULY 31, 1850.

With reference to the subjects referred to the Council by the General Committee assembled in Birmingham, the Council have to report as follows:—

1. In respect to the proposed Recommendation to Her Majesty's Government, to establish a Reflecting Telescope of large optical power at a suitable station for the systematic observation of the Nebulæ of the Southern Hemisphere, the Council having communicated with the President and

Council of the Royal Society, had the satisfaction of being informed of the entire agreement of that body in the importance attached by the British Association to the active use of a large Reflector in the Southern Hemisphere, and of their readiness to concur in a recommendation to that effect to Her Majesty's Government. The Council have further to report, that the following Memorial has been drawn up by the Rev. Dr. Robinson, President of the British Association, with the concurrence of the Earl of Rosse, President of the Royal Society, and has been presented to Lord John Russell.

Copy of the Memorial to Lord John Russell.

"My Lord,—At the last Meeting of the British Association for the Advancement of Science, that Assembly came to a resolution which has been adopted by the Royal Society, and which therefore I am directed, conjointly with the President of that illustrious body, to lay before your Lordship.

"The purpose is, that the Government be requested to establish, in some fitting part of Her Majesty's dominions, a powerful reflecting telescope (not less than 3 feet aperture), and to appoint an Observer charged with the duty of employing it in a review of the Nebulæ of the Southern Hemisphere.

"In evidence of the high importance of such an investigation, it is sufficient to refer to the way in which its proposal was welcomed by the British Association. That assembly, comprising upwards of 1500 persons, among whom were found almost every British name of scientific renown, and of whom all are more or less devoted to the pursuit of physical knowledge, may not unfairly be considered an exponent of the national mind on such an occasion; and I have never seen it admit any similar resolution with a more enthusiastic approval.

"For the department of Nebular Astronomy is that which at present has the most powerful hold on public attention, and stands most in need of public assistance. Others are worked out by the pen and in the closet, or by instruments of easy attainment, and in establishments already fully organized: the only results which they can now yield are uninteresting except to a few, and are valued by the mass only from an instinctive perception of the glory which they confer on human intellect. But it is far otherwise with this; the mysterious forms on which it is employed are at present objects of universal curiosity, from their position (outworks as it were of the universe), their evident analogy to the system of which we are a part, and which we may hope to study in them, and the Dynamic questions which the marvellous arrangements of many of them suggest. I may add, that in its origin it is almost exclusively ours; the fame which will reward its completion should be ours also. The history may be very briefly given. About sixty-eight Nebulæ had been ill seen and worse described, when the elder Herschel was led to explore them by the encouragement and aid of his sovereign George III. To those previously known, he not only added 2500 more, but by classing them, by clear and methodical description, and directing attention to the relations which connect them with other portions of the universe, he gave this branch of astronomy its powerful vitality. His no less distinguished son, following his example with even greater success, has not merely extended the list of northern nebulæ to an amount which would have ennobled any other name, but has given the whole work complete precision by an accurate determination of the position of all contained in his own and his father's lists, thus placing them fully within the reach of subsequent observers. Not content with this, he transported to the other hemisphere those instruments which had rendered such good service in our own, and has thus enriched astronomy with 1600 more equally well observed, but beyond the reach of European astronomers.

"Yet powerful as those instruments were, a much nearer approach to the extreme limit of *useful* optical power has been made by Lord Rosse: it was therefore to be expected that his telescope would add considerably to our knowledge of the Nebulæ, and this has been fully realized. It was in fact a communication of some results obtained by him which directed the attention of the British Association to this subject, and excited a desire of having the same work performed for the southern sky which he is accomplishing in our own. That work implies a minute re-examination of at least all the brighter Nebulæ of Sir John Herschel's catalogues; embodied in drawings, based on micrometer measures, and so correct that each of them may be referred to without doubt by future astronomers as an *authentic record* of the original's appearance at a given epoch. Of such drawings we at present possess very few: most of the sketches given by the Herschels are stated by them to be made merely by eye; and even those that were more accurately taken by them are found to require amendment when compared with the appearances in more powerful telescopes.

"A task of this kind can only be wrought out by severe and long-continued labour; and the instrumental means required are such as very few individuals can obtain by their private resources. Even in Europe there are but three telescopes known to exist which are capable of making any great additions to the discoveries of the Herschels; and those three are in the British Islands. This field of research is therefore still exclusively our own; and I trust your Lordship will share my feeling, that the nation's honour will be sullied if we let it be preoccupied in its most interesting portion by the energy and liberality of any other people.

"In submitting to your Lordship this request of the British Association, I feel it my duty to give with it some approximative estimate of the sum which might be required for its accomplishment.

"First, as to the instrument: it has been proved by the experience of Lord Rosse, Mr. Lassels and others, that one of sufficient power can be constructed with certainty and at no overwhelming cost. I have made inquiries of an artist (with whose abilities in this line I am practically acquainted), and have come to the conclusion that a telescope similar to the smaller of Lord Rosse's 3 feet aperture and 27 feet focal length might be constructed for £2000. This would include an equatorial mounting; clock-work to make the telescope travel with a star; apparatus for supporting the observer; and a machine for polishing the speculum, when that operation may be required. If a second speculum were supplied (which seems almost essential in case of accident), it would add about £500 more. Of course some latitude must be allowed in this, but it need not be wide; the work could not be completed in less than a year, possibly would employ two. As telescopes so gigantic are erected in the open air, no outlay would be necessary for any building except the Observer's dwelling.

"Secondly, the Observer need not possess very high mathematical attainments; acute sight, and skill as a draughtsman, being his most important requisites; and his staff need not consist of more than two or three labourers, one of whom should be a practical mechanic.

"I am quite aware that there are some persons who will consider the sum that I have named above, and the moderate annual expenditure which would be required for a few years, a very unprofitable waste of public money. I feel also assured that your Lordship is not of their number; no man can be who has ever drunk of the fountain of knowledge, or added to the domain of intellect. I feel confident that the public itself is not with them, and that it would resent as an insult the imputation of valuing at a mere market price the only true elements of personal dignity or national glory. If the spirit of the age be such that the most despotic sovereigns of Europe feel that they cannot avoid the necessity of encouraging physical science, much more does it belong to the rulers of the freest and most enlightened nation of the world; and it is due to your Lordship and your colleagues to say that we have always found you to carry out in the fullest extent the requirements of science.

"In hopes that in this instance also our appeal may not be in vain,

"I have the honour to be
"Your Lordship's obedient Servant,
"T. R. Robinson,
"*President of the British Association for the Advancement of Science.*"

"The Right Hon. The Lord John Russell."

2. In consequence of the Resolution passed by the General Committee relative to the correction of the levels of the Ordnance Survey of Ireland, the President communicated with the Rev. Dr. Lloyd, President of the Royal Irish Academy. The President and Council of the Royal Irish Academy have addressed the Master-General of the Ordnance, recommending that the correction should be made, and have received a favourable reply.

3. In respect to the proposed application to the Master-General of the Ordnance to have the British Arc of the Meridian published in its full extent, the Council have had the satisfaction of learning that the President and Council of the Royal Society entirely agreed with the British Association in their estimate of the importance of the proposed publication, and that with the concurrence of the Marquis of Anglesey, Master-General of the Ordnance, an application has been made by the President of the Royal Society to Lord John Russell, to place the necessary funds at the disposal of the Ordnance Department, and that the application has been favourably received by Lord John Russell on the part of Her Majesty's Government.

4. The Sub-Committee who were appointed to organise a Committee of Members of the Association, who are also Members of the Legislature, for the purpose of watching over the interests of Science, request permission to submit their plan of proceeding to the Committee of Recommendations, in order that it may come before the General Committee.

5. In pursuance of the authority granted by the General Committee to the Council to make arrangements for the proper distribution of the unsold Copies of the Volumes of Reports of the British Association, the Council appointed a Select Committee to consider and report on the subject. A first report of the Committee has been received and will be taken into early consideration.

6. For the more effectual discharge of the trust reposed in them of general superintendence of the Observatory at Kew, the Council named a Committee, consisting of Members of their own body, who at their request undertook the duty of frequent visitation, and of special superintendence over the experiments and observations to be made there. The Council have great satisfaction in stating that the gentlemen who undertook the duties of this Committee have discharged them with remarkable assiduity, and that they have been assisted at their Meetings by the attendance of other Members of the Council who participate in the desire of rendering Kew an effective and important establishment. The Council have received

from the Committee the subjoined Report on the present state and prospects of the Observatory.

Report of the Kew Committee.—" The grant made by the General Committee for maintaining the establishment at Kew Observatory during the present year being in a considerable degree founded on the results actually secured, and others likely to be obtained by the electrical observations which have been instituted there, the Committee for superintending the Observatory have kept the prosecution and extension of these experiments steadily in view.

" Ever since 1843 a series of measures of the intensity of atmospheric electricity has been accumulated at Kew. By direction of the General Committee in 1848, Mr. Birt was engaged on the discussion of these, and his Report is published in the Transactions of the Association for 1849. By this investigation the seeming irregularity of these phænomena has been in some degree elucidated, and results having a general and systematic value obtained. For example, during the twenty-four hours the electrical tension of the atmosphere acquires two *maxima*, viz. about 10 A.M. and 10 P.M., and suffers two *minima*, viz. about 4 A.M. and 4 P.M., these being also nearly the hours of *barometrical maxima* and *minima*. Moreover, in the course of the twelve months, there is distinctly a periodicity of electrical tension; the maximum for the year being in the depth of winter, and the minimum in the height of summer. Mr. Birt has shown the relation of the curve which represents the annual movement of the electrical tension to that which describes the *humidity* of the air.

" To the experiments from which these and other interesting relations have arisen, the Committee has been enabled to add a new series of observations on *electrical frequency*, by which not the intensity of the atmospheric charge, but the *rate* at which the instrument receives it will become known. These observations were begun under Mr. Ronalds's direction in March 1850, and were continued for three weeks; but unfortunately the state of Mr. Birt's health has not only stopped the observations, but deprived the Observatory of the further services of that gentleman.

" The Committee will be able to supply the deficiency thus occasioned, and conduct these and other researches in a satisfactory manner, if the General Committee shall think fit to empower them, by the appointment of Mr. Welsh, late Assistant in the Observatory of Sir Thomas Brisbane, a gentleman of whose qualifications for the duties of Observer at Kew, the Committee have ample testimony.

" In originally accepting the charge of this Observatory (1842), the Association was influenced by the facilities which it would afford for the prosecution of experimental inquiries in the physical sciences, for which its locality is peculiarly suitable, and at the close of the first year the Council had established the following registers in addition to the electrical observations already noticed:—

" An ordinary meteorological record with standard instruments; and had made arrangements with Professor Wheatstone for the completion of a self-registering meteorological instrument on a new construction.

" The advantage to be derived from self-recording instruments by meteorology and magnetism has been often expressed by votes of the Association from an early period of its career. The establishment of Kew Observatory brought these ideas into practical operation. That Observatory has given to science self-recording instruments for electrical, magnetical, and meteorological phænomena, already of great value, and certainly capable of great further improvement. Mr. Ronalds, whose valuable services have been given gratuitously to the Observatory from nearly its foundation, is still intent on improving these instruments; and lately, by employing the new invention of gelatine paper, he has not only been able to copy exactly the line which is traced on the plate by light, but further to print other copies for distribution. Mr. Ronalds's Report of the Proceedings at Kew during the past year, which is prepared for reading in the Physical Section, will make known other facts illustrative of the state of the Observatory. Kreil's Barometrograph, which was received in 1845, has been put in working order. Electrical, magnetical, and meteorological phænomena are those for which the apparatus now collected at Kew is specially adapted, and it is in a condition to admit of their being regularly and constantly registered—in a great degree by self-recording instruments. But to provide for the constant and regular registration of all these phænomena would be quite incompatible with the limited funds at the disposal of the Association, and inconsistent with the general intention of the establishment—which is an *Experimental Observatory*, devoted to open out new physical inquiries, and to make trial of new modes of inquiry, but only in a few selected cases to preserve continuous records of passing phænomena.

"It is on this view of the character of the Observatory that the Committee found their opinion, that it may be maintained in a state of efficiency, and kept always ready to take its proper share in the Advancement of Science, by means of a moderate annual grant from the Association. They have further the satisfaction to report, that the progress of the Observatory in its peculiar field of research is likely to be materially aided by funds provided from another source, the Royal Society having allotted £100 for the purchase of new instruments to be tried at Kew, out of the sum placed at their disposal by Her Majesty's Government."

7. The Council have been informed by Sir John Burgoyne, Inspector-General of Fortifications, that the publication of the Mountjoy Meteorological Observations will be at once proceeded with in compliance with the directions of the Marquis of Anglesey, Master-General of the Ordnance.

8. The Council have added the following names to the list of the Corresponding Members of the British Association, viz.

Professor Gustav Magnus of Berlin.
Professor W. B. Rogers of Virginia.

Recommendations adopted by the General Committee at the Edinburgh Meeting in August 1850.

Involving Application to Government or Public Institutions.

That a Committee, consisting of the President, the Duke of Argyll, Sir R. I. Murchison, Professor Forbes, and the Marquis of Breadalbane, be appointed for the purpose of urging on Her Majesty's Government the completion of the Geographical Survey of Scotland, as recommended by the British Association, at their former meeting in Edinburgh in 1834.

That application be made to the Admiralty for the Publication of the Reports of their Committee on Metals.

That a Committee be appointed by the Council, for the purpose of waiting upon Her Majesty's Government to request that some means be taken to ensure to the Science of Natural History an effective representation in the Trusteeship of the British Museum.

That the Council of the Association be requested to communicate with the Council of the Royal Society, and also with the Government, if necessary, respecting the possibility of relieving the Association from the expense of maintaining the establishment at Kew.

That Her Majesty's Government be requested to institute a Statistical Survey relative to the Extent and Prevalence of Infantile Idiocy as a measure greatly conducive to the public welfare.

Involving Grants of Money.

That the Establishment at Kew Observatory be continued (at the disposal of the Council for that purpose), with £300.

That Professor J. D. Forbes be requested to institute a Series of Experiments, for the purpose of testing the results of the Mathematical Theory of Heat; that Professor Kelland be requested to co-operate with him; and that £50 be placed at the disposal of Prof. Forbes for the purpose.

That the Committee for superintending the Publication of the Tabular Forms in reference to Periodical Phænomena of Animals and Plants, be continued, with £5 at their disposal.

That Professor E. Forbes and Mr. Bell be requested to continue their assistance to Dr. Thomas Williams in his researches on the Annelida, with £10 at their disposal.

That the Committee on the Vitality of Seeds be requested to continue their attention to that subject, with £11 at their disposal.

That a Committee, consisting of Mr. R. Hunt, Dr. G. Wilson, and Dr. Gladstone, be requested to investigate the influence of the solar radiations or chemical combinations, electrical phænomena, and the vital powers of plants growing under different atmospheric conditions, with £50 at their disposal.

That Dr. Smith be requested to continue his investigation on the Air and Water of Towns, with £10 at his disposal.

That, as the printed Queries formerly circulated for the purpose of obtaining Ethnological data are now out of print, a new and revised Edition of them be issued by Sir Charles Malcolm and Dr. Hodgkin, with £12 at their disposal for the purpose.

Rules.

That the subject of Geography be separated from Geology, and combined with Ethnology, to constitute a separate Section, under the title of the Geographical and Ethnological Section.

That in future no Section shall omit to meet on account of Excursions, unless it be specially so determined in each case by the Sectional Committee.

That for the future the names of officers and members of Committees not attending the Meetings of the Association be not published.

Notice was given of an intention to propose at the next Meeting, that the sum now paid for Life Composition and Book Subscription (viz. £10) be divided into two sums of £5 and £5, the former sum being a necessary payment by all who compound for Annual Subscription; the latter an optional payment as a special Book Subscription.

Reports requested.

Professor Stokes.—On the General Theory of Vibratory Motions in Elastic Media.

Professor Willis.—On Acoustics.

Mr. G. Buchanan.—On the Strength of Materials .

Mr. Thomas Stevenson.—On the various modes of constructing Sea Walls, and the actual state of knowledge as to their power of resisting the forces to which they are exposed.

Mr. J. Whitworth.—On his Experiments for the purpose of constructing Accurate Standards of Measure.

Dr. Hugh Cleghorn, Professor Royle, Messrs. R. Baird Smith, and R. Strachey, H.E.I.C.S.—On the probable effects, in an œconomical and physical point of view, of the Destruction of Tropical Forests.

Researches, &c.

That the Committee on the influence of Carbonic Acid on the growth of Ferns be requested to continue their investigations.

That Dr. Percy and Professor Miller be requested to continue their researches on Crystalline Slags.

That the Committee on Shooting Stars and Auroral Phænomena be reappointed.

That the Committee on the Instrumental Measurement of Earthquake Waves be reappointed.

That the Committee of superintendence of the Kew Observatory be continued.

Miscellaneous.

That the Committee of Members of Legislature, who are also Members of the British Association, who were requested to watch over the interests of Science, and to inspect the various measures which might from time to time be introduced into Parliament, likely to affect such interests, be reappointed, and that the further steps to be taken in this matter be referred to the Council.

That the Presidents of the several Sections be requested, with such assistance from the Members as they may find desirable, to revise the recommendations which have from time to time been adopted in reference to the branches of Science which are taken into consideration by those Sections respectively, and to communicate thereon with the Assistant General Secretary previous to the next Meeting.

That a Committee, consisting of Sir John Herschel, The Astronomer Royal, Prof. Forbes and Prof. Powell, with power to add to their number, be empowered to communicate with the Astronomers of Pulkowa on the observations to be made at the next approaching total Eclipse of the Sun, July 28, 1851, and to draw up suggestions for the guidance of observers generally.

That the Memorial of M. Kupffer be printed for circulation among the officers.

It appearing that two recommendations for Reports, viz. On the Anatomy and Physiology of the Nervous System, and on the History and Advances of Vegetable Physiology, which had been adopted by the Committee of Section D, had not been presented to the Committee of Recommendations, it was directed that these be communicated to the Council at its next Meeting: the following are the terms of these Resolutions:—

"That Professors Sharpey, Goodsir and Allen Thompson, and Dr. Laycock, with power to add to their number, be requested to prepare for the next Meeting of the Association a Report on the History of, and Advances in our knowledge of the Anatomy and Physiology of the Nervous System, from the date of the last Report on this subject.

"That Dr. Lindley, Arthur Henfrey, F.L.S., and Dr. Lankester, with power to add to their number, be requested to prepare for the next Meeting of the Association a Report on the Advances in our knowledge of Vegetable Physiology, from the date of the last Report on this subject."

That two Botanical Works, presented by Professor Parlatore, be deposited in the Library of the University of Edinburgh.

That the Tables of the distribution (in depth) of Marine Animals, by Mr. M'Andrew, be printed *in extenso* in the Volume of Reports of this Meeting of the Association.

That Major General Briggs's paper On the Aboriginal Tribes of India be printed entire in the next Volume of Transactions.

Synopsis of Grants of Money appropriated to Scientific Objects by the General Committee at the Edinburgh Meeting in August 1850, *with the Name of the Member, who alone, or as the First of a Committee, is entitled to draw for the Money.*

	£	s.	d.
Kew Observatory.			
At the disposal of the Council for defraying Expenses........	300	0	0
Mathematical and Physical Science.			
FORBES, Prof. J. D.—Experiments for the purpose of testing the results of the Mathematical Theory of Heat	50	0	0
Chemical Science.			
HUNT, Mr. R.—Influence of the Solar Radiations or Chemical Combinations, Electrical Phænomena, and the Vital Powers of Plants growing under different atmospheric conditions..	50	0	0
SMITH, Dr.—Investigations on the Air and Water of Towns...	10	0	0
Natural History.			
STRICKLAND, H. E.—Vitality of Seeds.....................	11	0	0
LANKESTER, Dr.—Periodical Phænomena of Animals and Vegetables	5	0	0
FORBES, Prof. E.—Report on British Annelida	10	0	0
Ethnology.			
MALCOLM, Sir CHARLES.—Printed Queries for obtaining Ethnological Data	12	0	0
Grants........	£448	0	0

General Statement of Sums which have been paid on Account of Grants for Scientific Purposes.

	£	s.	d.
1834.			
Tide Discussions	20	0	0
1835.			
Tide Discussions	62	0	0
British Fossil Ichthyology	105	0	0
	£167	0	0
1836.			
Tide Discussions	163	0	0
British Fossil Ichthyology	105	0	0
Thermometric Observations, &c.	50	0	0
Experiments on long-continued Heat	17	1	0
Rain Gauges	9	13	0
Refraction Experiments	15	0	0
Lunar Nutation	60	0	0
Thermometers	15	6	0
	£434	14	0
1837.			
Tide Discussions......	284	1	0
Chemical Constants ..	24	13	6
Lunar Nutation	70	0	0
Observations on Waves.	100	12	0
Tides at Bristol	150	0	0
Meteorology and Subterranean Temperature .	89	5	0
Vitrification Experiments	150	0	0
Heart Experiments....	8	4	6
Barometric Observations	30	0	0
Barometers	11	18	6
	£918	14	6
1838.			
Tide Discussions......	29	0	0
British Fossil Fishes ..	100	0	0
Meteorological Observations and Anemometer (construction)	100	0	0
Cast Iron (strength of) .	60	0	0
Animal and Vegetable Substances (preservation of)	19	1	10
Carried forward	£308	1	10
Brought forward	308	1	10
Railway Constants	41	12	10
Bristol Tides	50	0	0
Growth of Plants	75	0	0
Mud in Rivers	3	6	6
Education Committee ..	50	0	0
Heart Experiments....	5	3	0
Land and Sea Level ..	267	8	7
Subterranean Temperature	8	6	0
Steam-vessels	100	0	0
Meteorological Committee	31	9	5
Thermometers	16	4	0
	£956	12	2
1839.			
Fossil Ichthyology	110	0	0
Meteorological Observations at Plymouth ..	63	10	0
Mechanism of Waves ..	144	2	0
Bristol Tides	35	18	6
Meteorology and Subterranean Temperature .	21	11	0
Vitrification Experiments	9	4	7
Cast Iron Experiments .	100	0	0
Railway Constants	28	7	2
Land and Sea Level ..	274	1	4
Steam-Vessels' Engines.	100	0	0
Stars in Histoire Céleste	331	18	6
Stars in Lacaille	11	0	0
Stars in R.A.S. Catalogue	6	16	6
Animal Secretions	10	10	0
Steam-engines in Cornwall	50	0	0
Atmospheric Air......	16	1	0
Cast and Wrought Iron.	40	0	0
Heat on Organic Bodies	3	0	0
Gases on Solar Spectrum	22	0	0
Hourly Meteorological Observations, Inverness and Kingussie ..	49	7	8
Fossil Reptiles	118	2	9
Mining Statistics......	50	0	0
	£1595	11	0

	£	s.	d.
1840.			
Bristol Tides	100	0	0
Subterranean Temperature	13	13	6
Heart Experiments....	18	19	0
Lungs Experiments ..	8	13	0
Tide Discussions......	50	0	0
Land and Sea Level ..	6	11	1
Stars (Histoire Céleste)	242	10	0
Stars (Lacaille)	4	15	0
Stars (Catalogue)	264	0	0
Atmospheric Air......	15	15	0
Water on Iron........	10	0	0
Heat on Organic Bodies	7	0	0
MeteorologicalObservations	52	17	6
Foreign Scientific Memoirs	112	1	6
Working Population ..	100	0	0
School Statistics	50	0	0
Forms of Vessels	184	7	0
Chemical and Electrical Phænomena........	40	0	0
Meteorological Observations at Plymouth ..	80	0	0
Magnetical Observations	185	13	9
	£1546	16	4
1841.			
Observations on Waves.	30	0	0
Meteorologyand Subterranean Temperature .	8	8	0
Actinometers	10	0	0
Earthquake Shocks ..	17	7	0
Acrid Poisons........	6	0	0
Veins and Absorbents..	3	0	0
Mud in Rivers........	5	0	0
Marine Zoology	15	12	8
Skeleton Maps	20	0	0
Mountain Barometers..	6	18	6
Stars (Histoire Céleste).	185	0	0
Stars (Lacaille)	79	5	0
Stars (Nomenclature of)	17	19	6
Stars (Catalogue of) ..	40	0	0
Water on Iron........	50	0	0
Meteorological Observations at Inverness ..	20	0	0
Meteorological Observations (reduction of)..	25	0	0
Carried forward	£539	10	8

	£	s.	d.
Brought forward	539	10	8
Fossil Reptiles	50	0	0
Foreign Memoirs	62	0	0
Railway Sections	38	1	6
Forms of Vessels	193	12	0
Meteorological Observations at Plymouth ..	55	0	0
MagneticalObservations	61	18	8
Fishes of the Old Red Sandstone	100	0	0
Tides at Leith........	50	0	0
Anemometer at Edinburgh	69	1	10
Tabulating Observations	9	6	3
Races of Men........	5	0	0
Radiate Animals......	2	0	0
	£1235	10	11
1842.			
Dynamometric Instruments	113	11	2
Anoplura Britanniæ ..	52	12	0
Tides at Bristol	59	8	0
Gases on Light	30	14	7
Chronometers	26	17	6
Marine Zoology	1	5	0
British Fossil Mammalia	100	0	0
Statistics of Education..	20	0	0
Marine Steam-vessels' Engines	28	0	0
Stars (Histoire Céleste)	59	0	0
Stars (British Association Catalogue of) ..	110	0	0
Railway Sections......	161	10	0
British Belemnites	50	0	0
Fossil Reptiles (publication of Report)	210	0	0
Forms of Vessels.......	180	0	0
Galvanic Experiments on Rocks	5	8	6
Meteorological Experiments at Plymouth..	68	0	0
Constant Indicator and DynamometricInstruments	90	0	0
Force of Wind........	10	0	0
LightonGrowthof Seeds	8	0	0
Vital Statistics	50	0	0
Vegetative Power of Seeds	8	1	11
Carried forward	£1442	8	8

	£	s.	d.
Brought forward	1442	8	8
Questions on Human Race	7	9	0
	£1449	17	8

1843.

	£	s.	d.
Revision of the Nomenclature of Stars	2	0	0
Reduction of Stars, British Association Catalogue	25	0	0
Anomalous Tides, Frith of Forth	120	0	0
Hourly Meteorological Observations at Kingussie and Inverness	77	12	8
Meteorological Observations at Plymouth	55	0	0
Whewell's Meteorological Anemometer at Plymouth	10	0	0
Meteorological Observations, Osler's Anemometer at Plymouth	20	0	0
Reduction of Meteorological Observations	30	0	0
Meteorological Instruments and Gratuities	39	6	0
Construction of Anemometer at Inverness	56	12	2
Magnetic Co-operation	10	8	10
Meteorological Recorder for Kew Observatory	50	0	0
Action of Gases on Light	18	16	1
Establishment at Kew Observatory, Wages, Repairs, Furniture and Sundries	133	4	7
Experiments by Captive Balloons	81	8	0
Oxidation of the Rails of Railways	20	0	0
Publication of Report on Fossil Reptiles	40	0	0
Coloured Drawings of Railway Sections	147	18	3
Registration of Earthquake Shocks	30	0	0
Report on Zoological Nomenclature	10	0	0
Carried forward	£977	6	7

	£	s.	d.
Brought forward	977	6	7
Uncovering Lower Red Sandstone near Manchester	4	4	6
Vegetative Power of Seeds	5	3	8
Marine Testacea (Habits of)	10	0	0
Marine Zoology	10	0	0
Marine Zoology	2	14	11
Preparation of Report on British Fossil Mammalia	100	0	0
Physiological operations of Medicinal Agents	20	0	0
Vital Statistics	36	5	8
Additional Experiments on the Forms of Vessels	70	0	0
Additional Experiments on the Forms of Vessels	100	0	0
Reduction of Observations on the Forms of Vessels	100	0	0
Morin's Instrument and Constant Indicator	69	14	10
Experiments on the Strength of Materials	60	0	0
	£1565	10	2

1844.

	£	s.	d.
Meteorological Observations at Kingussie and Inverness	12	0	0
Completing Observations at Plymouth	35	0	0
Magnetic and Meteorological Co-operation	25	8	4
Publication of the British Association Catalogue of Stars	35	0	0
Observations on Tides on the East Coast of Scotland	100	0	0
Revision of the Nomenclature of Stars.. 1842	2	9	6
Maintaining the Establishment in Kew Observatory	117	17	3
Instruments for Kew Observatory	56	7	3
Carried forward	£384	2	4

	£	s.	d.
Brought forward	384	2	4
Influence of Light on Plants	10	0	0
Subterraneous Temperature in Ireland	5	0	0
Coloured Drawings of Railway Sections	15	17	6
Investigation of Fossil Fishes of the Lower Tertiary Strata	100	0	0
Registering the Shocks of Earthquakes, 1842	23	11	10
Researches into the Structure of Fossil Shells	20	0	0
Radiata and Mollusca of the Ægean and Red Seas.......1842	100	0	0
Geographical distributions of Marine Zoology.......1842	0	10	0
Marine Zoology of Devon and Cornwall	10	0	0
Marine Zoology of Corfu	10	0	0
Experiments on the Vitality of Seeds	9	0	3
Experiments on the Vitality of Seeds..1842	8	7	3
Researches on Exotic Anoplura	15	0	0
Experiments on the Strength of Materials	100	0	0
Completing Experiments on the Forms of Ships	100	0	0
Inquiries into Asphyxia	10	0	0
Investigations on the internal Constitution of Metals	50	0	0
Constant Indicator and Morin's Instrument, 1842	10	3	6
	£981	12	8

1845.

	£	s.	d.
Publication of the British Association Catalogue of Stars	351	14	6
Meteorological Observations at Inverness	30	18	11
Magnetic and Meteorological Co-operation	16	16	8
Carried forward	£399	10	1
Brought forward	399	10	1
Meteorological Instruments at Edinburgh	18	11	9
Reduction of Anemometrical Observations at Plymouth	25	0	0
Electrical Experiments at Kew Observatory	43	17	8
Maintaining the Establishment in Kew Observatory	149	15	0
For Kreil's Barometrograph	25	0	0
Gases from Iron Furnaces	50	0	0
Experiments on the Actinograph	15	0	0
Microscopic Structure of Shells	20	0	0
Exotic Anoplura..1843	10	0	0
Vitality of Seeds..1843	2	0	7
Vitality of Seeds..1844	7	0	0
Marine Zoology of Cornwall	10	0	0
Physiological Action of Medicines	20	0	0
Statistics of Sickness and Mortality in York	20	0	0
Registration of Earthquake Shocks..1843	15	14	8
	£831	9	9

1846.

	£	s.	d.
British Association Catalogue of Stars, 1844	211	15	0
Fossil Fishes of the London Clay	100	0	0
Computation of the Gaussian Constants for 1839	50	0	0
Maintaining the Establishment at Kew Observatory	146	16	7
Experiments on the Strength of Materials	60	0	0
Researches in Asphyxia	6	16	2
Examination of Fossil Shells	10	0	0
Vitality of Seeds..1844	2	15	10
Vitality of Seeds..1845	7	12	3
Marine Zoology of Cornwall	10	0	0
Carried forward	£605	15	10

	£	s.	d.
Brought forward	605	15	10
Marine Zoology of Britain	10	0	0
Exotic Anoplura..1844	25	0	0
Expenses attending Anemometers	11	7	6
Anemometers' Repairs	2	3	6
Researches on Atmospheric Waves	3	3	3
Captive Balloons..1844	8	19	8
Varieties of the Human Race 1844	7	6	3
Statistics of Sickness and Mortality at York	12	0	0
	£685	16	0
1847.			
Computation of the Gaussian Constants for 1839	50	0	0
Habits of Marine Animals	10	0	0
Physiological Action of Medicines	20	0	0
Marine Zoology of Cornwall	10	0	0
Researches on Atmospheric Waves	6	9	3
Vitality of Seeds	4	7	7
Maintaining the Establishment at Kew Observatory	107	8	6
	£208	5	4
1848.			
Maintaining the Establishment at Kew Observatory	171	15	11
Carried forward	£171	15	11

	£	s.	d.
Brought forward	171	15	11
Researches on Atmospheric Waves	3	10	9
Vitality of Seeds	9	15	0
Completion of Catalogues of Stars	70	0	0
On Colouring Matters	5	0	0
On Growth of Plants	15	0	0
	£275	1	8
1849.			
Electrical Observations at Kew Observatory	50	0	0
Maintaining Establishment at ditto	76	2	5
Vitality of Seeds	5	8	1
On Growth of Plants	5	0	0
Registration of Periodical Phænomena	10	0	0
Bill on account of Anemometrical Observations	13	9	0
	£159	19	6
1850.			
Maintaining the Establishment at Kew Observatory	255	18	0
Transit of Earthquake Waves	50	0	0
Periodical Phænomena	15	0	0
Meteorological Instrument, Azores	25	0	0
	£345	18	0

Extracts from Resolutions of the General Committee.

Committees and individuals, to whom grants of money for scientific purposes have been entrusted, are required to present to each following meeting of the Association a Report of the progress which has been made; with a statement of the sums which have been expended, and the balance which remains disposable on each grant.

Grants of pecuniary aid for scientific purposes from the funds of the Association expire at the ensuing meeting, unless it shall appear by a Report that the Recommendations have been acted on, or a continuation of them be ordered by the General Committee.

In each Committee, the Member first named is the person entitled to call on the Treasurer, John Taylor, Esq., 6 Queen Street Place, Upper Thames Street, London, for such portion of the sum granted as may from time to time be required.

In grants of money to Committees, the Association does not contemplate the payment of personal expenses to the Members.

In all cases where additional grants of money are made for the continuation of Researches at the cost of the Association, the sum named shall be deemed to include, as a part of the amount, the specified balance which may remain unpaid on the former grant for the same object.

General Meetings (in the Music Hall).

On Wednesday, July 31st, at 8 P.M., the late President, The Rev. T. R. Robinson, D.D., M.R.I.A., resigned his Office to Sir David Brewster, K.H., D.C.L., LL.D., F.R.S., V.P.R.S.E., who took the Chair at the General Meeting, and delivered an Address, for which see p. xxxi.

On Thursday, August 1st, Professor Bennett, M.D., F.R.S.E., delivered a Discourse on the Passage of the Blood through the minute Vessels of Animals, in connection with Nutrition.

On Monday, August 5th, Dr. Mantell, F.R.S. &c., delivered a Discourse on the Extinct Birds of New Zealand.

On Wednesday, August 7th, at 3 P.M., the concluding General Meeting of the Association was held, when the Proceedings of the General Committee, and the grants of money for scientific purposes were explained to the Members.

The Meeting was then adjourned to Ipswich in 1851*.

* The Meeting is appointed to take place on Wednesday, the 2nd of July.

ADDRESS

BY

SIR DAVID BREWSTER, K.H. D.C.L.

F.R.S.L. & V.P.R.S. Edinb.

ASSOCIATE OF THE NATIONAL INSTITUTE OF FRANCE.

Gentlemen,—The kind and flattering expressions with which Dr. Robinson has been pleased to introduce me to this Chair, and to characterise my scientific labours, however coloured they are by the warmth of friendship, cannot but be gratifying even at an age when praise ceases to administer to vanity or to stimulate to ambition. The appreciation of intellectual labour by those who have laboured intellectually, if not its highest, is at least one of its high rewards. When I consider the mental power of my distinguished friend, the value of his original researches, the vast extent of his acquirements, and the eloquence which has so often instructed and delighted us at our annual reunions, I feel how unfit I am to occupy his place, and how little I am qualified to discharge many of those duties which are incident to the Chair of this Association. It is some satisfaction, however, that you are all aware of the extent of my incapacity, and that you have been pleased to accept of that which I can both promise and perform—to occupy any post of labour, either at the impelling or the working arm of this gigantic lever of science.

On the return of the British Association to the metropolis of Scotland, I am naturally reminded of the small band of pilgrims who, in 1831, carried the seeds of this Institution into the more genial soil of our sister land—of the zeal and talent with which it was fostered and organized by the Philosophical Society of York—of the hospitality which it enjoyed from the Primate of England—of the invaluable aid which it received from the universities and scientific societies of the south—and of the ardent support with which it was honoured by some of the most accomplished of our nobility. From its cradle at York, the infant Association was ushered into the gorgeous halls of Oxford and Cambridge—the seats of ancient wisdom and the foci of modern science. University honours were liberally extended to its more active members; and, thus decorated, our Institution was eagerly welcomed into the rich marts of our commerce, and into the active localities of our manufacturing industry. Europe and America speedily recognized the importance of our rising Association, and deputies from every civilized nation hastened to our annual congress, assisted at our sectional meetings, and have even contributed to our Transactions valuable reports on different branches of science.

It may be interesting to those who are here for the first time to learn the names of some of those distinguished individuals by whose exertions and talents this Association has attained its present magnitude and position; and I feel as if it were peculiarly my duty to do honour to their zeal and their labours. Sir John Robison, Professor Johnston, and Professor J. D. Forbes, were the earliest friends and promoters of the British Association. They went to York to assist in its establishment, and they found there the very men who were qualified to foster and organise it. The Rev. Mr. Vernon Harcourt, whose name cannot be mentioned here without the expression of our admiration and gratitude, had provided laws for its government, and, along with Mr. Phillips, the oldest and most valuable of our office-bearers, had made all those arrangements by which its success was ensured. Headed by Sir Roderick Murchison, one of the very earliest and most active advocates of the Association, there assembled at York about 200 of the friends of science. Dalton, Pritchard, Greenough, Scoresby, William Smith, Sir Thomas Brisbane, Dr. Daubeny, Dr. B. Lloyd Provost of Trinity College Dublin, Professor Potter, Lord Fitzwilliam, and Lord Morpeth, took an active part in its proceedings; and so great was the interest which they excited, that Dr. Daubeny ventured to invite the Association to hold its second meeting at Oxford. Here it received the valuable co-operation of Dr. Buckland, Professor Powell, and the other distinguished men who adorn that seat of literature and science. Cambridge sent us her constellation of philosophers—bright with stars of the first magnitude—Whewell, Peacock, Sedgwick, Airy, Herschel, Babbage, Lubbock, Challis, Kelland, and Hopkins; while the metropolitan institutions were represented by Colonel Sabine, one of our General Secretaries, Mr. Taylor, our Treasurer, Sir Charles Lyell, Colonel Sykes, Mr. Brown, Mr. Faraday, Professors Owen and Wheatstone, Dr. Mantell, Lord Northampton, Lord Wrottesley, Sir Philip Egerton, and Sir Charles Lemon. From Ireland we received the distinguished aid of Lord Rosse, Lord Enniskillen, Lord Adare*, Dr. Robinson, Dr. Lloyd, Sir William Hamilton, and Professor Maccullagh; and men of immortal names were attracted from the continents of Europe and America —Arago, Bessel, Struve, Liebig, Jacobi, Le Verrier, Encke, Erman, Kupffer, Ehrenberg, Matteucci, Rogers, Bache, and Agassiz. The young members of the Association, to whom we owe much, and from whom we expect more, will excuse me for not making an individual reference to their labours. Their day of honour will come when our brief pilgrimage has closed. To them we bequeath a matured institution, and we trust that they will leave it to a succeeding race with all the life which it now breathes, and with all the glory which now surrounds it.

It has been the custom of some of my predecessors in this Chair, to give a brief account of the progress of the sciences during the preceding year; but, however interesting might be such a narrative, it would be beyond the power of any individual to do justice to so extensive a theme, even if your time would permit, and your patience endure it. I shall make no apology,

* Now the Earl of Dunraven.

however, for calling your attention to a few of those topics, within my own narrow sphere of study, which, from their prominence and general interest, may be entitled to your attention.

I begin with Astronomy, a study which has made great progress under the patronage of this Association; a subject, too, possessing a charm above all other subjects, and more connected than any with the deepest interests—past, present, and to come—of every rational being. It is upon a planet that we live and breathe. Its surface is the arena of our contentions, our pleasures, and our sorrows. It is to obtain a portion of its alluvial crust that man wastes the flower of his days, and prostrates the energies of his mind, and risks the happiness of his soul; and it is over, or beneath, its verdant turf that his ashes are to be scattered, or his bones to be laid. It is from the interior, too—from the inner life of the earth, that man derives the materials of civilization—his coal, his iron, and his gold. And deeper still, as geologists have proved—and none with more power than the geologists around me—we find in the bosom of the earth, written on blocks of marble, the history of primæval times, of worlds of life created, and worlds of life destroyed. We find there, in hieroglyphics as intelligible as those which Major Rawlinson has deciphered on the slabs of Nineveh, the remains of forests which waved in luxuriance over its plains—the very bones of huge reptiles that took shelter under their foliage, and of gigantic quadrupeds that trod uncontrolled its plains—the lawgivers and the executioners of that mysterious community with which it pleased the Almighty to people his infant world. But though man is but a recent occupant of the earth—an upstart in the vast chronology of animal life—his interest in the paradise so carefully prepared for him is not the less exciting and profound. For him it was made: he was to be the lord of the new creation, and to him it especially belongs to investigate the wonders it displays, and to learn the lesson which it reads.

But, while our interests are thus closely connected with the surface and the interior of the earth, interests of a higher kind are associated with it as a body of the system to which we belong. The object of geology is to unfold the history and explain the structure of a planet; and that history and that structure may, within certain limits, be the history and the structure of all the other planets of the system—perhaps of all the other planets of the universe. The laws of matter must be the same wherever matter is found. The heat which warms our globe radiates upon the most distant of the planets; and the light which twinkles in the remotest star, is, in its physical, and doubtless in its chemical properties, the same that cheers and enlivens our own system; and if men of ordinary capacity possessed that knowledge which is within their reach, and had that faith in science which its truths inspire, they would see in every planet around them, and in every star above them, the home of immortal natures—of beings that suffer and of beings that rejoice—of souls that are saved, and of souls that are lost.

Geology is therefore the first chapter of astronomy. It describes that portion of the solar system which is nearest and dearest to us—the cosmopolitan observatory, so to speak, from which the astronomer is to survey the sidereal universe, where revolving worlds, and systems of worlds, summon him to investigate and adore. There, too, he obtains the great base line of the earth's radius to measure the distances and magnitudes of the starry host, and thus to penetrate by the force of reason into those infinitely distant regions where the imagination dare not venture to follow him. But astronomy, though thus sprung from the earth, seeks and finds, like Astræa, a more congenial sphere above. Whatever cheers and enlivens our terrestrial paradise is derived from the orbs around us. Without the light and the heat of our sun, and without the uniform movements of our system, we should have neither climates nor seasons. Darkness would blind, and famine destroy everything that lives. Without influences from above, our ships would drift upon the ocean, the sport of wind and wave, and would have less certainty of reaching their destination than balloons floating in the air, and subject to the caprice of the elements.

But, while a knowledge of astronomy is essential to the very existence of social life, it is instinct with moral influences of the highest order. In the study of our own globe, we learn that it has been rent and upheaved by tremendous forces—here sinking into ocean depths, and there rising into gigantic elevations. Even now, geologists are measuring the rise and fall of its elastic crust; and men who have no faith in science often learn her great truths to their cost, when they see the liquid fire rushing upon them from the volcano, or stand above the yawning crevice in which the earthquake threatens to overwhelm them. Who can say that there is a limit to agencies like these? Who could dare to assert that they may not concentrate their yet divided energies, and rend in pieces the planet which imprisons them? Within the bounds of our own system, and in the vicinity of our own earth, between the orbits of Mars and Jupiter, there is a wide space, which, according to the law of planetary distances, ought to contain a planet. Kepler predicted that a planet would be found there; and, strange to say, the astronomers of our own times discovered at the beginning of the present century four small planets—Ceres, Pallas, Juno, and Vesta—occupying the very place in our system where the anticipated planet ought to have been found. Ceres, the first of these, was discovered by Piazzi, at Palermo, in 1801; Pallas, the second of them, by Dr. Olbers of Bremen, in 1802; Juno, the third, by Mr. Harding, in 1804; and Vesta, the fourth, by Dr. Olbers, in 1807. After the discovery of the third, Dr. Olbers suggested the idea that they were the fragments of a planet that had been burst in pieces; and, considering that they must all have diverged from one point in the original orbit, and ought to return to the opposite point, he examined those parts of the heavens, and thus discovered the planet Vesta.

But though this principle had been long in the possession of astronomers, nearly forty years elapsed before any other planetary fragment was discovered. At last, in 1845, Mr. Hencke, of Driessen, in Prussia, discovered the fragment called Astræa, and in 1847 another called Hebe. In the same year our countryman, Mr. Hind, discovered other two, Iris and Flora. In 1848, Mr. Graham, an Irish astronomer, discovered a ninth fragment called Metis. In 1849, Mr. Gasparis of Naples discovered another which he calls Hygeia; and, within the last two months, the same astronomer has discovered the eleventh fragment, to which he has given the name of Parthenope*. If these eleven small planets are really, as they doubtless are, the remains of a larger one, the size of the original planet must have been considerable.

* Ceres,	1801, Jan. 1,	Piazzi.	Iris,	1847, August 13,	Hind.
Pallas,	1802, March 28,	Olbers.	Flora,	1847, Oct. 18,	Hind.
Juno,	1804, Sept. 1,	Harding.	Metis,	1848, April 25,	Graham.
Vesta,	1807, March 29,	Olbers.	Hygeia,	1849, April 12,	Gasparis.
Astræa,	1845, Dec. 8,	Hencke.	Parthenope,	1850, May 11,	Gasparis.
Hebe,	1847, July 1,	Hencke.	Victoria,	1850, Sept. 13,	Hind.

It is remarkable that *eight* of these *twelve* planets were discovered by astronomers, each of whom discovered *two*. Mr. Hind has now discovered *three*.

What its size was would seem to be a problem beyond the grasp of reason. But human genius has been permitted to triumph over greater difficulties. The planet Neptune was discovered by Adams and Le Verrier, before a ray of its light had entered the human eye; and, by a law of the solar system recently announced to the world, we can determine the original magnitude of the broken planet long after it has been shivered into fragments; and we might have determined it even after a single fragment had proved its existence. This law we owe to Mr. Daniel Kirkwood of Pottsville, a humble American, who, like the illustrious Kepler, struggled to find something new among the arithmetical relations of the planetary elements. Between every two adjacent planets there is a point where their attractions are equal. If we call the distance of this point from the sun the radius of a planet's sphere of attraction, then Mr. Kirkwood's law is, that in every planet the square of the length of its year, reckoned in days, varies as the cube of the radius of its sphere of attraction. This law has been verified by more than one American astronomer; and there can be no doubt, as one of them expresses it, that it is at least a physical fact in the mechanism of our system. This law requires, like that of Bode, the existence of a planet between Mars and Jupiter; and it follows from the law that the broken planet must have been a little larger than Mars, or about 5000 miles in diameter, and that the length of its day must have been about $57\frac{1}{2}$ hours. The American astronomers regard this law as amounting to a demonstration of the nebular hypothesis of Laplace; but we venture to say that this opinion will not be adopted by the astronomers of England.

Among the more recent discoveries within the bounds of our own system, I cannot omit to mention those of our distinguished countryman, Mr. Lassell of Liverpool. By means of a fine twenty feet reflector, constructed by himself, he detected the only satellite of Neptune which has yet been discovered, and more recently an eighth satellite circulating round Saturn—a discovery which was made on the very same day, by Mr. Bond, Director of the Observatory of Cambridge in the United States. Mr. Lassell has still more recently, and under a singularly favourable state of the atmosphere, examined the very minute, but extremely black shadow of the ring of Saturn, upon the body of the planet. He observed the line of shadow to be notched, as it were, and almost broken up into a line of dots, thus indicating mountains upon the plane of the ring—mountains, doubtless, raised by the same internal forces, and answering the same ends, as those of our own globe.

In passing from our solar system to the frontier of the sidereal universe around us, we traverse a gulf of inconceivable extent. If we represent the radius of the solar system, or of Neptune's orbit (which is 2900 millions of miles), by a line two miles long, the interval between our system, or the orbit of Neptune, and the nearest fixed star, will be greater than the whole circumference of our globe—or equal to a length of 27,600 miles. The parallax of the nearest fixed star being supposed to be one second, its distance from the sun will be nearly 412,370 times the radius of the earth's orbit, or 13,746 times that of Neptune, which is 30 times as far from the sun as the earth. And yet to that distant zone has the genius of man traced the Creator's arm,—working the wonders of his power, and diffusing the gifts of his love—the heat and the light of suns—the necessary elements of physical and intellectual life.

It is by means of the gigantic telescope of Lord Rosse that we have become acquainted with the form and character of those great assemblages of stars which compose the sidereal universe. Drawings and descriptions of the more remarkable of these nebulæ, as resolved by this noble instrument, were communicated by Dr. Robinson to the last Meeting of the Association, and it is with peculiar satisfaction that I am able to state that many important discoveries have been made by Lord Rosse and his assistant, Mr. Stoney, during the last year. In many of the nebulæ, the peculiarities of structure are very remarkable, and, as Lord Rosse observes, "seem even to indicate the presence of dynamical laws almost within our grasp." The spiral arrangement so strongly developed in some of the nebulæ, is traceable more or less distinctly in many; but, "more frequently," to use Lord Rosse's own words, "there is a nearer approach to a kind of irregular, interrupted, annular disposition of the luminous material, than to the regularity observed in others;" but his Lordship is of opinion that these nebulæ are systems of a very similar nature, seen more or less perfectly, and variously placed with reference to the line of sight. In re-examining the more remarkable of these objects, Lord Rosse intends to view them with the full light of his six-feet speculum, undiminished by the second reflexion of the small mirror. By thus adopting what is called the *front view*, he will doubtless, as he himself expects, discover many new features in these interesting objects.

It is to the influence of Lord Rosse's example that we are indebted for the fine reflecting telescope of Mr. Lassell, of which I have already spoken; and it is to it, also, that we owe another telescope, which, though yet unknown to science, I am bound in this place especially to notice. I allude to the reflector recently constructed by Mr. James Nasmyth, a native of Edinburgh, already distinguished by his mechanical inventions and his observations on the moon's surface, and one of a family well known to us all, and occupying a high place among the artists of Scotland. This instrument has its great speculum twenty feet in focal length, and twenty inches in diameter; but it differs from all other telescopes in the remarkable facility with which it can be used. Its tube moves vertically upon hollow trunnions, through which the astronomer, seated in a little observatory, with only a horizontal motion, can view at his ease every part of the heavens. Hitherto, the astronomer has been obliged to seat himself at the upper end of his Newtonian telescope; and if no other observer will acknowledge the awkwardness and insecurity of his position, I can myself vouch for its danger, having fallen from the very top of Mr Ramage's twenty-feet telescope, when it was directed to a point not very far from the zenith.

Though but slightly connected with astronomy, I cannot omit calling your attention to the great improvements—I may call them discoveries—which have been recently made in *Photography*. I need not inform this meeting that the art of taking photographic *negative* pictures upon paper was the invention of Mr. Fox Talbot, a distinguished member of this Association. The superiority of the Talbotype to the Daguerreotype is well known. In the latter, the pictures are reverted and incapable of being multiplied, while in the Talbotype there is no reversion, and a single negative will supply a thousand copies, so that books may now be illustrated with pictures drawn by the sun. The difficulty of procuring good paper for the negative is so great, that a better material has been eagerly sought for; and M. Niepce, an accomplished officer in the French service, has successfully substituted for paper a film of albumen, or the white of an egg, spread upon glass. This new process has been brought to such perfection in this city by Messrs. Ross and Thomson, that Talbotypes taken by them, and lately exhibited by myself to the National Institute of France, and to M. Niepce, were universally regarded as the finest that had yet been executed. Another process, in which gelatine is substituted for albumen, has been invented and successfully practised by M. Poitevin, a French officer of engineers; and by an ingenious method which has been minutely described in the weekly proceedings of the Institute of France, M. Edmund Becquerel has succeeded in transferring to a Daguerreotype plate the prismatic spectrum, with all its brilliant colours, and also, though in an inferior degree, the colours of the landscape. These colours, however, are very fugacious; and, though no method of fixing them has yet been discovered, we cannot doubt that the difficulty will be surmounted, and that we shall yet see all the colours of the natural world transferred by their own rays to surfaces both of silver and paper.

But the most important fact in photography which I have now to mention is the singular acceleration of the process discovered by M. Niepce, which enables him to take the picture of a landscape illuminated by diffused light, in a single second, or at most in two seconds. This acceleration is produced by adding from 30 to 45 grains of honey to the white of each egg according to its size. By this process, he obtained a picture of the sun on albumen so instantaneously, as to confirm the remarkable discovery, previously made by M. Arago, by means of a silver plate, that the rays which proceed from the central parts of the sun's disc have a higher photogenic action than those which issue from its margin. This interesting discovery of M. Arago is one of a series on photometry which that distinguished philosopher is now occupied in publishing. Threatened with a calamity which the civilized world will deplore—the loss of that sight which has detected so many brilliant phænomena, and penetrated so deeply the mysteries of the material world —he is now completing, with the aid of other eyes than his own, those splendid researches which will immortalise his own name and add to the scientific glory of his country.

From these brief notices of the progress of science, I must now call your attention to two important objects with which the British Association has been occupied since its last meeting. It has been long known, both from theory and in practice, that the imperfect transparency of the earth's atmosphere, and the inequal refraction which arises from differences of temperature, combine to set a limit to the use of high magnifying powers in our telescopes. Hitherto, however, the application of such high powers was checked by the imperfections of the instruments themselves; and it is only since the construction of Lord Rosse's telescope that astronomers have found that, in our damp and variable climate, it is but during a few days of the year that telescopes of such magnitude can give sufficiently distinct vision with the high magnifying powers which they are capable of bearing. Even in a cloudless sky, when the stars are sparkling in the firmament, the astronomer is baffled by influences which are invisible; and while new planets and new satellites are being discovered by instruments comparatively small, the gigantic Polyphemus lies slumbering in his cave, blinded by thermal currents, more irresistible than the firebrand of Ulysses.

As the astronomer, however, cannot command a tempest to clear his atmosphere, nor a thunder-storm to purify it, his only alternative is to remove his telescope to some southern climate, where no clouds disturb the serenity of the firmament, and no changes of temperature distract the emanations of the stars. A fact has been recently mentioned, which entitles us to anticipate great results from such a measure. The Marquis of Ormonde is said to have seen from Mount Etna, with his naked eye, the satellites of Jupiter.

If this be true, what discoveries may we not expect, even in Europe, from a fine telescope working above the grosser strata of our atmosphere? This noble experiment of carrying a large reflector to a southern climate has been but once made in the history of science. Sir John Herschel transported his telescopes and his family to the south of Africa, and during a voluntary exile of four years' duration, he enriched astronomy with many splendid discoveries. Such a sacrifice, however, is not likely to be made again; and we must therefore look to the aid of Government for the realization of a project which every civilized people will applaud, and which, by adding to the conquests of science, will add to the glory of our country. At the Birmingham meeting of the Association, its attention was called to this subject; and, being convinced that great advantages would accrue to science from the active use of a large reflecting telescope in the southern hemisphere, it was resolved to petition Government for a grant of money for that purpose. The Royal Society readily agreed to second this application; and, as no request from the British Association has ever been refused, whatever Government was in power, we have every reason to expect a favourable answer to an able memorial from the pen of Dr. Robinson, which has just been submitted to the minister.

A recent and noble act of liberality to science on the part of the Government justifies this expectation. It is, I believe, not yet generally known that Lord John Russell has granted £1000 a-year to the Royal Society for promoting scientific objects. The Council of that distinguished body has been very solicitous to make this grant effective in promoting scientific objects; and I am persuaded that the measures they have adopted are well-fitted to justify the liberality of the Government. One of the most important of these has been to place £100 at the disposal of the Committee of the Kew Observatory. This establishment, which has for several years been supported by the British Association, was given to us by the Government as a depository for our books and instruments, and as a locality well-fitted for carrying on electrical, magnetical, and meteorological observations. During the last six years, the Observatory has been under the honorary superintendence of Mr. Ronalds, who is well known to the scientific world by his ingenious photographic methods of constructing self-registering magnetical and meteorological apparatus. On the joint application of the Marquis of Northampton and Sir John Herschel, as members of the Association, her Majesty's Government have granted to Mr. Ronalds a pecuniary recompense of £250 for these inventions; and I am glad to be able to state, that Mr. Brooke has also received from them a suitable reward for inventions of a similar kind.

Under the fostering care of the British Association, the most valuable electrical observations have been made at Kew, and Mr. Ronalds has continued, from year to year, to make those improvements upon his apparatus which experience never fails to suggest; but I regret to say, that in consequence of our diminished resources, the Association, at its meeting in 1848, came to the resolution of discontinuing the observations at Kew—appropriating, at the same time, an adequate sum for completing those which were in progress, and for reducing and discussing the five years' electrical observations which had been published in our annual reports. I trust, however, that means will yet be found to maintain the Observatory in full activity, and to carry out the original objects contemplated by the Committee. Having had an opportunity of visiting this establishment a few weeks ago, after having inspected two of the best conducted observatories on the Continent, where the same class of observations is made, I have no hesitation in speaking in the highest terms of the value of Mr. Ronalds' labours, and in recommending the institution which he so liberally superintends to the continued protection of the Association, and to the continued liberality of the Royal Society.

From the facts which I have already mentioned, and from many others to which I might have referred, the members of the Association will observe with no common pleasure, that the Government of this country has, during the last twenty years, been extending its patronage of science and the arts. That this change was effected by the interference of the British Association, and by the writings and personal exertions of its members, could, were it necessary, be easily proved. But though men of all shades of political feeling have applauded the growing wisdom and liberality of the state, and though various individuals are entitled to share in the applause, yet there is one statesman, alas! too early and too painfully torn from the affections of his country, whom the science of England must ever regard as its warmest friend and its greatest benefactor. To him we owe new institutions for advancing science, and new colleges for extending education; and had Providence permitted him to follow out, in the serene evening of life, and in the maturity of his powerful intellect, the views which he had cherished amid the distractions of political strife, he would have rivalled the Colbert of another age, and would have completed that systematic organization of science, and literature, and art, which has been the pride and the glory of another land. These are not the words of idle eulogy, or the expressions of a groundless expectation. Sir Robert Peel had entertained the idea of attaching to the Royal Society a number of active members, who should devote themselves wholly to scientific pursuits; and I had the satisfaction of communicating to him, through a mutual friend, the remarkable fact, that I had found among the MSS. of Sir Isaac Newton a written scheme of improving the Royal Society, precisely similar to that which he contemplated. Had this idea been realized, it would have been but the first instalment of a debt long due to science and the nation; and it would have fallen to the lot of some more fortunate statesman to achieve a glorious name by its complete discharge.

It has always been one of the leading objects of the British Association, and it is now the only one of them which has not been wholly accomplished, "to obtain a more general attention to the objects of science, and a removal of any disadvantages of a public kind which impedes its progress." Although this object is not very definitely expressed, yet Mr. Harcourt, in moving its adoption, included under it the revision of the law of patents, and the direct national encouragement of science, two subjects to which I shall briefly direct your attention.

In 1831, when the Association commenced its labours, the patent laws were a blot on the legislation of Great Britain; and though some of their more obnoxious provisions have since that time been modified or removed, they are a blot still, less deep in its dye, but equally a stain upon the character of the nation. The protection which is given by statute to every other property in literature and the fine arts, is not accorded to property in scientific inventions and discoveries. A man of genius completes an invention, and, after incurring great expense, and spending years of anxiety and labour, he is ready to give the benefit of it to the public. Perhaps it is an invention to save life—the life boat; to shorten space and lengthen time—the railway; to guide the commerce of the world through the trackless ocean

—the mariner's compass; to extend the industry, increase the power, and fill the coffers of the state—the steam-engine; to civilise our species, to raise it from the depths of ignorance and crime to knowledge and to virtue—the printing-press. But, whatever it may be, a grateful country has granted to the inventor the sole benefit of its use for fourteen years. That which the statute freely gives, however, law and custom as freely take away, or render void. Fees, varying from £200 to £500, are demanded from the inventor; and the gift, thus so highly estimated by the giver, bears the great seal of England. The inventor must now describe his invention with legal precision. If he errs in the slightest point—if his description is not sufficiently intelligible—if the smallest portion of his invention has been used before—or if he has incautiously allowed his secret to be made known to two, or even to one individual—his patent will be invaded by remorseless pirates, who are ever on the watch for insecure inventions, and he will be driven into a court of law, where an adverse decision will be the ruin of his family and his fortunes. Impoverished by official exactions, or ruined by legal costs, the hapless inventor, if he escapes the asylum or the workhouse, is obliged to seek, in some foreign land, the just reward of his industry and genius. Should a patent escape unscathed from the fiery ordeal through which it has to pass, it often happens that the patentee has not been remunerated during the fourteen years of his term. In this case, the state is willing to extend his right for five or seven years more; but he can obtain this extension only by the expensive and uncertain process of an act of Parliament—a boon which is seldom asked, and which, through rival influence, has often been withheld.

Such was the patent law twenty years ago; but since that time it has received some important ameliorations; and though the British Association did not interfere as a body, yet some of its members applied energetically on the subject to some of the more influential individuals in Lord Grey's Government, and the result of this was, two acts of Parliament, passed in 1835 and 1839, entitled "Acts for Amending the Law touching Letters Patent for Inventions." Without referring to another important act for registering designs, which had the effect of withdrawing from the grasp of the patent laws a great number of useful inventions, depending principally on form, I shall notice only the valuable provisions of the two acts above mentioned—acts which we owe solely to the wisdom of Lord Brougham. By the first of these acts, the patentee is permitted to disclaim any part either of the title of his invention or of the specification of it, or to make any alteration on the title or specification. The same act gives the Privy Council the power of confirming any patent, or of granting a new one, when a patent had been taken out for an invention which the patentee believed to be new, but which was found to have been known before, though not publicly and generally used. By the same act, too, the power of extending letters patent was taken from Parliament and given to the Privy Council, who have, on different occasions, exercised it with judgement and discrimination. By the second act, of 1839, this last privilege was made more attainable by the patentee. These are doubtless valuable improvements which inventors will gratefully remember; but till the enormous fees, which are still exacted, are either partly or wholly abolished, and a real privilege given under the great seal, the genius of this country will never be able to compete with that of foreign lands, where patents are cheaply obtained and better protected. In proof of the justness of these views, it is gratifying to notice, that, within these few days, it has been announced in Parliament that the new Attorney-General has accepted his office on the express condition that the large fees which he derives from patents shall be subject to revision.

The other object contemplated by the British Association—the organization of science as a national institution—is one of a higher order, and not limited to individual or even to English interests. It concerns the civilized world :—not confined to time, it concerns eternity. While the tongue of the Almighty, as Kepler expresses it, is speaking to us in his Word, his finger is writing to us in his works; and to acquire a knowledge of these works is an essential portion of the great duty of man. Truth secular cannot be separated from truth divine; and if a priesthood has in all ages been ordained to teach and exemplify the one, and to maintain, in ages of darkness and corruption, the vestal fire upon the sacred altar, shall not an intellectual priesthood be organized to develope the glorious truths which time and space embosom—to cast the glance of reason into the dark interior of our globe, teeming with what was once life—to make the dull eye of man sensitive to the planet which twinkles from afar, as well as to the luminary which shines from above—and to incorporate with our inner life those wonders of the external world which appeal with equal power to the affections and to the reason of immortal natures? If the God of Love is most appropriately worshiped in the Christian Temple, the God of Nature may be equally honoured in the Temple of science. Even from its lofty minarets the philosopher may summon the faithful to prayer; and the priest and the sage may exchange altars without the compromise of faith or of knowledge.

Influenced, no doubt, by views like these, Mr. Harcourt has cited, in support of this object of the Association, the opinion of a philosopher, whose memory is dear to Scotland, and whose judgement on any great question will be everywhere received with respect and attention:—I refer to Professor Playfair, the distinguished successor, in our Metropolitan University, of the Gregorys, the Maclaurins, and the Stewarts of former days, who, in his able dissertation "On the Progress of the Mathematical and Physical Sciences," thus speaks of the National Institute of France :—

"This institution has been of considerable advantage to science. To detach a number of ingenious men from everything but scientific pursuits—to deliver them alike from the embarrassments of poverty or the temptations of wealth—to give them a place and station in society the most respectable and independent—*is to remove every impediment, and to add every stimulus to exertion*. To this institution, accordingly, operating upon a people of great genius and indefatigable activity of mind, we are to ascribe that superiority in the mathematical sciences which, in the last seventy years, has been so conspicuous*."

This just eulogy on the National Institute of France, in reference to abstract mathematics, may be safely extended to every branch of theoretical and practical science; and I have no hesitation in saying, after having recently seen the Academy of Sciences at its weekly labours, that it is the noblest and most effective institution that ever was organized for the promotion of science. Owing to the prevalence of scientific knowledge among all classes of the French population, and to their admirable system of elementary instruction, the advancement of science, the diffusion of knowledge, and the extension of education, are objects dear to every class of the people. The soldier as well as the citizen—the Socialist, the Republican, the Royalist

* Encyclopædia Britannica, Diss. 3d, sec. 5, p. 500.

—all look up to the National Institute as a mighty obelisk erected to science, to be respected, and loved, and defended by all. We have seen it standing, unshaken and active, amid all the revolutions and convulsions which have so long agitated that noble but distracted conntry—a common centre of affection, to which antagonist opinions, and rival interests, and dissevered hearts, have peacefully converged. It thus becomes an institution of order, calculated to send back to its contending friends a message of union and peace, and to replace in stable equilibrium the tottering institutions of the state.

It was, doubtless, with views like these that the great Colbert established the Academy of Sciences in Paris, and that the powerful and sagacious monarchs on the Continent of Europe have imitated his example. They have established in their respective capitals similar institutions—they have sustained them with liberal endowments—they have conferred rank and honours on their more eminent members; and there are now in this assembly distinguished foreigners who have well earned the rewards and distinctions they have received. It is, therefore, Gentlemen, no extravagant opinion, that institutions which have thus thriven in other countries should thrive in ours—that insulated societies, which elsewhere flourish in combination, should, when confined, flourish among us—and that men, ordained by the state to the undivided functions of science, should do more and better work than those who snatch an hour or two from their daily toil, or from their nightly rest.

In a great nation like ours, where the higher interests and objects of the state are necessarily organized, it is a singular anomaly that the intellectual interests of the country should, in a great measure, be left to voluntary support and individual zeal—an anomaly, that could have arisen only from the ignorance or supineness of ever-changing administrations, and from the intelligence and liberality of a commercial people—an anomaly, too, that could have been continued only by the excellence of the institutions they had founded. In the history of no civilized people can we find private establishments so generously fostered, so energetically conducted, and so successful in their objects, as the Royal Societies of London, Edinburgh, and Dublin, and the Astronomical, Geological, Zoological, and Linnæan Societies of the metropolis. They are institutions that do honour to the nation, and they will ever be gratefully remembered in the history of science. But they are nevertheless defective in their constitution, limited in their operation, and incapable, from their very nature, of developing, and directing, and rewarding the indigenous talent of the country. They are simply subscription societies, which pay for the publication of their own Transactions, and adjudicate medals entrusted to them by the beneficence of others. They are not bound to the exercise of any other function, and they are under no obligation to do the scientific work of the state, or to promote any of those national objects which are entrusted to the organized institutions of other lands. Their President and Council are necessarily resident in London; and the talent and genius of the provinces are excluded from their administration. From this remark we must except the distinguished philosophers of Cambridge and Oxford, who, from their proximity to the capital, have been the brightest ornaments of our metropolitan institutions, and without whose aid they never could have attained their present pre-eminence.

It is, therefore, in the more remote parts of the empire that the influence of a national institution would be more immediately felt, and nowhere more powerfully than in this its northern portion. Our English friends are, we believe, little aware of the obstructions which oppose the progress of science in Scotland. In our five universities, there is not a single fellowship to stimulate the genius and rouse the ambition of the student. The church, the law, and the medical profession hold out no rewards to the cultivators of mathematical and physical science; and were a youthful Newton or Laplace to issue from any of our universities, his best friends would advise him to renounce the divine gift, and to seek in professional toil the well-earned competency which can alone secure him a just position in the social scale, and an enviable felicity in the domestic circle. Did this truth require any evidence in its support, we find it in the notorious fact, that our colleges cannot furnish professors to fill their own important offices; and the time is not distant when all our chairs in mathematics, natural philosophy, and even natural history, will be occupied by professors educated in the English universities. But were a Royal Academy or Institute, like that of France, established on the basis of our existing institutions, and a class of resident members enabled to devote themselves wholly to science, the youth of Scotland would instantly start for the prize, and would speedily achieve their full share in the liberality of the state. Our universities would then breathe a more vital air. Our science would put forth new energies, and our literature might rise to the high level at which it stands in our sister land.

But it is to the nation that the greatest advantages would accrue. With gigantic manufacturing establishments, depending for their perfection and success on mechanics and chemistry—with a royal and commercial marine almost covering the ocean—with steam-ships on every sea—with a system of agriculture leaning upon science as its mainstay—with a net-work of railways, demanding for their improvement, and for the safety of the traveller, and for the remuneration of their public-spirited projectors, the highest efforts of mechanical skill—the time has now arrived for summoning to the service of the state all the theoretical and practical wisdom of the country—for rousing what is dormant, combining what is insulated, and uniting in one great institution the living talent which is in active but undirected and unbefriended exercise around us.

In thus pleading for the most important of the objects of the British Association, I feel that I am not pleading for a cause that is hopeless. The change has not only commenced, but has made considerable progress. Our scientific institutions have already, to a certain extent, become national ones. Apartments belonging to the nation have been liberally granted to them. Royal medals have been founded, and large sums from the public purse devoted to the objects which they contemplate. The Museum of Œconomic Geology, indeed, is itself a complete section of a Royal Institute, giving a scientific position to six eminent philosophers, all of whom are distinguished members of the British Association:—and in every branch of science and literature, the liberality of the Crown has been extended to numerous individuals, whose names would have been enrolled among the members of a National Institution. The cause, therefore, is so far advanced; and every act of liberality to eminent men, and every grant of money for scientific and literary purposes, is a distinct step towards its triumph. Our private institutions have in reality assumed the transition phase, and it requires only an electric spark from some sagacious and patriotic statesman to combine in one noble phalanx the scattered elements of our intellectual greatness, and guide to lofty achievements and glorious triumphs, the talent and genius of the nation.

But when such an institution has been completed, the duties of the state to science are not exhausted. It has appreciated knowledge but in its abstract and utilitarian phase. For the peace and happiness of society, it would be of little avail were the great truths of the material world confined to the educated and the wise. The organization of science, thus limited, would cease to be a blessing. Knowledge, secular and divine, the double current of the intellectual life-blood of man, must not merely descend through the great arteries of the social frame: it must be taken up by the minutest capillaries before it can nourish and purify society. Knowledge is at once the manna and the medicine of our moral being. When crime is the bane, knowledge is the antidote. Society may escape from the pestilence, and survive the famine; but the demon of ignorance, with his grim adjutants of vice and riot, will pursue her into her most peaceful haunts, destroying her institutions, and converting into a wilderness the paradise of social and domestic life. The state has, therefore, a solemn duty to perform. As it punishes crime, it is bound to devise means for its prevention. As it subjects us to laws, it must teach us to read them; and while it thus teaches, it must teach also the ennobling truths which display the power and the wisdom of the great Lawgiver—thus diffusing knowledge while it is extending education, and thus making men contented, and happy, and humble, while it makes them quiet and obedient subjects.

It is a great problem yet to be solved, to determine what will be the state of society when man's physical powers are highly exalted, and his physical condition highly ameliorated, without any corresponding change in his moral habits and position. There is much reason to fear that every great advance in material civilization requires some moral and compensatory antagonism; but however this may be, the very indeterminate character of the problem is a warning to the rulers of nations to prepare for the contingency by a system of national instruction, which shall either reconcile or disregard those hostile influences under which the people are now perishing for lack of knowledge.

REPORTS

ON

THE STATE OF SCIENCE.

First Report on the Facts of Earthquake Phænomena. *By* Robert Mallet, *C.E., M.R.I.A.*

Those striking phænomena of nature which are of comparatively rare and uncertain occurrence, have ever been the longest held bound in the darkness of superstition, the last to receive the light of truthful investigation.

In following down the long page of man's discovery of nature, we shall see that it is only in its latest lines that storms and tempests, hail and lightning, comets, meteors, volcanic eruptions and earthquakes, have been emancipated from the superstition (not confined alone to the vulgar) which viewed them not as occasional manifestations of the laws of one Creator, always acting and always fit and worthy of our highest efforts to discover and elucidate, but as the peculiar weapons given into the hands, and subject alone to the depraved and capricious wills of the powers of evil, by whose malignant aid the witch or the sorcerer should ride the tempest or blast the crop, the nations be stirred up to war, the fall of the great ones of the earth be portended, or monarchs perplexed with fear of change.

Thus, says Butler, in his 'Analogy of Religion,' cap. iv., "We know, indeed, several of the general laws of matter, and a great part of the behaviour of living agents is reducible to general laws, but we know nothing, in a manner, by what laws storms and tempests, earthquakes, famine and pestilence become the instruments of destruction to mankind. - - - These laws are so wholly unknown to us, that we call the events which come to pass by them accidental - - though all reasonable men - - conclude that the things which have this appearance are the result of general laws, and may be reduced to them."

Long since the comet has ceased to be a portent, and its recurrent period may be predicted. The lightning flash has been identified with and controlled into the electric carrier of our mandates, and we have begun to comprehend the chain of causation concerned in tempests, tornadoes and hailstorms. Last of all, the earthquake is but just emerging from the gloom of vulgar superstition and learned neglect into the light of physical truth, and is about to take its place as one of the phænomena of acknowledged cosmical laws, whose conditions shall be capable of complete interpretation, although perhaps from the number of these (as is the case throughout geology) we may be for ever incompetent to predict the occurrence of the phænomenon.

Such having been the past state of human knowledge as to earthquakes, an extensive research into the narratives and histories of these events soon convinces one, that in the absence on the part of past authors of any true guiding hypothesis, of any distinct idea of what an earthquake really is, of any notion of what facts might have been of scientific importance to observe, and what were merely highly striking or alarming, but only secondary accidental circumstances due to changes of surface, or the complication (never attempted to be disentangled) of all these with the facts of closely adjacent volcanic eruption,—in the want of all these, as well as of any calmness or unexaggerative observation during such alarming visitations, few facts of the character and precision requisite to render them of value to science can be collected with certainty. The true observation of earthquake phænomena is yet to be commenced and the required facts are to be collected, the most important of them by methods not dreamed of until very recently.

In collating the multitudinous and vague accounts of earthquakes, therefore, I have been compelled to reject vast numbers of statements, either for want of the necessary conditions to scientific value, or of sufficient authenticity (as when given, not as an eye-witness, but upon common hearsay by the narrator), or of the facts given having any real bearing upon the scientific question.

The staple of earthquake stories, in fact, consists of gossip made up of the most unusual, violent or odd accidents that befel men, animals or structures, rather than of the phænomenon itself. Very few of these narratives state even the precise direction or duration of the shock, and the chief value of a complete discussed catalogue of earthquakes, from such accounts as we have, would be to present some indications as to the nature of their diffusion over the earth's surface, and of their distribution in time; such catalogues have been prepared for limited districts by M. Perrey, by Von Hoff, and by some few others, and a much more extensive one will form a future part of this Report.

In the succeeding Report, I have not thought it necessary to refer to authorities except in cases of rarely noticed and important facts; in other instances the references might be innumerable.

As it is impossible to observe facts to any good purpose, so is it equally impracticable to select them from the records of others for any useful scientific end without some guiding hypothesis; in this respect I have been guided by that theory of earthquake dynamics, which I have enunciated *, and which defines an earthquake to be "the transit of a wave of elastic compression in any direction from vertically upwards to horizontally in any azimuth, through the surface and crust of the earth from any centre of impulse, or from more than one, and which may be attended with tidal and sound waves dependent upon the impulse, and upon circumstances of position as to sea and land."

It is unnecessary, I would hope, for me to add, that I have not selected the following facts to suit any theory, but have impartially taken note of all that I could find that appeared of importance to science, whether at first sight making for or against my own views. Let me add, that in this course of extensive research through earthquake narrations, I have not met with a single fact recorded that was not resoluble upon my theory, or equally irresoluble upon any, and of doubtful credence.

Before proceeding it may be desirable to take a very brief survey of the several other theories (if such they may be called) which have been at different times promulgated, in a word, of the literature generally of earthquakes, omitting those views now palpably absurd, such as the ancient Mongolian and Hindoo notion, that the earth rests upon a huge frog, which, when he scratches his head, produces an earthquake, &c.

As the best and most rapid mode of doing this, I shall give in the order of time, and as nearly as possible in each author's own words, the peculiar

* Trans. Roy. Irish Acad. vol. xxi. part 1.

views and statements made by the successive writers upon our subject, making few remarks by the way. I have deemed it worth while to transcribe Aristotle and Pliny's statements of the facts of earthquakes as observed in and before their days, more fully than perhaps some may think their views deserve; this however I have done, because it is not unimportant to compare now, the observations as to fact of those confessedly accurate observers, in very ancient periods, with our own latest ones, upon phænomena presumedly, and as proved to be by the comparison, the same.

I omit the earliest Greek notices of earthquakes, and take the matter up with Aristotle, through whose works, and even those portions usually supposed spurious, as the book "De Plantis," many passages occur touching upon our subject. His main views, however, are contained in the following extracts:—

"Περὶ δὲ σεισμοῦ καὶ κινήσεως γῆς μετὰ ταῦτα λεκτέον· ἡ γὰρ αἰτία τοῦ πάθους ἐχομένη τούτου τοῦ γένους ἐστίν. Ἔστι δὲ τά γε παρειλημμένα μέχρι τοῦ νῦν χρόνου τρία καὶ παρὰ τριῶν. Ἀναξαγόρας τε γὰρ ὁ Κλαζομένιος καὶ πρότερος Ἀναξιμένης ὁ Μιλήσιος ἀπεφήναντο, καὶ τούτων ὕστερος Δημόκριτος ὁ Ἀβδηρίτης. Ἀναξαγόρας μὲν οὖν φησὶ τὸν αἰθέρα πεφυκότα φέρεσθαι ἄνω, ἐμπίπτοντα δ' εἰς τὰ κάτω τῆς γῆς καὶ τὰ κοῖλα κινεῖν αὐτήν· τὰ μὲν γὰρ ἄνω συναληλίφθαι διὰ τοὺς ὄμβρους, ἐπεὶ φύσει γε πᾶσαν ὁμοίως εἶναι σομφὴν, ὡς ὄντος τοῦ μὲν ἄνω τοῦ δὲ κάτω τῆς ὅλης σφαίρας, καὶ ἄνω μὲν τούτου ὄντος τοῦ μορίου ἐφ' οὗ τυγχάνομεν οἰκοῦντες, κάτω δὲ θατέρου. Πρὸς μὲν οὖν ταύτην τὴν αἰτίαν οὐθὲν ἴσως δεῖ λέγειν ὡς λίαν ἁπλῶς εἰρημένην· τό τε γὰρ ἄνω καὶ κάτω νομίζειν οὕτως ἔχειν ὥστε μὴ πρὸς τὴν γῆν πάντῃ φέρεσθαι τὰ βάρος ἔχοντα τῶν σωμάτων, ἄνω δὲ τὰ κοῦφα καὶ τὸ πῦρ, εὔηθες, καὶ ταῦθ' ὁρῶντας τὸν ὁρίζοντα τὴν οἰκουμένην, ὅσην ἡμεῖς ἴσμεν, ἕτερον ἀεὶ γιγνόμενον μεθισταμένων, ὡς οὔσης κυρτῆς καὶ σφαιροειδοῦς· καὶ τὸ λέγειν μὲν ὡς διὰ τὸ μέγεθος ἐπὶ τοῦ ἀέρος μένει, σείεσθαι δὲ φάσκειν τυπτομένην κάτωθεν ἄνω δι' ὅλης. Πρὸς δὲ τούτοις οὐθὲν ἀποδίδωσι τῶν συμβαινόντων περὶ τοὺς σεισμούς· οὔτε γὰρ χῶραι οὔτε ὧραι αἱ τυχοῦσαι μετέχουσι τούτου τοῦ πάθους. Δημόκριτος δέ φησι πλήρη τὴν γῆν ὕδατος οὖσαν, καὶ πολὺ δεχομένην ἕτερον ὄμβριον ὕδωρ, ὑπὸ τούτου κινεῖσθαι· πλείονός τε γὰρ γενομένου διὰ τὸ μὴ δύνασθαι δέχεσθαι τὰς κοιλίας ἀποβιαζόμενον ποιεῖν τὸν σεισμὸν, καὶ ξηραινομένην καὶ ἕλκουσαν εἰς τοὺς κενοὺς τόπους ἐκ τῶν πληρεστέρων τὸ μεταβάλλον ἐμπίπτον κινεῖν. Ἀναξιμένης δὲ φησι βρεχομένην τὴν γῆν καὶ ξηραινομένην ῥήγνυσθαι, καὶ ὑπὸ τούτων τῶν ἀποῤῥηγνυμένων κολώνων ἐμπιπτόντων σείεσθαι· διὸ καὶ γίγνεσθαι τοὺς σεισμοὺς ἔν τε τοῖς αὐχμοῖς καὶ πάλιν ἐν ταῖς ὑπερομβρίαις· ἔν τε γὰρ τοῖς αὐχμοῖς, ὥσπερ εἴρηται, ξηραινομένην ῥήγνυσθαι, καὶ ὑπὸ τῶν ὑδάτων ὑπερυγραινομένην διαπίπτειν. Ἔδει δὲ τούτου συμβαίνοντος ὑπονοστοῦσαν πολλαχοῦ φαίνεσθαι τὴν γῆν. Ἔτι δὲ διὰ τίν' αἰτίαν περὶ τόπους τινὰς πολλάκις γίνεται τοῦτο τὸ πάθος οὐδεμιᾷ διαφέροντας ὑπερβολῇ τοιαύτῃ παρὰ τοὺς ἄλλους; καίτοι ἐχρῆν. Ὅλως δὲ τοῖς οὕτως ὑπολαμβάνουσιν ἀναγκαῖον ἧττον ἀεὶ τοὺς σεισμοὺς φάναι γίγνεσθαι, καὶ τέλος παύσασθαί ποτε σειομένην· τὸ γὰρ σαττόμενον τοιαύτην ἔχει φύσιν. Ὥστ' εἰ τοῦτ' ἀδύνατον, δῆλον ὅτι ἀδύνατον καὶ ταύτην εἶναι τὴν αἰτίαν.

"Ἀλλ' ἐπειδὴ φανερὸν ὅτι ἀναγκαῖον καὶ ἀπὸ ὑγροῦ καὶ ἀπὸ ξηροῦ γίγνεσθαι ἀναθυμίασιν, ὥσπερ εἴπομεν ἐν τοῖς πρότερον, ἀνάγκη τούτων ὑπαρχόντων γίγνεσθαι τοὺς σεισμούς. Ὑπάρχει γὰρ ἡ γῆ καθ' αὑτὴν μὲν ξηρὰ, διὰ δὲ τοὺς ὄμβρους ἔχουσα ἐν αὑτῇ νοτίδα πολλὴν, ὥσθ' ὑπό τε τοῦ ἡλίου καὶ τοῦ ἐν αὑτῇ πυρὸς θερμαινομένης πολὺ μὲν ἔξω πολὺ δ' ἐντὸς γίνεσθαι τὸ πνεῦμα· καὶ τοῦτο ὅτε μὲν συνεχὲς ἔξω ῥεῖ πᾶν, ὅτε δ' εἴσω πᾶν, ἐνίοτε δὲ καὶ μερίζεται. Εἰ δὴ τοῦτ' ἀδύνατον ἄλλως ἔχειν, τὸ μετὰ τοῦτο σκεπτέον ἂν εἴη ὁποῖον κινητικώτατον ἂν εἴη τῶν σωμάτων· ἀνάγκη γὰρ τὸ ἐπὶ πλεῖστόν τε πεφυκὸς ἰέναι καὶ σφοδρότατον μάλιστα τοιοῦτον εἶναι. Σφοδρότατον μὲν οὖν ἐξ ἀνάγκης τὸ τάχιστα φερόμενον· τύπτει γὰρ μάλιστα διὰ τὸ τάχος· ἐπὶ πλεῖστον δὲ πέφυκε διϊέναι τὸ διὰ παντὸς ἰέναι μάλιστα δυνάμενον, τοιοῦτον δὲ τὸ λεπτότατον. Ὥστ' εἴπερ ἡ τοῦ πνεύματος φύσις τοιαύτη, μάλιστα τῶν σωμάτων τὸ πνεῦμα κινητικόν· καὶ γὰρ τὸ πῦρ ὅταν μετὰ πνεύματος ᾖ, γίγνεται φλὸξ καὶ φέρεται ταχέως. Οὐκ ἂν οὖν ὕδωρ οὐδὲ γῆ αἴτιον εἴη, ἀλλὰ πνεῦμα τῆς κινήσεως, ὅταν ἔσω τύχῃ ῥυὲν τὸ ἔξω ἀναθυμιώμενον. Διὸ γίγνονται νηνεμίᾳ οἱ πλεῖστοι καὶ μέγιστοι τῶν σεισμῶν· συνεχὴς γὰρ οὖσα ἡ ἀναθυμίασις ἀκολουθεῖ ὡς ἐπὶ τὸ πολὺ τῇ ὁρμῇ τῆς ἀρχῆς, ὥστε ἢ ἔσω ἅμα ἢ ἔξω ὁρμᾷ πᾶσα. Τὸ δ' ἐνίους γίνεσθαι καὶ πνεύματος ὄντος οὐδὲν ἄλογον· ὁρῶμεν γὰρ ἐνίοτε ἅμα πλείους πνέοντας ἀνέμους, ὧν ὅταν εἰς τὴν γῆν ὁρμήσῃ θάτερον, ἔσται πνεύματος ὄντος ὁ σεισμός. Ἐλάττους δ' οὗτοι τὸ μέγεθος γίγνονται διὰ τὸ διῃρῆσθαι τὴν ἀρχὴν καὶ τὴν αἰτίαν αὐτῶν. Καὶ νυκτὸς δ' οἱ πλείους καὶ μείζους γίγνονται τῶν σεισμῶν, οἱ δὲ τῆς ἡμέρας περὶ μεσημβρίαν· νηνεμώτατον γάρ ἐστιν ὡς ἐπὶ τὸ πολὺ τῆς ἡμέρας ἡ μεσημβρία (ὁ γὰρ ἥλιος ὅταν μάλιστα κρατῇ, κατακλείει τὴν ἀναθυμίασιν εἰς τὴν γῆν· κρατεῖ δὲ μάλιστα περὶ τὴν μεσημβρίαν) καὶ αἱ νύκτες δὲ τῶν ἡμερῶν νηνεμώτεραι διὰ τὴν ἀπουσίαν τὴν τοῦ ἡλίου· ὥστ' εἴσω γίγνεται πάλιν ἡ ῥύσις, ὥσπερ ἄμπωτις, εἰς τοὐναντίον τῆς ἔξωθεν πλημμυρίδος, καὶ πρὸς ὄρθρον μάλιστα· τηνικαῦτα γὰρ καὶ τὰ πνεύματα πέφυκεν ἄρχεσθαι πνεῖν. Ἐὰν οὖν εἴσω τύχῃ μεταβάλλουσα ἡ ἀρχὴ αὐτῶν ὥσπερ Εὔριπος, διὰ τὸ πλῆθος ἰσχυρότερον ποιεῖ τὸν σεισμόν. Ἔτι δὲ περὶ τόπους τοιούτους οἱ ἰσχυρότατοι γίνονται τῶν σεισμῶν, ὅπου ἡ θάλασσα ῥοώδης ἢ ἡ χώρα σομφὴ καὶ ὕπαντρος. Διὸ καὶ περὶ Ἑλλήσποντον καὶ περὶ Ἀχαΐαν καὶ Σικελίαν, καὶ τῆς Εὐβοίας περὶ τούτους τοὺς τόπους· δοκεῖ γὰρ διαυλωνίζειν ὑπὸ τὴν γῆν ἡ θάλαττα. Διὸ καὶ τὰ θερμὰ τὰ περὶ Αἴδεψον ἀπὸ τοιαύτης αἰτίας γέγονεν. Περὶ δὲ τοὺς εἰρημένους τόπους οἱ σεισμοὶ γίνονται μάλιστα διὰ τὴν στενότητα· τὸ γὰρ πνεῦμα γενόμενον σφοδρὸν διὰ τὸ πλῆθος τῆς θαλάττης πολλῆς προσφερομένης ἀπωθεῖται πάλιν εἰς τὴν γῆν, τό γε πεφυκὸς ἀποπνεῖν ἀπὸ τῆς γῆς. Αἵ τε χῶραι ὅσαι σομφοὺς ἔχουσι τοὺς κάτω τόπους, πολὺ δεχόμεναι πνεῦμα σείονται μᾶλλον. Καὶ ἔαρος δὲ καὶ μετοπώρου μάλιστα καὶ ἐν ἐπομβρίαις καὶ αὐχμοῖς γίνονται διὰ τὴν αὐτὴν αἰτίαν· αἱ γὰρ ὧραι αὗται πνευματωδέσταται· τὸ γὰρ θέρος καὶ ὁ χειμὼν, τὸ μὲν διὰ τὸν πάγον, τὸ δὲ διὰ τὴν ἀλέαν ποιεῖ τὴν ἀκινησίαν· τὸ μὲν γὰρ ἄγαν ψυχρὸν, τὸ δ' ἄγαν ξηρόν ἐστιν. Καὶ ἐν μὲν τοῖς αὐχμοῖς πνευματώδης ὁ ἀήρ· τοῦτο γὰρ αὐτό ἐστιν ὁ αὐχμὸς, ὅταν πλείων ἡ ἀναθυμίασις ἡ ξηρὰ γίγνηται τῆς ὑγρᾶς· ἐν δὲ ταῖς ὑπερομβρίαις πλείω τε ποιεῖ τὴν ἐντὸς ἀναθυμίασιν, καὶ τῷ ἐν-

απολαμβάνεσθαι ἐν στενωτέροις τόποις καὶ ἀποβιάζεσθαι εἰς ἐλάττω τόπον τὴν τοιαύτην ἀπόκρισιν, πληρουμένων τῶν κοιλιῶν ὕδατος, ὅταν ἄρξηται κρατεῖν διὰ τὸ πολὺ εἰς ὀλίγον πιληθῆναι τόπον, ἰσχυρῶς κινεῖ ῥέων ὁ ἄνεμος καὶ προσπίπτων. Δεῖ γὰρ νοεῖν ὅτι ὥσπερ ἐν τῷ σώματι ἡμῶν καὶ τρόμων καὶ σφυγμῶν αἴτιόν ἐστιν ἡ τοῦ πνεύματος ἐναπολαμβανομένη δύναμις, οὕτω καὶ ἐν τῇ γῇ τὸ πνεῦμα παραπλήσια ποιεῖν, καὶ τὸν μὲν τῶν σεισμῶν οἷον τρόμον εἶναι τὸν δ' οἷον σφυγμὸν, καὶ καθάπερ συμβαίνει πολλάκις μετὰ τὴν οὔρησιν διὰ τοῦ σώματος (γίνεται γὰρ ὥσπερ τρόμος τις ἀντιμεθισταμένου τοῦ πνεύματος ἔξωθεν ἔσω ἀθρόου), τοιαῦτα γίνεσθαι καὶ περὶ τὴν γῆν. Ὅσην δ' ἔχει τὸ πνεῦμα δύναμιν, οὐ μόνον ἐκ τῶν ἐν τῷ ἀέρι δεῖ θεωρεῖν γιγνομένων (ἐνταῦθα μὲν γὰρ διὰ τὸ μέγεθος ὑπολάβοι τις ἂν τοιαῦτα δύνασθαι ποιεῖν) ἀλλὰ καὶ ἐν τοῖς σώμασι τοῖς τῶν ζῴων· οἵ τε γὰρ τέτανοι καὶ οἱ σπασμοὶ πνεύματος μέν εἰσι κινήσεις, τοσαύτην δ' ἔχουσιν ἰσχὺν ὥστε πολλοὺς ἅμα πειρωμένους ἀποβιάζεσθαι μὴ δύνασθαι κρατεῖν τῆς κινήσεως τῶν ἀῤῥωστούντων. Τὸ αὐτὸ δεῖ νοεῖν γινόμενον καὶ ἐν τῇ γῇ, ὡς εἰκάσαι πρὸς μικρὸν μεῖζον. Σημεῖα δὲ τούτων καὶ πρὸς τὴν ἡμετέραν αἴσθησιν πολλαχοῦ γέγονεν· ἤδη γὰρ σεισμὸς ἐν τόποις τισὶ γινόμενος οὐ πρότερον ἔληξε, πρὶν ἐκρήξας εἰς τὸν ὑπὲρ γῆς τόπον φανερῶς ὥσπερ ἐκνεφίας ἐξῆλθεν ὁ κινήσας ἄνεμος, οἷον καὶ περὶ Ἡράκλειαν ἐγένετο τὴν ἐν τῷ Πόντῳ νεωστὶ, καὶ πρότερον περὶ τὴν Ἱερὰν νῆσον· αὕτη δ' ἐστὶ μία τῶν Αἰόλου καλουμένων νήσων. Ἐν ταύτῃ γὰρ ἐξανῴδει τι τῆς γῆς, καὶ ἀνῄει οἷον λοφώδης ὄγκος μετὰ ψόφου· τέλος δὲ ῥαγέντος ἐξῆλθε πνεῦμα πολὺ, καὶ τὸν φέψαλον καὶ τὴν τέφραν ἀνῆκε, καὶ τὴν τε Λιπαραίων πόλιν οὖσαν οὐ πόῤῥω πᾶσαν κατετέφρωσε, καὶ εἰς ἐνίας τῶν ἐν Ἰταλίᾳ πόλεων ἦλθεν· καὶ νῦν ἔτι ὅπου τὸ ἀναφύσημα τοῦτο ἐγένετο, δῆλόν ἐστιν. Καὶ γὰρ δὴ τοῦ γιγνομένου πυρὸς ἐν τῇ γῇ ταύτην οἰητέον εἶναι τὴν αἰτίαν, ὅταν κοπτόμενον ἐκπρησθῇ πρῶτον εἰς μικρὰ κερματισθέντος τοῦ ἀέρος. Τεκμήριον δ' ἐστὶ τοῦ ῥεῖν ὑπὸ τὴν γῆν τὰ πνεύματα καὶ τὸ γιγνόμενον περὶ ταύτας τὰς νήσους· ὅταν γὰρ ἄνεμος μέλλῃ πνευσεῖσθαι νότος, προσημαίνει πρότερον· ἠχοῦσι γὰρ οἱ τόποι ἐξ ὧν γίνεται τὰ ἀναφυσήματα, διὰ τὸ τὴν θάλατταν μὲν προωθεῖσθαι ἤδη πόῤῥωθεν, ὑπὸ δὲ ταύτης τὸ ἐκ τῆς γῆς ἀναφυσώμενον ἀπωθεῖσθαι πάλιν εἴσω, ᾗπερ ἐπέρχεται ἡ θάλαττα ταύτῃ. Ποιεῖ δὲ ψόφον ἄνευ σεισμοῦ διά τε τὴν εὐρυχωρίαν τῶν τόπων (ὑπερχεῖται γὰρ εἰς τὸ ἀχανὲς ἔξω) καὶ δι' ὀλογότητα τοῦ ἀπωθουμένου ἀέρος. Ἔτι τὸ γίγνεσθαι τὸν ἥλιον ἀχλυώλη καὶ ἀμαυρότερον ἄνευ νέφους, καὶ πρὸ τῶν ὀρθρίων σεισμῶν ἐνίοτε νηνεμίαν τε καὶ κρύος ἰσχυρὸν, σημεῖον τῆς εἰρημένης αἰτίας ἐστιν. Τόν τε γὰρ ἥλιον ἀχλυώδη καὶ ἀμαυρὸν ἀναγκαῖον εἶναι, ὑπονοστεῖν ἀρχομένου τοῦ πνεύματος εἰς τὴν γῆν, τοῦ διαλύοντος τὸν ἀέρα καὶ διακρίνοντος, καὶ πρὸς τὴν ἕω, καὶ περὶ τοὺς ὄρθρους, νηνεμίαν τε καὶ ψῦχος. Τὴν μὲν γὰρ νηνεμίαν ἀναγκαῖον ὡς ἐπὶ τὸ πολὺ συμβαίνειν, καθάπερ εἴρηται καὶ πρότερον, οἷον μεταῤῥοίας εἴσω γινομένης τοῦ πνεύματος· καὶ μᾶλλον πρὸ τῶν μειζόνων σεισμῶν· μὴ διασπώμενον γὰρ τὸ μὲν ἔξω, τὸ δ' ἐντὸς, ἀλλ' ἀθρόον φερόμενον ἀναγκαῖον ἰσχύειν μᾶλλον. Τὸ δὲ φῦχος συμβαίνει διὰ τὸ τὴν ἀναθυμίασιν εἴσω περιτρέπεσθαι, φύσει θερμὴν οὖσαν καθ' αὑτήν. Οὐ δοκοῦσι δ' οἱ ἄνεμοι εἶναι θερμοὶ διὰ τὸ κινεῖν τὸν ἀέρα πλήρη ψυχρᾶς ὄντα καὶ πολλῆς ἀτμίδος, ὥσπερ τὸ πνεῦμα τὸ διὰ τοῦ στόματος φυσώμενον. Καὶ γὰρ τοῦτο ἐγγύθεν μεν ἐστι θερμὸν, ὥσπερ καὶ ὅταν ἀάζωμεν· ἀλλὰ δι' ὀλιγότητα οὐκ ὁμοίως ἐπίδηλον. Πόῤῥωθεν δὲ ψυχρὸν, διὰ τὴν αὐτὴν αἴτιαν τοῖς ἀνέμοις. Ἐπιλειπούσης οὖν εἰς τὴν γῆν τῆς τοιαύτης δυνάμεως, συνιοῦσα διὰ ὑγρότητα ἡ ἀτμιδώδης ἀποῤῥοὴ ποιεῖ τὸ ψῦχος, ἐν οἷς συμβαίνει τόποις γίνεσθαι τοῦτο τὸ πάθος· τὸ δ' αὐτὸ αἴτιον καὶ τοῦ εἰωθότος ἐνίοτε γίγνεσθαι σημείου πρὸ τῶν σεισμῶν· ἢ γὰρ μεθ' ἡμέραν, ἢ μικρὸν μετὰ δυσμὰς, αἰθρίας οὔσης, νεφέλιον λεπτὸν φαίνεται διατεῖνον, καὶ μακρὸν, οἷον γραμμῆς μῆκος εὐθύτητι διηκριβωμένον, τοῦ πνεύματος ἀπομαραινομένου διὰ τὴν μετάστασιν. Τὸ δ' ὅμοιον συμβαίνει καὶ ἐν τῇ θαλάττῃ περὶ τοὺς αἰγιαλούς· ὅταν μὲν γὰρ κυμαίνουσα ἐκβάλλῃ, σφόδρα παχεῖαι καὶ σκολιαὶ γίνονται αἱ ῥηγμῖνες· ὅταν δὲ γαλήνη ᾖ, διὰ τὸ μικρὰν ποιεῖσθαι τὴν ἔκκρισιν λεπταί εἰσι καὶ εὐθεῖαι. Ὅπερ οὖν ἡ θάλαττα ποιεῖ περὶ τὴν γῆν, τοῦτο τὸ πνεῦμα περὶ τὴν ἐν τῷ ἀέρι ἀχλὺν, ὥσθ' ὅταν γένηται νηνεμία, πάμπαν εὐθεῖαν καὶ λεπτὴν καταλείπεσθαι, ὥσπερ ῥηγμῖνα οὖσαν ἀέρος τὴν νεφέλην. Διὰ ταῦτα δὲ καὶ περὶ τὰς ἐκλείψεις ἐνίοτε τῆς σελήνης συμβαίνει γίγνεσθαι σεισμόν· ὅταν γὰρ ἤδη πλησίον ᾖ ἡ ἀντίφραξις, καὶ μήπω μὲν ᾖ πάμπαν ἀπολελοιπὸς τὸ φῶς, καὶ τὸ ἀπὸ τοῦ ἡλίου θερμὸν ἐκ τοῦ ἀέρος, ἤδη δ' ἀπομαραινόμενον, νηνεμία γίνεται, ἀντιμεθισταμένου τοῦ πνεύματος εἰς τὴν γῆν, ὃ ποιεῖ τὸν σεισμὸν πρὸ τῶν ἐκλείψεων. Γίνονται γὰρ καὶ ἄνεμοι πρὸ τῶν ἐκλείψεων πολλάκις, ἀκρόνυχοι μὲν πρὸ τῶν μεσονυκτίων ἐκλείψεων, μεσονύκτιοι δὲ πρὸ τῶν ἑῴων. Συμβαίνει δὲ τοῦτο, διὰ τὸ ἀμαυροῦσθαι τὸ θερμὸν τὸ ἀπὸ τῆς σελήνης, ὅταν πλησίον ἤδη γίγνηται ἡ φορὰ ἐν ᾧ γενομένων ἔσται ἡ ἔκλειψις. Ἀνιεμένου οὖν ᾧ κατείχετο ὁ ἀὴρ καὶ ἠρέμει, πάλιν κινεῖται καὶ γίγνεται πνεῦμα τῆς ἐκλείψεως πρωϊαίτερον. Ὅταν δ' ἰσχυρὸς γένηται σεισμὸς, οὐκ εὐθὺς, οὐδ' εἰσάπαξ παύεται σείσας, ἀλλὰ τὸ πρῶτον μὲν μέχρι περὶ τετταράκοντα πρόεισι πολλάκις ἡμέρας, ὕστερον δὲ καὶ ἐφ' ἓν, καὶ ἐπὶ δύο ἔτη ἐπισημαίνει κατὰ τοὺς αὐτοὺς τόπους. Αἴτιον δὲ τοῦ μὲν μεγέθους τὸ πλῆθος τοῦ πνεύματος, καὶ τῶν τόπων τὰ σχήματα δι' ὧν ἂν ῥυῇ· ᾗ γὰρ ἂν ἀντιτυπήσῃ, καὶ μὴ ῥᾳδίως διέλθῃ, μάλιστά τε σείει, καὶ ἐγκαταλείπεσθαι ἀναγκαῖον ἐν ταῖς εὐσχωρίαις, οἷον ὕδωρ οὐ δυνάμενον διεξελθεῖν. Διὸ καθάπερ ἐν σώματι οἱ σφυγμοὶ οὐκ ἐξαίφνης παύονται, οὐδὲ ταχέως, ἀλλ' ἐκ προσαγωγῆς ἅμα καταμαραινομένου τοῦ πάθους, καὶ ἡ ἀρχὴ ἀφ' ἧς ἡ ἀναθυμίασις ἐγένετο, καὶ ἡ ὁρμὴ τοῦ πνεύματος δῆλον ὅτι οὐκ εὐθὺς ἅπασαν ἀνάλωσε τὴν ὕλην, ἐξ ἧς ἐποίησε τὸν ἄνεμον, ὃν καλοῦμεν σεισμόν. Ἕως ἂν οὖν ἀναλωθῇ τὰ ὑπόλοιπα τούτων, ἀνάγκη σείειν· ἠρεμαίτερον δὲ καὶ μέχρι τούτου, ἕως ἂν ἔλαττον ᾖ τὸ ἀναθυμιώμενον, ἢ ὥστε δύνασθαι κινεῖν ἐπιδήλως. Ποιεῖ δὲ καὶ τοὺς ψόφους τοὺς ὑπὸ τὴν γῆν γινομένους τὸ πνεῦμα, καὶ τοὺς πρὸ τῶν σεισμῶν. Καὶ ἄνευ δὲ σεισμῶν, ἤδη που γεγόνασιν ὑπὸ γῆν· ὥσπερ γὰρ καὶ ῥαπιζόμενος ὁ ἀὴρ παντοδαποὺς ἀφίησε ψόφους, οὕτως καὶ τύπτων αὐτός· οὐθὲν γὰρ διαφέρει· τὸ γὰρ τύπτον ἅμα καὶ αὐτὸ τύπτεται πᾶν. Προέρχεται δ' ὁ ψόφος τῆς κινήσεως διὰ τὸ λεπτομερέστερον εἶναι, καὶ μᾶλλον διὰ παντὸς ἰέναι τοῦ πνεύματος τὸν ψόφον. Ὅταν δ' ἔλαττον ᾖ ἢ ὥστε κινῆσαι τὴν γῆν διὰ λεπτότητα, διὰ μὲν τὸ ῥᾳδίως διηθεῖσθαι οὐ δύναται κινεῖν· διὰ δὲ τὸ προσπίπτειν στερεοῖς ὄγκοις καὶ κοίλοις καὶ παντοδαποῖς σχήμασι, παντοδαπὰς ἀφίησε φωνάς· ὥστ' ἐνίοτε δοκεῖν, ὅπερ λέγουσιν οἱ τερατολογοῦντες, μυκᾶσθαι *τὴν γῆν. Ἤδη δὲ καὶ ὕδατα ἀνεῤῥάγη γιγνομένων σεισμῶν· ἀλλ' οὐ διὰ τοῦτο αἴτιον τὸ ὕδωρ τῆς κινήσεως, ἀλλ' ἂν ᾖ ἐξ ἐπιπολῆς ἢ κάτωθεν βιάζηται τὸ πνεῦμα, ἐκεῖνο τὸ κινοῦν ἐστὶν, ὥσπερ τῶν κυμάτων οἱ ἄνεμοι, ἀλλ' οὐ τὰ κύματα τῶν ἀνέμων ἐστὶν αἴτια· ἐπεὶ καὶ τὴν γῆν οὕτως ἄν τις αἰτιῷτο τοῦ πάθους· ἀνατρέπεται γὰρ σειομένη, καθάπερ ὕδωρ (ἡ γὰρ ἔκχυσις ἀνάτρεψίς τις ἐστιν)· ἀλλ' αἴτια ταῦτα μὲν ἄμφω ὡς ὕλη (πάσχει γὰρ, ἀλλ' οὐ ποιεῖ)· τὸ δὲ πνεῦμα ὡς ἀρχή· ὅπου δ' ἅμα κῦμα σεισμῷ γέγονεν, αἴτιον, ὅταν ἐναντία γίγνηται τὰ πνεύματα. Τοῦτο δὲ γίγνεται, ὅταν τὸ σεῖον τὴν γῆν πνεῦμα φερομένην ὑπ' ἄλλου πνεύματος τὴν θάλασσην, ἀπῶσαι μὲν ὅλως μὴ δύνηται· προωθοῦν δὲ καὶ συστέλλον εἰς ταὐτὸν συναθροίσῃ πολλήν· τότε γὰρ ἀναγκαῖον ἡττηθέντος τοῦτον τοῦ πνεύματος ἀθρόαν ὠθουμένην ὑπὸ τοῦ ἐναντίου πνεύματος ἐκρήγνυσθαι καὶ ποιεῖν τὸν κατακλυσμόν. Ἐγένετο δὲ τοῦτο καὶ περὶ Ἀχαΐαν· ἔξω μὲν γὰρ ἦν νότος, ἐκεῖ δὲ βορέας. Νηνεμίας δὲ γενομένης, καὶ ῥυέντος εἴσω τοῦ ἀνέμου, ἐγένετο τό, τε κῦμα καὶ ὁ σεισμὸς ἅμα· καὶ μᾶλλον διὰ τὸ τὴν θάλατταν μὴ διδόναι διαπνοὴν τῷ ὑπὸ τὴν γῆν ὡρμημένῳ πνεύματι, ἀλλ' ἀντιφράττειν. Ἀποβιαζόμενα γὰρ ἄλληλα, τὸ μὲν πνεῦμα τὸν σεισμὸν ἐποίησεν, ἡ δὲ ὑπόστασις τοῦ κύματος τὸν κατακλυσμόν. Κατὰ μέρος δὲ γίγνονται οἱ σεισμοὶ τῆς γῆς, καὶ πολλάκις ἐπὶ μικρὸν τόπον· οἱ δ' ἄνεμοι οὐ κατὰ μέρος. Κατὰ μέρος μὲν, ὅταν αἱ ἀναθυμιάσεις αἱ κατὰ τὸν τόπον αὐτὸν καὶ τὸν γειτνιῶντα συνέλθωσιν εἰς ἕν· ὥσπερ καὶ τοὺς αὐχμοὺς ἔφαμεν γίγνεσθαι, καὶ τὰς ὑπερομβρίας τὰς κατὰ μέρος. Καὶ οἱ μὲν σεισμοὶ γίγνονται διὰ τοῦτον τὸν τρόπον· οἱ δ' ἄνεμοι, οὔ. Τὰ μὲν γὰρ ἐν τῇ γῇ τὴν ἀρχὴν ἔχει, ὥστ' ἐφ' ἓν ἁπάσας ὁρμᾶν· ὁ δ' ἥλιος οὐχ ὁμοίως δύναται· τὰς δὲ μετεώρους μᾶλλον, ὥστε ῥεῖν, ὅταν ἀρχὴν λάβωσιν ἀπὸ τῆς τοῦ ἡλίου φορᾶς ἤδη κατὰ τὰς διαφορὰς τῶν τόπων, ἐφ' ἕν. Ὅταν μὲν οὖν ᾖ πολὺ τὸ πνεῦμα, κινεῖ τὴν γῆν, ὥσπερ ἂν ὁ τρόμος, ἐπὶ πλάτος μὲν, γίγνεται δ' ὀλιγάκις καὶ κατά τινας τόπους, οἷον ὁ σφυγμὸς, ἄνω καὶ κάτωθεν· διὸ καὶ ἐλαττονάκις σείει τοῦτον τὸν τρόπον· οὐ γὰρ ῥᾴδιον οὕτω πολλὴν συνελθεῖν ἀρχήν· ἐπὶ μῆκος γὰρ πολλαπλασία τῆς ἀπὸ τοῦ βάθους, ἡ διάκρισις. Ὅπου δ' ἂν γένηται τοιοῦτος σεισμὸς, ἐπιπολάζει πλῆθος λίθων, ὥσπερ τῶν ἐν τοῖς λίκνοις ἀναβρατομένων. Τοῦτον γὰρ τὸν τρόπον γενομένου σεισμοῦ τὰ περὶ Σίπυλον ἀνετραπη καὶ τὸ Φλεγραῖον καλούμενον πεδίον, καὶ τὰ περὶ τὴν Λιγυστικὴν χώραν. Ἐν δὲ ταῖς νήσοις ταῖς ποντίαις ἧττον γίγνεται σεισμὸς, τῶν προσγείων. Τὸ γὰρ πλῆθος τῆς θαλάττης καταψύχει τὰς ἀναθυμιάσεις, καὶ κωλύει τῷ βάρει, καὶ ἀποβιάζεται. Ἔτι δὲ ῥεῖ, καὶ οὐ σείεται κρατουμένη ὑπὸ τῶν πνευμάτων. Καὶ διὰ τὸ πολὺν ἐπέχειν τόπον, οὐκ εἰς ταύτην, ἀλλ' ἐκ ταύτης αἱ ἀναθυμιάσεις γίγνονται, καὶ ταύταις ἀκολουθοῦσιν αἱ ἐκ τῆς γῆς. Αἱ δ' ἐγγὺς τῆς ἠπείρου νησοῖ μόριόν εἰσι τῆς ἠπείρου. Τὸ γὰρ μεταξὺ διὰ μικρότητα οὐδεμίαν ἔχει δύναμιν· τὰς δὲ ποντίας οὐκ ἔστι κινῆσαι ἄνευ τῆς θαλάττης ὅλης, ὑφ' ἧς περιεχόμεναι τύγχάνουσιν. Περὶ μὲν οὖν σεισμῶν, καὶ τίς ἡ φύσις αὐτῶν, καὶ διὰ τίν' αἰτίαν γίγνονται, καὶ περὶ τῶν ἄλλων τῶν συμβαινόντων περὶ αὐτοὺς, εἴρηται σχεδὸν περὶ τῶν μεγίστων."*—Ἀριστοτέλους, περὶ Μετεωρολογικῶν, Β, Κεφάλαια *ή καὶ θ'.*

"Πολλάκις *δὲ καὶ συγγενὲς πνεῦμα εὔκρατον ἐν γῇ παρεξωσθὲν εἰς* *μυχίους σήραγγας αὐτῆς, ἔξεδρον γενόμενον ἐκ τῶν οἰκείων τοπων, πολλὰ μέρη συνεκράδανεν. Πολλάκις δὲ πολὺ γενόμενον ἔξωθεν ἐγκατειλήθη τοῖς ταύτης κοιλώμασι, καὶ ἀποκλεισθὲν ἐξόδου μετὰ βίας αὐτὴν συνετίναξε, ζητοῦν ἔξοδον ἑαυτῷ, καὶ ἀπειργάσατο πάθος τοῦτο, ὃ καλεῖν εἰώθαμεν σεισμόν· τῶν δὲ σεισμῶν, οἱ μὲν εἰς πλάγια σείοντες κατ' ὀξείας γωνίας, ἐπικλίνται καλοῦνται· οἱ δὲ ἄνω ῥιπτοῦντες, καὶ κάτω κατ' ὀρθὰς γωνίας, βράσται· οἱ δὲ συνιζήσεις ποιοῦντες εἰς τὰ κοῖλα, χασματίαι· οἱ δὲ χάσματα ἀνοίγοντες, καὶ γῆν ἀναῤῥηγνύντες, ῥῆκται καλοῦνται. Τούτων δὲ, οἱ μὲν, καὶ πνεῦμα προσαναβάλλουσιν· οἱ δὲ, πέτρας· οἱ δὲ, πηλόν· οἱ δὲ, πηγὰς φαίνουσι τὰς πρότερον οὐκ οὔσας· τινὲς δὲ, ἀνατρέποντες κἄτὰ μίαν πρόωσιν, οὓς καλοῦσιν ὤστας· οἱ δὲ ἀναπάλλοντες, καὶ ταῖς εἰς ἑκάτερον ἐγκλίσεσι καὶ ἀναπάλσεσι διορθοῦντες ἀεὶ τὸ σειόμενον, παλματίαι λέγονται, τρόμῳ πάθος ὅμοιον ἀπεργαζόμενοι."—Ἀριστοτέλους, περὶ Κόσμου, Κεφάλαιον δ' *.*

Such are Aristotle's facts and opinions. The main difficulty of mastering his views, consists in the interpretation we put upon the word *πνεῦμα*. It is very difficult to discover whether by it he means, simply the wind, or some "universal life of the world," the expansive efforts of elastic gases, or merely some unknown force beneath, that which Humboldt calls "the reaction of the interior of a planet upon its exterior." I incline to adopt the latter view.

The doctrines of the eloquent Seneca are next in ancient importance; they have been well said by Humboldt to contain the germ of almost everything that has been advanced in modern times as to volcanic action in its large sense.

"Ideoque antequam terra moveatur, solet mugitus audiri, ventis in abdito tumultuantibus: nec enim aliter posset, ut ait noster Virgilius,

'Sub pedibus mugire solum, et juga celsa moveri,'

nisi hoc esset ventorum opus. Vices deinde hujus pugnæ sunt; desinit calidi congregatio, ac rursus eruptio. Tunc frigida compescuntur et succedunt, mox futura potentiora. Dum ergo alterna vis cursat, et ultro citroque spiritus commeat, terra concutitur."—Senec. *Natur. Quæst.*, lib. vi. 13.

"Quidam ita existimant. Terra multis locis perforata est, nec tantum primos illos aditus habet, quos velut spiramenta ab initio sui recepit, sed multos illic casus imposuit. Alicubi diduxit, quidquid superne terreni erat, aqua: alia torrentes exedere, illa æstibus magnis dirupta patuere. Per hæc intervalla intrat spiritus: quem si inclusit mare, et altius adegit, nec fluctus retro abire permisit, tunc ille exitu simul redituque præcluso, volutatur. Et quia in rectum non potest tendere, quod illi naturale est, in sublime se intendit, et terram prementem diverberat.

"Etiam nunc dicendum est, quod plerisque auctoribus placet, et in quod fortasse fiet discessio. Non esse terram sine spiritu, palam est. Non tantum illo dico, quo se tenet, ac partes sui jungit, qui inest etiam saxis mortuisque corporibus; sed illo dico vitali, et vegeto, et alente omnia. Hunc nisi haberet, quomodo tot arbustis spiritum infunderet, non aliunde viventibus, et tot satis? Quemadmodum tam diversas radices, aliter atque aliter in se mersas foveret, quasdam summa receptas parte, quasdam altius tractas, nisi multum haberet animæ, tam multa, tam varia generantis, et haustu atque alimento suo educantis? Levibus adhuc argumentis ago. Totum hoc cœlum, quod igneus æther, mundi summa pars, claudit, omnes hæ stellæ, quarum inveniri non potest numerus, omnis hic cœlestium cœtus, et, ut alia præter-

* See note at end.

eam, hic tam prope a nobis agens cursum sol, omni terrarum ambitu non semel major, alimentum ex terreno trahunt, et inter se partiuntur; nec ullo alio scilicet, quam halitu terrarum sustinentur. Hoc illis alimentum, hic pactus est. Non posset autem tam multa, tantaque, et seipsa majora, terra nutrire, nisi plena esset animæ, quam per diem et noctem ab omnibus partibus suis fundit. Fieri enim non potest, ut non multum illi supersit, ex qua tantum petitur ac sumitur; et ad tempus quidem, quod exeat, nascitur. Nec enim esset perennis illi copia suffecturi in tot cœlestia spiritus, nisi invicem ista excurrerent, et in aliud alia solverentur. Sed tamen necesse est abundet ac plena sit, et ex condito proferat. Non est ergo dubium, quin multum spiritus interlateat, et cæca sub terra spatia aër latus obtineat. Quod si verum est, necesse est id sæpe moveatur, quod re mobilissima plenum est. Numquid enim dubium esse potest cuiquam, quin nihil sit tam inquietum quam aër, tam versabile et agitatione gaudens?" —*Natur. Quæst.*, lib. vi. 15, 16.

"Maxima ergo causa est, propter quam terra moveatur, spiritus natura citus, et locum e loco mutans. Hic quamdiu non impellitur, et in vacanti spatio latet, jacet innoxius, nec circumjectis molestus est. Ubi illum extrinsecus superveniens causa solicitat, compellitque et in arctum agit, scilicet adhuc cedit tantum, et vagatur. Ubi exemta discedendi facultas est, et undique obsistitur, tunc,

'. . . . . . magno cum murmure montis
Circum claustra fremunt,'

quæ diu pulsata convellit ac jactat; eo acrior, quo cum valentiore mora luctatus est."—*Natur. Quæst.*, lib. vi. 18.

After Seneca we may at once transcribe the views of Pliny:—

"Haustu aquæ e puteo præsensisse ac prædixisse ibi terræ motum. . . . . Et hæc quidem arbitrio cujusque existimanda relinquantur; ventos in causa esse non dubium reor.

"Neque enim unquam intremiscunt terræ nisi sopito mari, cœloque adeo tranquillo ut volatus avium non pendeant, subtracto omni spiritu qui vehit: nec unquam nisi post ventos, condito scilicet in venas et cava ejus occulta flatu. Neque aliud est in terra tremor quam in nube tonitruum; nec hiatus aliud quam cum fulmen erumpit: incluso spiritu luctante et ad libertatem exire nitente.

"Varie itaque quatitur, et mira eduntur opera alibi prostratis mœnibus, alibi hiatu profundo haustis, alibi egestis molibus, alibi emissis amnibus: nonnunquam etiam ignibus, calidisve fontibus, alibi averso fluminum cursu. Procedit vero, comitaturque terribilis sonus, alias murmur, similius mugitibus, aut clamori humano, armorumve pulsantium fragori: pro qualitate materiæ excipientis formaque vel cavernarum vel cuniculi per quem meat, exilius, grassante in angusto eodem rauco in recurvis, resultante in duris, fervente in humidis, fluctuante in stagnantibus, item fremente contra solida. Itaque et sine motu sæpe editur sonus. Nec simplici modo quatitur, sed tremit vibratque. Hiatus vero alias remanet, ostendens quæ sorbuit, alias occultat ore compresso, rursusque ita inducto solo, ut nulla vestigia extent, urbibus plerumque devoratis, agrorumque tractu hausto. Maritima autem maxime quatiuntur. Nec montuosa tali malo carent. Exploratum est mihi Alpes, Apenninumque sæpius tremuisse. . . . . . Ideo Galliæ et Ægyptus minime quatiuntur, quoniam hic æstatis causa obstat, illic hyemis. . . . . .

"Navigantes quoque sentiunt non dubia conjectura, sine flatu intumescente fluctu subito aut quatiente icti. Intremunt vero et in navibus posita æque quam in ædificiis crepituque prænuntiant: quin et volucres non impavidæ sedentes. Est et in cœlo signum præceditque motu futuro, aut interdiu, aut paulo post occasum sereno ceu tenuis linea nubis in longum porrectæ spatium. Est et in puteis turbidior aqua nec sine odoris tædio.

"Sicut in iisdem est remedium quale et crebri specus præbent: conceptum enim spiritum exhalant, quod in certis notatur oppidis quæ minus quatiuntur, crebris ad eluviem cuniculis cavata. Multoque sunt tutiora in iisdem illis quæ pendent: sicut Neapoli in Italia intelligitur, parte ejus quæ solida est ad tales casus obnoxia.

"Intissimi sunt ædificiorum fornices, anguli quoque parietum, postesque, alterno pulsu renitente. Et latere terreno facti parietes minore noxa quatiuntur. Magna differentia est et in ipso genere motus; pluribus siquidem modis quatitur. Intissimum est cum vibrat crispante ædificiorum crepitu: et cum intumescit assurgens, alternoque motu residet: innoxium et cum concurrentia tecta contrario ictu arietant: quoniam alter motus alteri renititur. Undantis inclinatio et fluctus more quædam volutatio infesta est: aut cum in unam partem totus se motus impellit.

"Desinunt autem tremores, cum ventus emersit: sin vero duravere non ante quadraginta dies sistuntur: plerumque et tardius, utpote cum quidam annuo et biennii spatio duraverint.

"Factum est et hoc semel, quod equidem in Etruscæ disciplinæ voluminibus inveni, ingens terrarum portentum....... Namque montes duo inter se concurrerunt, crepitu maximo assultantes, recedentesque inter eos flamma fumoque in cœlum exeunte interdiu....... Eo concursu villæ omnes elisæ: animalia permulta quæ intra fuerant exanimata sunt. ...... Non minus mirum ostentum et nostra cognovit ætas, anno Neronis principis supremo ...... pratis oleisque intercedente via publica in contrarias sedes transgressis in agro Marrucino.......

"Fiunt simul cum terræ motu et inundationes maris, eodem videlicet spiritu infusi ac terræ residentis sinu recepti.......

"Eadem nascentium causa terrarum est, cum idem ille spiritus, attollendo potens solo non valuit erumpere. Nascuntur enim nec fluminum tantum invectu, sicut Echinades insulæ ab Acheloo amne congestæ, majorque pars Ægypti a Nilo, in quam a Pharo insula noctis et diei cursum fuisse Homero credimus; sed et recessu maris, sicut eidem de Circeiis.

"Quod et accidisse in Ambraciæ portu decem millium passuum intervallo et Atheniensium quinque millium ad Piræeum memoratur, et Ephesi ubi quondam ædem Dianæ alluebat. Herodoto quidem si credimus, mare fuit supra Memphim usque ad Æthiopum montes: itemque a planis Arabiæ. Mare et circa Ilium, et tota Teuthrania quoque campos intulerit Mæander. Nascuntur et alio modo terræ ac repente in aliquo mari emergunt velut paria secum faciente natura, quæque hauserit hiatus alio loco reddente."—Plin. *Nat. Hist.*, lib. xi. 81, 89.

And thus we may pass from classic times to the middle age of earthquake history.

Multitudes of tracts, pamphlets and books, of the fifteenth, sixteenth and seventeenth centuries, exist on our subject, most of them recording some particular earthquake, and straightway founding a theory thereupon; but others there are giving good *résumés* of all past knowledge of the subject, and a few of remarkable interest from the singularity or originality of their views. A mere list of these books would fill many pages; and as in a second part of this Report I hope to present as perfect a bibliography as possible of earthquakes, so I shall only notice here such of these works as having come under my notice, appear to be of more than ordinary interest, still proceeding in order of time.

Liberti Fromondi, Coll. Louvainiensi Proff., was the author of a work on meteorology, 'Meteorologicorum Libri sex' (4to, Antwerp, 1527). The last chapter of his fourth book is dedicated to a good *résumé* of all the ancient knowledge of earthquakes, divided under the heads of—

1. Quæ causa efficiens terræ motus.
2. Species terræ motus.
3. Quæ loca obnoxia terræ motibus.
4. De magnitudine et duratione terræ motus.
5. Quæ anni tempora maxime sentiunt terræ motus.
6. Quæ signa antecedentia terræ motus.
7. Effectus terræ motus.
8. Timor numinis causa finalis terræ motus.
9. Comparatio cuniculorum nostrorum militarium cum terræ motu.

As to the first cause, after noticing the old Greek notions of Neptune, Ἐννοσίγαιον καὶ Σεισίχθονα, and several others of a mythological character, he agrees with Aristotle:—

"Sententia Aristotelis et verissima est, spiritum subterraneum causam esse terræ motus effectricem. Probatur, quia quoties terra pulsu pertunditur aut dehiscit, evolant halitus aliqui, sæpe pestilentes, ignis etiam aliquando et cineres: ergo ille fuit qui terram rupit et eam suffodiendo concussit. Idem patebit post ex omnibus terræ motus affectibus."—p. 197.

This passage is remarkable, as showing the sense in which "spiritus terræ," πνεῦμα, as used by Aristotle, is interpreted by Fromondi, *i.e.* as our volcanic force of elevation in Humboldt's extended sense, "the reaction of the interior upon the exterior of our planet."

As to the species of earthquakes (art. 2), Fromondi thus classifies:—

"Auctor libri de mundo et ex eo D. Damascenus, septem species accidentarias terræ motus fecit, *i. e.*

1. Epiclintæ seu inclinatores.
2. Brastæ seu effervescentes.
3. Chasmatiæ.
4. Rhectæ (viam effringunt).
5. Ostæ (uno impulsu).
6. Palmatiæ (vibrant).
7. Mycetiæ (cum mugitu).

"Aristoteles tamen duabus speciebus, pulsu et tremore, contentus fuit, sed tertiam inclinationem optime Seneca adjecit.

"Pulsus est motus quo terra, instar arteriæ animalis, diastole et systole vicissim erigitur et subsidit, vel generalius est qui terram succutit, unde a Seneca vocatur succussio. Tremor enim concutit et vibrat: inclinatio vero in unam solam partem totum onus suspendit...... septem autem aliæ species a diversitate effectuum sumptæ sunt et ad tres istas possunt revocari."—p. 201.

Of the Rhectæ, Fromondi says:—

"Ceterum pulsus Rhectes et effractor, omnium sine dubio est perniciocissimus, deinde longa et undans inclinatio quæ parietes et fastigia ædificiorum extra fundamenti perpendiculum suspendit. Brevis autem et crispans tremor partem inclinatam statim contrario motu in sedem restituit, prævenitque lapsum, unde Plinius, lib. ii. cap. 82, 'Latere etiam facti parietes minore noxa quatiuntur,' inquit."—p. 202.

As to the places subject to earthquakes:—Egypt, he says, was very free from them, and so was Belgium, especially its southern and Dutch portions; but he quotes from 'Gemma Cosmocritica,' lib. ii. cap. 1, an account of two earthquakes in Flanders in the years 1554 and 1569.—p. 204.

On the magnitude and duration of earthquakes he gives several facts:—About the year 369, under Valentinian, and in 1116, nearly the whole world was shaken, and in 1601 Asia, Hungary, Germany, Italy, Gaul: "uno fere momento feruntur tremuisse."—p. 205.

Of the duration he judiciously says, "incerta etiam est et inconstans." The earthquake of 1601 was forty days, that in Italy of 1538 fifteen days according to Fallopius, and again in 1570, one lasted for two whole years, according to Fabricius of Padua. Averröes says Spain shook for three whole years in his time. Aristotle says forty days was a usual time: "Sæpe solennes fuisse." It is remarkable that this early author well distinguishes between the total duration of the earthquake and the time of and intermittence between the several shocks—a distinction so much neglected by modern narrators. Fromondi enumerates several presages of earthquakes, and then classifies their effects into nine species in cap. 7; but his division is bad, mixing up primary, secondary, and doubly secondary effects without distinction.

Passing chapter 8th as not bearing on physical questions, the chapter 9th is perhaps the most remarkable in Fromondi's book. In this he seeks to show the strong analogy that subsists between the effects of mines charged with gunpowder, and even of bombshells, when exploded, with those of earthquakes; and he gives a curious diagram to illustrate his views (p. 219, Antwerp Edit.), which however he does much more forcibly by referring to the effects observed at the blowing up of the bridge over the Scheldt at Antwerp by the Duke of Parma, by means of a lighter full of powder floated in under it and so exploded, and the blow of which was felt over great part of Holland; and again by those observed in 1546, on occasion of the blowing up by a stroke of lightning of a tower at Malines, containing much gunpowder, when part of the town walls were shaken down by the blow, and the water so emptied out of the neighbouring river that the fish were found at a distance on dry land.

'Del. Terræmoto dialogo del. Signor Lucio Maggio, Gentilhuomo Bolognese.' 4to, Bolog. 1571. A curious book with much observation, and a digest of all the ancient and then current opinions. Lib. i. gives a discussion of all the conceivable causes of earthquakes.

In lib. iii. he enunciates eleven signs or presages of earthquakes, viz. 1. Stillness of the air. 2. Gloom and obscurity of the sun, haze, &c. 3. Eclipse of the sun. 4. Unusual conduct of animals. 5. Muddiness of wells. 6 and 7. Motions and swellings, or odours of the sea without any wind. 8. Various sounds in the earth and air. 9. The appearance of columns of smoke or of exhalations in the air. 10. Comets. 11. Certain appearances of the sun on the night preceding the earthquake. These were partly the learned, partly the popular notions of his time in Italy, and continue nearly unaltered as matters of popular belief in that country to the present day.

One of the most remarkable tracts or works on earthquakes which I have discovered is that "Francisci Travagini, super observationibus a se partis, tempore ultimorum terræmotuum, ac potissimum Ragusiani: Physica disquisitio, seu giri terræ diurni indicium." 4to, Lug. Bat. 1679; and also a Venetian edition of 1683: a copy exists in the British Museum. It seems to be about the earliest attempt to found a physical theory of earthquake motion, and presents a singular instance of that coasting along very close to a truth which is yet never attained, of which the history of all observational science is full.

The author begins by stating that a horrible earthquake had occurred on the 6th of April, 1667, which had almost thrown down the whole of Ragusa, and then proceeds in a very clear way to relate the observations which he had made during its occurrence, while at Venice, the earthquake having shaken the whole of Romagna, &c. He then describes the motions of the earth, "moveri multiplicatis vibrationibus, ab occidente ad orientem et reciproce;" then the wave motions of the water in the Venetian canals, noticing the relations of the directions in length of these channels to that of the shock, the waves running along the canals, whose lengths were from west to east, and from bank to bank, or across all others. He then describes the directions in which belfries and other buildings were shaken; then the motions of pendulous bodies, as church lamps, and describes his own sensations as like those of a man in a boat in motion which had struck some obstacle.

From all his observations he concludes, "Ecce igitur, mi lector, ex observatione communi in eodem terræmotu, quasi tres gradationes seu facies; prima qua motus illi est mixtus ex succussatione atque ex laterali illa vibratione, ita tamen ut lateralis ista vibratio minor sit succussatione, quod accedit eo loco ubi maxime desævit causa movens.

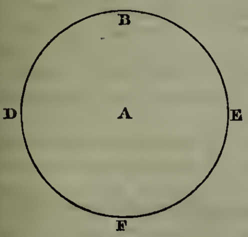
"Altera qua motus iste etiamnum mixtus minore præfert succussationem, quam vibrationem, quod contingit in locis remotioribus abs causa movente, ubi plus minusve desidit illa succussatio pro ratione, majoris aut minoris suæ remotionis causa movente.

"Tertia denique, ubi sola lateralis illa vibratio percipitur, quod contingit in locis remotissimis ab illa causa movente, quæ tamen sint intra sphæram activitatis illius, cujusmodi erat Venetia nostra respectu motus Ragusæi."

Having found that all the lateral vibrations were from west to east and the contrary, he proceeds further to inquire into the physical conditions that will satisfy the above complex motions, and without troubling himself much to inquire as to the nature of the first mover, but merely glancing at the opinions commonly held up to his time, he at once assumes any force whatever to break through the crust of the earth.

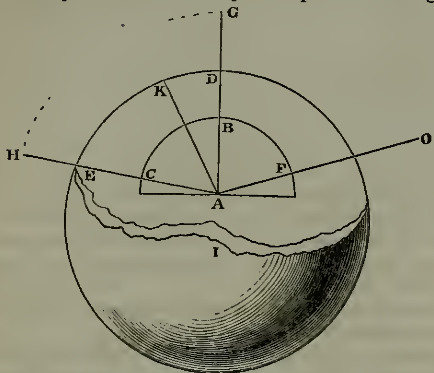
"Ex natura inquam cum semper tempore terræmotu aliquid videatur alicubi foras prorumpere certe quicquid illud sit ut sic foras prorumpat debet revera terram supra stantem succutere, sed nihil omnino quod prorumpendo debeat sic lateraliter eandem vibrare: enimvero ita si foret sequeretur totum terræ globum eodem motu tunc sic vibrari et ex æquo vibrari super axem suum, quod experientia ipsa arguit falsitatis manifestissimæ."

In illustration of this he gives the following figure: "Terra sit A, loco ubi sunt vel sulphura vel nitrum, vel aquæ bullientes, &c., sit B. Sentiatur motus corporis exiturientis a D per B usque ad E. Si motus iste esset etiam vibrationis lateralis a B ad D, necessario deberet etiam terra vibrari a D in F, et ab F in E ob solidam continuitatem totius globi, secundum omnes suæ partes."



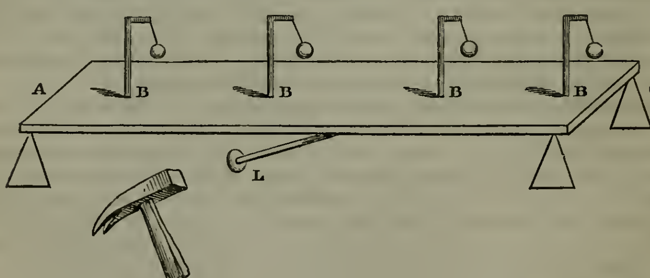
This last expression is a very remarkable one; it is the first glimpse, as it were, that I can find in any author, of a true conception of pulse forces moving in solids, a notion that none of the ancient authors on earthquakes seem ever to have approached; all of them insisting upon the cavernous and perforated interior of the globe being the condition essential to the transmission of earthquakes.

He then proceeds to a diagram explanatory of the Ragusan earthquake: "Verum ut magis sibi constet hæc nostra opinio, ac solidius firmetur, ipsi diligentius hic consideremus singulares omnes illos affectus qui supradictis materiis dum terram movent atque exitum suum moliuntur possunt adscribi quocumque modo debeant prorumpere: statuo igitur hanc figuram. ABCF

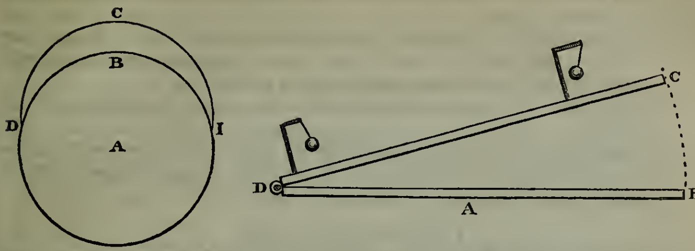


sit hypogæum seu locus subterraneus in quo materia ejusmodi recluditur. Ragusium sit in D, Venetiæ in E, Neapolis in I—Pars terræ concussæ sit in E, D, O, I hoc supposito— videtur certe quod spiritus ille exituriens debeat quaquaversum sphærice agere ac diffundi nempe ab A ad C, ad B et ad F, ita tamen ut haud dubie longe violentius feratur in altum secundum lineam perpendicularem ad B quam per lineas obliquas AC et AF, cum de spirituum ejusmodi natura sit potissimum ut perpendiculariter in altum deferantur: atque adeo sua succussione deferent terram BD versus G, ut contigit Ragusii, ubi et exhalationes et flammæ et odores ac similia visa sunt expirare."

Travagini then proceeds further to develope the conditions according to which the pulses (succussationes) will travel to the outward points of his diagram. He finds the vast mass of matter moved in the directions AH, AO, by the smaller force in these directions, a difficulty in his way; and by another diagram (which I copy as an illustration of the peculiar mode of treatment of the author) he proposes to show the effect of distance upon the pulses and their mode of propagation:—



"Certum enim quod iteratos dicti mallei ictus omnia vibrabuntur versus illam partem ad quam ictus illi adiguntur, et quod tamen ipsa tabula nullatenus usquam discessit a loco suo aut divelletur ab aliis tabulis contiguis." He then proceeds to show by another pair of diagrams, how that upward and downward pulses of the earth's crust may produce a lateral swing in bodies fixed upon it. Thus he says, let A represent the earth, whose surface,



DBI, is thrown up by some force so as to assume the form between D and I of DCI; further, let there be two rods, DC, DB, jointed at D, which shall represent one-half of the elevated portion of the earth's crust, viz. DC, DB in the former figure. Now, he says, if motion towards and away from the rod A be given to the rod DC, round the point D, then will the pendulums fixed to the rod DC swing laterally.

The question of partial elevations by earthquakes, and their presumed effects upon the length of the day at the place, are then discussed. The author then proceeds to show how that, by the repetition of insensible pulses, motion may at last become sensible at a given point; from this, and from the (unhappy) assumption that all earthquakes vibrate from west to east and the contrary, which he admits to be an essential condition upon which his final conclusion depends, he proceeds to make out an imaginary theory to account for all earthquakes as being related to a sudden or partial cessation of the earth's rotation, according to the Copernican view, taking care, however, to put in a precautionary clause, " Salva quam ecclesiasticis statutis debeo reverentia." On this conclusion we need make no remark, but in the author's own words, from his Epistle Dedicatory, " Nempe quod cum isti tunc crederent motum illum esse in suo capite, qui tamen fere erat in terra ipsa; ego e contrario gyrum illum quem mihi videor in terra conspicere, totum in capite meo perpetior."

Although thus finally led off from all that is true in his subject and to an absurd conclusion, the work of Travagini is a truly remarkable one, from the peculiar inductive and experimental manner in which he treats a subject previously never regarded but as matter of the vaguest guessing, and from his appearing to be the first who obtained some imperfect glimpse of earthquake motions being due to pulses, or wave forces, in solids.

Hooke's discourses of earthquakes were delivered before the Royal Society about 1690, and were published in his posthumous works, by R. Waller, Sec. R.S., in 1705, fol. Though called a discourse of earthquakes, these lectures are, in fact, a sort of system of physical geology, in which the forces, forms, conditions and effects of elevation of land are largely considered, but in which the ingenious author loses sight perfectly of what an earthquake is, and systematically confounds all sources, sorts and degrees of elevatory forces and their effects, with the transient action and secondary effects of earthquakes as rightly defined. These lectures are a repertory of much valuable information and thought to the geologist, but add little indeed to the subject of their title. Hooke divides the effects of earthquakes into four sorts; viz.—

The first sort or genus.

1st species.—The raising a considerable part of a country which before lay level with the sea, many feet, nay sometimes many fathoms above its former height.

2nd species.—The raising of a considerable part of the bottom of the sea, and making it lie above the surface of the water, by which means divers islands have been generated and produced.

3rd species.—Raising considerable mountains out of a plain or level country.

4th species.—The raising of the parts of the earth by the throwing on of a great access of new earth, and for burying the former surface under a covering of new earth many fathoms thick.

The second sort or genus.

1st species.—A sinking of some part of the earth's surface lying a good way inland, and converting it into a lake of almost unmeasurable depth.

2nd species.—The sinking of a considerable part of the plain land near to the sea below its former level, so that the adjoining sea comes in and overflows it.

3rd species.—A sinking of the parts of the bottom of the sea much lower, and creating therein vast vorages and abysses.

4th species.—A making bare or uncovering divers parts of the earth which were before a good way below the surface, and this either by suddenly throwing away these upper parts by some subterraneous motion, or else by washing them away by some kind of eruption of waters from unusual places vomited out by some earthquake.

The third sort or genus.

Species 1.—Are the subversions, conversions, and transpositions of the parts of the earth.

The fourth sort or genus.

Species 1.—Are liquefaction, baking, calcining, petrifaction, transformation, sublimation, distillation, &c.

So much will serve for a sample of Hooke, who in fact uses earthquake in a sense commensurate with *all geological action* on the earth's surface; and it is perhaps rather in this sense, than in its strict one, that he comes to the true conclusion that "there is no country almost in the world but has been some time or other shaken by earthquakes."—p. 311.

He even gives an undue importance to his own sense of the word. Thus he supposes that elevations by earthquakes may have changed the centre of gravity of the earth and the length of the year.

One sentence will suffice to give a notion of Woodward's views:—

"This subterranean heat or fire being in any part of the earth stopt by some accidental glut or obstruction in the passages through which it used to ascend, and being preternaturally assembled in great quantity into one place, causes a great rarefaction and intumescence of the water of the abyss, putting it into very great commotions; and making the like effort upon the earth expanded upon the face of the abyss, occasions that agitation and concussion which we call an earthquake."—Woodward, *Nat. Hist.*, 1695.

'The Earth twice shaken wonderfully, or an analogical Discourse of Earthquakes,' by J. D. R. 4to, Lond. 1693–94, said to be by Rouffional, a French Protestant minister, a curious and learned tract, with ten corollaries discussed. He previously inquires,—Cap. 1. How many sorts of earthquakes there are. Cap. 2. What was the nearest natural cause of this earthquake. Cap. 3.

An earthquake hath not properly an end, yet its chief ends are sickness, inundation and sterility. Cap. 4. An examination of how earthquakes differ and agree in form and second causes, and in regard to aspects of the planets. The ten corollaries are—

1. Whether it be true, as Pliny affirms, that France and Egypt are seldom shaken, by reason of the heat and cold, &c.
2. Why rivers decrease by earthquakes.
3. Why those places lying on or encompassed by sea and rivers are obnoxious to earthquakes.
4. What credit may be given to Plato of the island Atlantis drowned by an earthquake.
5. Whether exterior wind entering the earth from above be able to move it.
6. Whether subterraneous exhalations are generated by the sun's beams.
7. Whether some more solemn times of earthquakes are to be appointed for any certain reason. In this he discusses Aristotle's opinion of the Equinoxes, and quotes 'Agricola de Metal.' p. 29, against him.
8. Why birds are frightened by an earthquake.
9. Whether vaults in houses are safest from earthquakes.
10. If the late earthquake be so ended that the same countries through which it went are secure from its iteration. He decides in the negative, giving a long list of authorities for earthquakes occurring repeatedly in the same places, with short intervals and continuing for long periods.

In the year 1693, John Flamsteed published a letter, in which, after detailing with a sort of method, some of the facts observed, he proposes a physical theory of earthquakes. His views, however, are abundantly vague and obscure; he supposes some ætherial explosive matter to exist in the atmosphere, by the occasional firing of which, the shock is given to buildings, ships, &c. Nothing but the name of the illustrious author would make this pamphlet deserve notice.

There is a curious book by Höttinger (Höttingeri Dissertationes de Terræ Motu), partly scientific, partly theological. The title of one dissertation (the fourth) will give an idea of the book:—

"Unde Terræ motus immittantur, sintne fortuna pure naturales an θεήλατοι."

Amontons (Mém. Acad. des Sciences, 1703) endeavoured to prove that atmospheric air might be expanded by heat to a sufficient degree of pressure, when confined under the earth, to produce volcanic effects, and those of earthquakes. Stukeley's arguments, against this and all other views, that assume the direct expansion of elastic fluids as the immediate cause of earthquakes, derived from a consideration of the vast areas shaken at once by the latter, are worthy of perusal, though not free from error, and intended to sustain his own views of their electrical origin only.

That electricity in some unknown undescribed and incomprehensible way was the direct cause of earthquakes, was specially pleaded for by Stukeley, Percival, Beccaria, Priestley and several others, whose imaginations, filled with the power and grandeur of the electrical phænomena, which their experiments perpetually brought before them, and adapting in a loose and confused way some of the electrical phænomena that are constantly observed to accompany the secondary effects of great earthquakes, referred the whole to the agency of their favourite force, and were satisfied.

Their precise works and words need not be quoted.

The Rev. John Mitchell, Fellow of Queen's College, Cambridge, published a paper on earthquakes, in the 51st volume of the Philosophical Transactions, in 1760, which, up to a very recent date, was by far the most important and remarkable work upon the subject, though very much overlooked. His principal views are best given in his own words.

He commences by refuting the notion, that there is any necessary connection between the air, or the weather, or state of moon and tide and earthquakes.

And assuming then that they have an origin under ground, he enunciates the following propositions, sustaining each with its appropriate facts:—

1st. The same places are subject to returns of earthquakes, not only at small intervals for some time after any considerable one has happened, but also at greater intervals for some ages.

2nd. Those places that are in the neighbourhood of burning mountains are always subject to frequent earthquakes, and the eruptions of those mountains, when violent, are generally attended with them.

3rd. The motion of the earth in earthquakes is partly tremulous and partly propagated by waves, which succeed one another, sometimes at larger and sometimes at smaller distances; and this latter motion is generally propagated much further than the former.

4th. It is observed in places which are subject to frequent earthquakes, that they generally come to one and the same place, from the same point of the compass. I may add also, that the velocity with which they proceed (as far as one can collect it from the accounts) is the same, but the velocity of earthquakes of different countries is very different.

5th. A great earthquake (such as the Lisbon one) has been succeeded by several local ones since, the extent of which has been much less.

From a discussion then of the known facts of volcanoes, he concludes, " That in all probability the fires of volcanoes produce earthquakes. That, however, the vibrations, &c. felt close to volcanic foci, either at their first formation or after, are not of the precise nature of earthquakes, or at least, differ in degree from them: and that—

" The greater earthquakes seem rather to be occasioned by other fires that lie deeper in the same tract of country, and the eruptions of volcanoes which happen at the same time with earthquakes, may with more probability be ascribed to those earthquakes, than the earthquakes to the eruptions, whenever, at least, the earthquakes are of any considerable extent."

He then proceeds to give, considering the time he wrote, a wonderfully large and accurate view of the general conformation of the superficial crust of the earth, its arrangement into strata and beds, their relative position and co-ordination at distant places as to horizon, the nature of faults, dykes, &c., and from all he concludes that " from the want of correspondence in the fissures of the upper and lower strata, as well as on account of those strata which are little or not at all shattered, it will come to pass that the earth cannot easily be separated in a direction perpendicular to the horizon if we take any considerable portion of it together; but in the horizontal direction, as there is little or no adhesion between one stratum and another, it may be separated without difficulty."

After this he endeavours to show that the explosive power of volcanoes is due to pent-up vapour or steam, produced by the contact of water with masses of incandescent matter in the earth; that the alternate repose and activity of their action may be accounted for on this hypothesis, and that the expansive force is adequate to the phænomena, &c.; and having established this mechanism, he proceeds to announce the precise mode of formation and of propagation of the wave, in which he conceives earthquake motion to consist: he says, " As a small quantity of vapour almost instantly generated at some considerable depth below the surface of the earth will produce a vibratory motion, so a very large quantity (whether it be generated almost instantly or in any small portion of time) will produce a wave-like motion: the manner in which this wave-like motion will be propagated, may in some measure be represented by the following experiment:—

"Suppose a large cloth or carpet (spread upon a floor) to be raised at one edge, and then suddenly brought down again to the floor, the air under it, being by this means propelled, will pass along till it escapes at the opposite side, raising the cloth in a wave all the way as it goes. In like manner a large quantity of vapour may be conceived to raise the earth in a wave as it passes along between the strata, which it may easily separate in a horizontal direction, there being, as I have said before, little or no cohesion between one stratum and another; the part of the earth which is first raised being bent from its natural form will endeavour to restore itself by its elasticity, and the parts next to it beginning to have their weight supported by the vapour, which will insinuate itself under them, will be raised in their turn, till it either finds some vent, or is again condensed by the cold into water, and by that means prevented from proceeding any further."

Several successive waves, he then proposes to show, might be thus generated, and their height will be greater the nearer they are to the point of their origin.

In the third part of the paper he endeavours more minutely to describe the mechanism of the focus, as to how the water gains access; why the roof should fall in, &c., and applies some of the facts or fancies to the recorded secondary conditions of earthquakes, and to the fluctuations of the sea, which result from them. And in the seventh section, he shows, that by investigating the point of departure of various great sea-waves, when observed at distant points of arrival, after any great earthquake, whose origin is (as he supposes that of all great earthquakes to be) under the sea, we may find the point vertically over the focus of original disturbance. This he does as respects the great Lisbon earthquake, and shows a most remarkable perception of the nature of the motion of waves of translation, far more than the state of exact knowledge of the subject at the time would have made us suppose possible. Lastly, he inquires whether it be then possible to determine anything as to the depth of the focus of disturbance below the surface, but thinks it can be only guessed at; but that, if we could carefully observe and reckon the thickness of upturned strata at some great volcanoes, we should arrive at it.

Such is Mitchell's paper, which I have analysed at some length, from its importance. It contains much that is useful, mixed with the leading fallacy as to the nature of the earthquake wave of shock.

Two other works on the facts of earthquakes require to be mentioned, viz.—'The History and Philosophy of Earthquakes,' and 'Mémoires Historiques et Physiques sur les Tremblemens de Terre,' par Mons. Bertrand, à la Haye, 1757.

In the former, the facts of ten great earthquakes are recorded, and in the latter, those of Switzerland, and all such others as the author could collect.

Bouguer, in his 'Voyage en Peru,' whither he accompanied the French academicians to measure an arc of the meridian, conceives volcanoes and earthquakes as one and the same, and "due to gaseous inflammations and explosions. The weakest shocks are those from the earth already shaken; the strongest, those caused immediately by the inflammation, which are analogous to the roarings of the volcanoes, and which are repeated more or less frequently, according to the facility with which the materials take fire, and also as their volume has relation with the extent of the spaces in which they are enclosed." His views are nearly identical with those of Don Ulloa, but are more clearly expressed by the latter, who says—

"The bursting of a new volcano causes a violent earthquake; this tremulous motion, which we properly call an earthquake, does not so usually happen in case of a second eruption, when an aperture has been before made, or at least the motion is comparatively small." "Volcanoes owe their origin to sulphurous, nitrous, and other combustible substances in the bowels of the earth; these, mixed and turned into a paste, with subterraneous waters, ferment and take fire (this was Lemeri's view); by dilating the contiguous wind or air its volume is so increased, as to produce the same effect as gunpowder fired in a narrow space." "The subterraneous noise proceeds from the ignition of the airs on exploding."

Dolomieu's theories, as to the Calabrian earthquake of 1783, are not very different. "Interior waters, increased by those from the surface, may have run into the focus of Ætna: they would in consequence be converted into very expansive vapour, and strike against every obstacle to their dilatation." He has previously shown that Calabria itself is not a volcanic country; he therefore proceeds:—

"Provided these should have met with channels conducting them to the cavities below Calabria, they would have been capable of occasioning all those convulsions of which I have given a description."

Sir W. Hamilton concludes from all his examinations of the Calabrian earthquakes, that "some great chemical operation of the nature of the volcanic sort was the cause." (Phil. Trans. vol. lxxiii.)

Thus the older writers fix their regards wholly upon the presumed focus or origin of the explosion, as Dolomieu calls it, but none, except Mitchell, attempt to show any distinct train of causes by which the forces here originating, in a centre of volcanic activity, are transferred and become operative at vast distances and in lands not subject to volcanic action. Nor, it must be confessed, have modern authors, even Humboldt, been much more successful in this, or in shaping to themselves a distinct idea of what the nature of the earthquake shock itself is. The words—"a trembling," "a vibration," "a concussion," "a movement," "an undulation," are to be found scattered through the narratives of earthquakes, but even amongst scientific authors these records refer merely to the effect upon their senses, of the motions of the earth's surface, and not to any definite or precise idea, either of the origin or the mode of propagation of the shock.

Humboldt in his latest work, the 'Cosmos,' as well as in his 'Personal Narrative,' does not express himself with clearness upon earthquake movements. He seems disposed at one place to adopt the theory of Mitchell implicitly; yet at another, one fancies he has some notion of the earth-shock being a wave of elastic compression, and therefore propagated in a totally different manner from that of the subteraneous lava tidal wave, moving the solid crust above it, in which Mitchell's theory consists: his clearest expression of view is perhaps in the following sentence:—"The filling up of fissures with crystalline matter interferes by degrees with the free escape of vapours, which confined become operative through their tension in three ways —*concussively*, *explosively*, or suddenly up and down, and as first observed in a large portion of Sweden, *liftingly or continuously*, and only in a long period of time perceptibly altering the level of the sea and land." Here he confounds as thoroughly as the ancient authors, the direct effects in permanent elevation of land by volcanic or other action from beneath, with the transient effects of the earthquake which may result from such actions. He does not attempt to assign the law of motion of any one of the several orders or sorts of earthquake waves. The shocks, he says, are either horizontal and vertical, or rotatory and vorticose in direction; the two former, he says, are always observed together—the latter is rare; several secondary effects of earthquake action, such as twisting of buildings or their parts, landslips, &c. he gives an erroneous account of.

But this is rather anticipating as to date: before concluding, however, the remarks that I am called upon to make upon the views of Humboldt, I would wish to add that they are made with the fullest appreciation of that almost universal and yet searching genius, that derives its resources from, and illustrates nearly every portion of creation.

Bakewell, who wrote his 'Introduction to Geology' as early as 1813, gives in his 10th chapter an account of earthquakes, which, for his day, is luminous and good. He briefly and correctly describes the principal phænomena; traces a distinct connection between volcanic and earthquake effects; proposes the sudden evolution of steam by contact of water with igneous matter at great depths as the immediate cause of both; conceives the horrid noises as due to the rending of rocks or strata, and seems to have had some obscure notion that the internal heat of our planet might be independent of any form of combustion.

In 1835, a copious and exceedingly strange work, the 'Théorie des Volcans,' par le Compte A. de Bylandt Palstercamp, appeared at Paris, 3 vols. 8vo, with fol. atlas.

We have here nothing to do with the author's singular attempt to build up a theory of volcanic action, indeed almost a cosmogony, from considerations derived from the relations and reactions on our planet, of light, heat, electricity and magnetism. With all its wildness and incoherence it carries perhaps a dim fore-shadowing of truth.

In his first volume, p. 373 to 392, he devotes a section to the consideration of earthquakes, as derivative effects of volcanoes. This, like indeed every other part of the book, bears the peculiarity of containing some truths, or quasi truths, much in advance of the author's day, mixed with a great deal of absolute error.

He clearly recognises earthquakes as merely one class of effects due to volcanic action; but although he uses the word vibration, &c., and has even arrived at some of the phænomena resulting from wave motion clearly enough, it is obvious that he has formed no clear idea of pulses transmitted through elastic media in virtue of the elasticity of the solids themselves; his vibrations, and their origin, are nearly analogous to those of Mitchell. Shocks or blows transmitted through and from *cavities* under the earth, suddenly filled or emptied of aëriform fluids, which actually lift up and again drop down the walls of these cavities in rising and falling, originate and constitute Bylandt's shock. So far, therefore, he is not beyond his predecessors. But further:—

"Etablissons d'abord comme principe que les effets des tremblemens de terre sont toujours contradictoires aux causes qui les produisent, et dirigés dans le sens inverse, et que les mêmes causes produisent des effets contradictoires dans les lieux opposés." "Les causes des tremblemens de terre resident toujours dans l'intérieure de la terre et à une certaine profondeur. Or en élévant une perpendiculaire du fond de cette profondeur et en transmettant le mouvement du point le plus bas au plus élévé, l'effet sera celui d'un pendule, c'est-à-dire contradictoire entre les deux extremités.

"Lorsqu'on a senti à la surface une vibration ou oscillation dans la direction du nord au sud, il fallait replier la cause vers sa veritable direction qui était du sud au nord."

He divides earthquake movements into three classes—"en *verticaux* ou directs, en *horizontaux* ou indirects, et en *circulaires* ou accidentels, comme ni tenant à aucune cause, ni à aucun systême regulier."

After explaining that by the first he means direct upward and downward motion over the volcanic centre, "et proviennent du gouflement de la matière," he proceeds to the horizontal motions:—

"Ce mouvement ondulatoire ressemble aux vagues de la mer, et ne dure, comme tous les tremblemens de terre, que peu d'instans; du moment ou l'élévation s'est fait, elle s'abaisse de suite, et ne reste jamais permanente. Un tremblement de terre quelque violent qu'il soit ne peut éléver le terrain que par ondulation de 4 à 5 pieds au plus."

He here, and in the succeeding passage, clearly recognizes the difference so usually overlooked, between the transient elevation, and as immediate depression of surface due to the passage of the earthquake shock, and the permanent elevation produced directly by volcanic action from beneath.

He seems to have had small knowledge of the facts of great sea-waves; and seems (p. 378) to consider them sufficiently explained by "the contradictory effects" in producing a surge, of severe shocks taking place under the sea bottom.

Although horizontal shocks are indirect and only "la conséquence d'une cause directe ou de son contrecoup," he considers they produce more formidable effects than the direct or vertical ones; but he does not get at the true cause: he says, "cela dépend des corps conducteurs et de la formation du sol, car il existe dans l'intérieur de la terre d'immenses cavernes sur lesquelles la croute superficielle n'est pour ainsi dire que suspendue;" and a violent direct shock, he thinks may throw these fragile crusts down at a distance, and bury cities, &c.

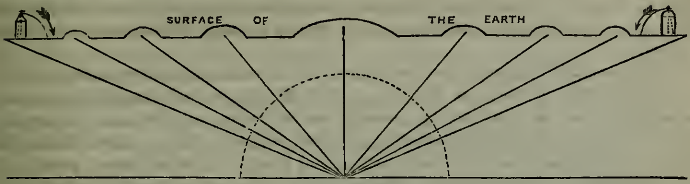
And as to the third class, or "secousses accidentelles," he is of opinion that they are due only to the occasional and capricious falling in of such cavities, and are in fact not properly a part of earthquake phænomena at all —an easy way of disposing of the question.

One of the most remarkable of the author's conclusions is, that,—"La distance à laquelle les tremblemens de terre étendent leur chocs, dépend en premier lieu de la profondeur du foyer dans lequel la commotion s'est développée, en second lieu de la liaison des conducteurs du mouvement dans l'intérieur de la terre."

It is to be borne in mind that his "conducteurs" are not solid vibratory bodies, but always hollow tubes or ducts in the interior of the cavernous earth.

In page 385, in a passage too long for transcript, Bylandt well insists upon the impossibility of earthquakes being properly considered as causes or means of geologic elevation, but simply effects and symptoms of the action elsewhere of the great elevatory forces acting slowly from beneath.

He proceeds:—"Mais après avoir comparé les tremblemens de terre entre eux, définissons les mathématiquement, et éprouvons que les effets des *tremblemens de terre, sont entre eux en raison inverse du carré de distance de chaque point de la surface au centre du foyer.*" Those who desire to know the author's demonstration of this, and that the effects of earthquake shocks are in the opposite direction to the shocks themselves (owing to the inertia of the bodies overthrown), must refer to the work itself, and to the very curious atlas of plates and diagrams accompanying it. One of Bylandt's diagrams, however, is so strange a mingling of the false and the true, that it is worth transcription.



Volcanic focus.

The title given to this diagram, in which, it is to be observed, the lines divergent from the centre do not merely represent lines of force, but *channels* of subterraneous volcanic communication, is, " Les effets des tremblemens de terre sont entr'eux en raison inverse du quarré des distances de chaque point de la surface au centre du foyer et leur produits seront contradictoires, dans les lieux opposés," that is, the towers at both sides will fall inwards.—(Bylandt, planche 7.)

Dr. Young, in his lectures upon Natural Philosophy, casually notices the probability that earthquake motions are vibratory, and are analogous to those of sound, &c. This view, however, was first put, I believe, in a definite form by Gay-Lussac, at the termination of an exceedingly able paper on the chemical theories of volcanoes, in the ' Annales de Chimie :' he says—

" Un tremblement de terre comme l'a très bien dit le Dr. Young est analogue à un tremblement d' air, c'est une très fort onde sonore, excité dans la masse solide de la terre par une commotion quelconque, qui s'y propage avec la même vitesse que le son s'y propagérait. Ce qui surprend dans ce grand et terrible phénomène de la nature c'est l'étendue immense à laquelle il se fait sentir les ravages qu'il produit et la puissance de la cause qu'il faut lui supposer.

" Mais on n'a pas assez fait attention au branlement facile de toutes les particules d'une masse solide. Le choc produit par la tête d'une épingle, à l'un des bouts d'une longue poutre, fait vibrer toutes ses fibres, et se transmet distinctement à l'autre bout à une oreille attentive. Le mouvement d'une voiture sur le pavé ébranle les plus vastes édifices et se communique à travers des masses considérables, comme dans les carrières profondes au dessous de Paris. Qu' y aurait il donc d'étonnant qu'une commotion très forte dans les entrailles de la terre la fit trembler dans un rayon de plusieurs centaines de lieues ? D'après la loi de transmission du mouvement dans les corps élastiques la couche extrême ne trouvant pas à transmettre son mouvement à d'autres couches, tend à se détacher de la masse ébranlée ; de la même manière que dans une file de billes, dont la première est frappée dans le sens des contacts, la dernière seule se détache et prend du mouvement. C'est ainsi que je conçois les effets des tremblemens à la surface de la terre, et comment j'expliquerais leur grand diversité en prenant d'ailleurs en considération, avec M. De Humboldt, la nature du sol et les solutions de continuité que peuvent s'y trouver.

" En un mot, les tremblemens de terre ne sont que la propagation d'une commotion à travers la masse de la terre, tellement, indépendante des cavités souterraines, qu'elle s'étendrait d'autant plus loin que la terre serait plus homogène."—*Annal. de Chim.* vol. xxii. p. 428, 429.

In Von Hoff's ' Geschichte der Veränderungen der Erdoberfläche,' 5 Theil, Gotha, 1822 to 1841, much information as to earthquakes is to be found ;

the author however limits himself almost wholly to the descriptive character which a history of the earth's superficial changes alone requires, and says little of theory, and as I shall have large occasion to refer to him hereafter in reference to earthquake catalogues, the present notice of his work may here suffice.

Hoffman and Kries may also be noticed as German authors on earthquakes.

In 1843, the Professors H. D. and W. B. Rogers of America communicated a paper to the British Association of rather an elaborate character upon the phænomena and theory of earthquakes. They adopt Mitchell's view, and suppose the earth-wave an actual fold of the solid crust, produced by a lava-wave of translation on the surface of the molten matter beneath.

They infer from two great earthquakes that this moves at from 27 to 30 miles per minute, either in nearly straight or in curved lines, according to the form and position of the focus or points of volcanic action.

The sea-waves of earthquakes they suppose to be broad undulations of the water moving in the same direction with the pulsation of the crust and corresponding in breadth with that of the undulations of the earth's crust; yet these, say they, moved at the rate of $3\frac{1}{2}$ miles per minute, in the case of the New England earthquake of 1756, and of 5 miles per minute in that of Lisbon; a striking inconsistency with the velocity previously assigned to the earth-wave.

The tremor or vibratory jar accompanying the great shock or earth-wave, they suppose arises from the crushing of the strata through which the shock passes.

In 1844 appeared Mr. Scott Russell's full report upon sea and other waves, the laws developed in which as to the motions of waves of translation had an important effect upon the immediately subsequent advance towards a complete and true theory of earthquake phænomena.

In February 1846, the author's paper upon the dynamics of earthquakes was read to the Royal Irish Academy, and published in vol. xxi. part 1 of the Transactions of that Academy, in which the first attempt was made to establish upon strict physical bases a theory that should embrace and account for *all the recorded phænomena* of earthquakes, both on land and sea. How far he has succeeded in this, futurity must decide.

In June 1847, Mr. Hopkins produced his report on the theories of elevation and earthquakes (Trans. Brit. Assoc.). The principal features of this paper are, a digest of his previously published mathematical papers on the formation of fissures, &c. by elevations and depressions; a popular *résumé* of the acknowledged laws of formation and propagation of elastic and fluid waves, and the partially placing in a mathematical dress the author's theory of earthquake motions as developed in the paper last alluded to; to this is to be added a demonstration of a method for finding analytically the depth of the centre of disturbance, from observations made with a seismometer, such as that described by the author. (Trans. Roy. Irish Acad. vol. xxi.)

I have thus brought the literature of earthquakes down to the present time; in doing so I would not be misunderstood as attempting a complete account thereof, but such merely as is sufficient to mark the progress of human knowledge of our subject; I have therefore omitted to notice the able *résumés* of such literature given by Sir C. Lyell (Prin. Geol. chap. 28 to 33), and by several other authors. Neither have I at all adverted to the works of authors writing specially of volcanoes, as, although connected with our subject, not properly belonging to it.

I now proceed to the more immediate subject of this Report.

In commencing a Report upon the facts of earthquakes, it would be desirable, if possible, first to discuss and state the distribution of their occurrence both in time and in space upon the earth: for either of these, however, complete data are not yet in existence; no catalogue of earthquakes has ever yet been compiled which endeavours to embrace in number and condition those recorded even since the invention of printing. The completest catalogue that could be compiled would not give much more than the places convulsed and the dates of the occurrence approximately; yet such would not be without important use, and I have accordingly made considerable progress in the laborious task of having such a catalogue prepared, and trust to be enabled to give the results of its completion and discussion in a second part of the present Report at a future meeting. Meanwhile I may state (provisionally) that

1st. Earthquakes occur over all parts of the earth's surface, both on land and under the ocean.

Egypt was one of the countries long believed to be free from earthquakes, from which no doubt, like many other parts of the world, it enjoyed during a long historical period a considerable immunity. But that even Egypt has been absolutely exempt from earthquakes, seems disproved by the scattering of the gigantic ruins of the Memnonium, bearing all the marks of having been thus overthrown, and by the distinct testimony of Strabo, that one of the two colossal figures of the plain of Thebes was commonly said in his time to have been overthrown by an earthquake:—

"*ἐνταῦθα δὲ δυοῖν κολοσσῶν ὄντων μονολίθων ἀλλήλων πλησίον, ὁ μὲν σώζεται, τοῦ δ' ἑτέρου τὰ ἄνω μέρη τὰ ἀπὸ τῆς καθέδρας πέπτωκε σεισμοῦ γενηθέντος, ὥς φασι.*"—*Strab. Rer. Geogr.* lib. xvii.

The question of earthquakes occurring in Egypt is set at rest however by Bishop Pocock the traveller, who tells us in his 'Description of Egypt,' p. 195, "It has hardly been known that they had any earthquakes in Egypt, but in January 1740 they had three great shocks, which threw down mosques and several houses."

2nd. They occur in all time, at all seasons, and at all hours of day and night.

So that were we able to survey this planet's history in all time, we should find no portion of its crust which had not at some period or other been convulsed by earthquakes; and could we have intelligence constantly from over its entire surface, we should find that no day passed free from one or many of these phænomena.

Seneca, in a passage as remarkable for its truth as for the dignity of its expression, affirms his belief in the universal dominion of change, and of earthquakes over all the earth:—

"Omnia ejusdem sortis sunt, etsi nondum mota tamen mobilia; erramus enim si ullam terrarum partem exceptam immunemque ab hoc periculo credimus: omnes sub eadem jacent lege, nihil ita ut immobile esset natura concepit: alia temporibus aliis cadunt; et quemadmodum in urbibus magnis nunc hæc domus, nunc illa suspenditur, ita in hoc orbe terrarum, nunc hæc pars facit vitium, nunc illa. Tyrus aliquando infamis ruinis fuit. Asia duodecim urbes simul perdidit. Anno priore Achaiam et Macedoniam quæcunque est ista vis mali quæ incurrit nunc Campaniam læsit. Circuit fatum, et siquid diu præteriit repetit. Quædam rarius solicitat, sæpius quædam: nihil immune esse et innoxium sinit. Non homines tantum, qui brevis et caduca res nascitur; urbes oræque terrarum et litora et ipsum mare in servitutem fati venit. Quo ergo nobis permansura promittimus bona fortunæ, et felicitatem (cujus ex omnibus rebus humanis velocissima est levitas) habituram in aliquo pondus et moram credimus? Perpetua sibi omnia promittentibus in mentem non venit, id ipsum supra quod stamus stabile non esse. Neque enim Campaniæ istud aut Achaiæ, sed omnis soli vitium est, male cohærere, et ex causis plurimis resolvi, et summa manere, partibus ruere."—*Quæst. Nat.* lib. vi.

3rd. There seems at present no sufficient ground for affirming that one portion of the earth's duration has been more subject to their occurrence than another;

4th. Or that one portion of the earth's crust has *always* been more subject to earthquakes than another.

4th *bis*. But some portions of the earth's crust appear to have sustained a sort of periodicity in their visitation by earthquakes —long periods of repose being followed by shorter, but still long periods of agitation.

Thus Antioch affords perhaps the most remarkable instance, having for a long period been shaken nearly every year during the Roman empire, then having a period of repose of nearly 300 years, and then again becoming very subject to these convulsions.

5th. But those portions of the earth's surface which lie in or around the great present lines or centres of volcanic action do appear at present to be most subject to earthquakes.

6th. And earthquakes are most prevalent and most violent in some relation to the activity and intensity of the volcanic action, at these lines or centres, at given times.

There appears to be beyond question the closest sympathy within all volcanic areas (*i.e.* areas where active volcanoes are found and surrounded with formations due to their former and present action), between the activity of the volcanic vents and the shocks of earthquakes.

Thus, in 1816, slight earthquakes at Scaccia in Sicily preluded the elevation of the new island Julia.

When Monte Nuovo was thrown up in 1538, on the day and night before above twenty shocks were felt.

When Monte Rossi was formed by Ætna in 1669, and when the enormous fissure of twelve miles in length at once opened up the bowels of the volcano, an earthquake shook down Nicolosi and damaged Catania. The eruptions of 1811 and 1819 were also attended with earthquakes.

In Iceland earthquakes long preluded the great eruption of Skaptar Jokul, and reached their maximum violence on the day of the eruption, 11th of June, 1783.

At Lancerote in the Canaries, violent earthquakes preceded and followed the eruptions, near the shore, of 1824. Santorin in the Greek Archipelago, was separated from Therasia by an eruption in the year before Christ 236, which, according to Pliny, was attended with earthquakes; and several more recent submarine eruptions, near it, have been also accompanied with earthquakes.

In a word, every great eruption, in whatever part of the world it has been observed, and whether from a volcanic vent on land, or formed beneath the sea, is accompanied by earthquake shocks of greater or less violence and duration.

But conversely, not only are eruptions thus accompanied by earthquakes, but earthquakes, though not always, are on almost all great occasions accompanied by eruptions or perturbations of established volcanic action. For example, during the great Calabrian earthquake Stromboli was noticed to be less active than it had been for years before, and at Messina, "the commandant of the citadel saw the sea at a quarter of a mile from the fortress rise up and boil in a most extraordinary manner, accompanied with a horrid noise, while all the rest of the water in the Faro was tranquil" (Sir W. Hamilton); and afterwards there was shoal water at the spot where before it had been deep.

In the great Chilian earthquake of 1820, at the moment the shock was felt at Valdivia, in lat. 39° 50′ S., two volcanoes near it burst at once into eruption for a few seconds, and then again became quiescent. (M. Place, Quart. Journ. vol. xvii.)

At Concepcion, volcanoes broke out from beneath the sea at the time the great sea-wave rolled in (or probably before it?).

Hot springs have frequently sympathized with earthquakes at great distances, as those at Tœpliz, which ran dry, and then again flowed discoloured with iron rust during the great Lisbon shocks. No one is ignorant of the melting of the chain cable of the Volage man-of-war at anchor during an earthquake off the coast of South America; and instances might be multiplied almost without limit of similar events during the period of earthquakes which have not been begun with visible eruptions from neighbouring vents.

Thus the close connection of volcanic action and of earthquake movements must be viewed as abundantly established.

There appear to be over the earth's surface at least twenty eruptions per annum, and probably quite as many considerable earthquakes. Several instances are on record of earthquakes having at once ceased on the opening up of volcanic vents near or more distant. Thus Strabo (lib. i. p. 85) relates, that the shocks of the island of Eubœa ceased as soon as a crevasse formed in the Lelantine plain, which discharged "a river of fiery mud," *i. e.* of lava. That such vents are efficient at enormous distances from the shaken country is well evidenced; it is only, in other words, that earthquake shocks are transmitted from their centres to vast distances.

There are not data to enable us now to affirm what portions of the earth's surface are now or have been at given epochs least affected by earthquakes, nor does it follow that those most remote from volcanic active centres will be those least subject to earthquakes; on the contrary, there is reason to suppose that the intervening formations, in the nature and depth of their rocks or loose materials, have much influence upon this. It is certain that

> 7th. Many portions of the earth's surface, which are not now active volcanic centres, nor very closely adjacent thereto, nor yet the centres of extinct volcanic action, are subject to frequent earthquakes.

Thus earthquake shocks have been felt even in the loosest alluvial deposits of Holland, around Middleburg and Flushing, in the great Prussian plain, and at Cutch, in the low-lying Delta of the Indus.

> 8th. Regions which are the centres now of extinct volcanic action do not appear more subject to earthquakes than other regions whose formations are altogether non-volcanic.
>
> 9th. Although regions of active volcanic action are those also of most frequent earthquake movements, yet the most violent

earthquakes do not appear to be those whose theatre of action is closest to the volcanic vents themselves: on the contrary, the most violent recorded earthquakes appear to have convulsed regions lying some degrees away from the nearest volcano in action.

10th. And in general the most violent recorded earthquakes have occurred within a certain undetermined radius round active volcanic centres, not far inland or in the heart of continents, but upon the sea-coasts, or near them.

Some doubt however hangs over this last, as some very ancient earthquakes of tremendous intensity appear to have occurred in central and northern Asia. Whether the proximity of the sea also is directly concerned or not is undetermined: it seems probable that all the great lines or centres of active volcanic action are near the sea-coast, and that *their* propinquity determines that of the earthquake.

10th *bis*. It seems to be the opinion of Humboldt, that the area of shaken country also sometimes enlarges in consequence of a previous violent earthquake.

Thus, "It is only since the destruction of Cumana in 1797, that every shock of the southern coast is felt in the mica-slate of the peninsula of Maniguarez."—(Cosmos.) The centre of disturbance also shifts its position during long-continued earthquakes. Thus, in the Calabrian earthquake it moved twice northward eight or nine leagues, and in the New Madrid earthquakes of 1811 to 1813, the progress northward in the basins of the Mississippi, the Ohio and the Arkansas was remarked.

This opinion, however, is hard to give unquestioned credence to, if we bear in mind that earthquake shocks are not communicated through tubes or vents, torn in any way or already existing under ground, but are best propagated and go furthest where the ground through which they pass is most solid, dense and homogeneous.

11th. Earthquake shocks have been felt on the ocean at vast distances from any land, and in some cases the shock has been nearly vertical and occurring in places where the depth of water was profound, and where no phænomenon on the surface of the ocean indicated any volcanic action then active beneath.

On this we may remark, however, that the most formidable volcanic activity, greater probably than we have any experience of on the dry land, may possibly exist constantly or occasionally in the bed of the deep ocean, and yet no trace of it beyond a transient earthquake shock be known to those floating over the surface. At a depth of five miles of sea water we can well imagine that lava poured out would be rapidly cooled, that steam formed would be condensed long before it reached the surface, that rocks projected upwards into so dense a resisting medium would fall back long before they reached even the sun's light, and that pumice or other light and porous products of volcanoes on land or in shallow water may have no existence under such prodigious pressure.

Great confusion prevails amongst earthquake narrators as to the use of the word *shock*. We find constant mention made of the "shock lasting several minutes;" "the shock continued nearly an hour," and other such vague expressions. The abuse of language here consists in almost every author using the words, duration of the shock, as synonymous with the whole period of motion, comprehended from any one commencement to the next great pause during the occurrence of the whole earthquake. To be able at all clearly to comprehend these narratives, it is necessary to bear in mind that the word, shock, is properly limited to the single motion due to a single impulse; that this motion occupies an extremely short time in passing a given station, and that when "the shock lasting some minutes," &c. is spoken of, it means that for some minutes there was a succession of these motions with short or variable intervals between them; *i.e.* a great number of shocks in quick succession. Hence we find that

12th. The earth-wave or shock is a motion of great velocity and occurring during a very short moment of time at any given spot.

It varies indefinitely however in force and in extent of motion; sometimes it amounts to a concussion like the blowing up of a mine at a great depth under one's feet; at other times it is a mere vibration scarcely to be felt, like that produced by a carriage running over a distant pavement; yet these are but degrees of the same thing. So again the rapidity with which the shocks succeed each other varies. Sometimes a single powerful shock is felt alone, or but two or three are felt in pretty rapid succession, and then a period of complete or of comparative tranquillity occurs, during which the shocks are so reduced in power as to require attention to perceive them; and in this case they often recur with such rapidity as to convey to the observer the idea of a vibration or continuous jar, and this often along with the roll of the greater wave-like shock.

It has been ascertained that sixteen vibrations per second, or 960 in a minute, is about the limit at which the ear distinguishes between a continuous sound or tone, and a regularly recurring noise or jar. I am not aware that any information exists as to the relative sensibility to recurrent vibrations of the ear, and of the nerves of feeling generally; but assuming them to be about the same, it follows, that when the number of shocks per second is about sixteen, nothing will be felt but a continuous vibration or jar by an earthquake observer, whilst below this number the separate vibrations or shocks can be distinguished. This view, I conceive, clears up one very puzzling circumstance hitherto looked upon as deducible from most earthquake narratives, namely, that there are two distinct sorts of shocks, the *explosive* and the *vibratory*, or three, as Humboldt makes out, by adding the *vorticose* to the number. It appears just to conclude from all narratives rightly interpreted, that there is but one order of earth-wave or shock, namely, the normal wave, and possibly small transversal vibrations transmitted along with it, and these capable of reflexion, dispersion, change of velocity, &c.; but that the rate of succession and the individual intensity of each shock vary indefinitely.

13th. The total duration of motion at a given spot varies indefinitely, or between limits which have not been ascertained.

It appears to be established that in the greatest earthquakes, the most violent shocks are very few in number, sometimes only one, usually not more than three or four, and that to these the great mischief is due, so that in a few seconds a vast country is laid waste and its cities and towns overturned, as in the great Calabrian earthquake of 1783; that these great shocks recur at intervals wholly irregular, but that in the intervals between (and preceding and following) these, there is occasionally a more or less continuous recurrence of smaller shocks; these also have their irregular periods of greater and of less repose; so that on the whole the earthquake is often, as to time, like an occasional cannonade during a continuous but irregular rattle of musketry.

The small rapid shocks are usually in close precession and succession to the great ones, and coexist with them. Thus, Don Palaccio Faxar, in his description of the earthquake at Caraccas, of March 26, 1812, says, "The weather being fine, a hollow roar like that of a cannon was heard and was followed by the shock, which lasted about 17 seconds; this was succeeded by a shock lasting 20 seconds; and after 14 seconds' interval by a third of 15 seconds' duration. Total duration 1 minute and 15 seconds with a motion from W. to E." (Quart. Journ. vol. ii. p. 402.)

The total duration of motion (*i. e.* of violent rising and transverse undulation) of the great earthquake of Caraccas (March 26, 1812), was estimated by some at 50 seconds, by others at 1 minute 12 seconds.—Humboldt, *Per. Nar.* vol. iv. p. 17.

Again, as to the New Zealand earthquake of 19th October 1848, "At five in the morning a sharp shock. The extreme force of the shock lasted rather less than a minute; there was considerable motion for $3\frac{1}{2}$ minutes, and the vibration lasted for 8 minutes from the commencement of the shock."—*West. Rev.* July 1849.

The Syrian earthquake of 1759 also lasted altogether about 8 minutes (Dr. Russell, Phil. Trans. 1760), but a continuance of very small shocks at intervals, or of very small and rapidly recurring shocks, has been often observed for long periods of time. Thus, in the Andes, the earth has quaked incessantly for days together; and on the eastern slopes of the Alps of Mont Cenis, about Fenestrella and Pignerol in 1808, in North America, at New Madrid and Little Prairie, north of Cincinnati after 1811, and at Aleppo in 1822, shocks were felt hour by hour for several months; so also at Comrie in Scotland, at longer intervals, they have long been felt; and at Zante, in the Greek Archipelago, slight shocks, at all hours, are almost continual, as long as the present inhabitants recollect.

Humboldt is of opinion that this prolonged continuance of slight shocks only occurs in districts remote from any active volcano. This however does not appear to be borne out by the observations made in New Zealand. In the earthquake there of October 1848, the shocks continued nearly five weeks before they became insensible, the district being one immediately adjacent to active volcanoes. There were during the larger portion of the time at least one thousand shocks per day. (West. Rev. July 1849.)

The recurrence of slight shocks at nearly regular intervals, and having an apparent connection with the recurrent projections from closely adjacent volcanoes, has been observed; thus, Humboldt remarked shocks on Vesuvius and on Pichincha, which were regularly periodic, and from 20 to 30 seconds before each projection of ashes and vapour.

14th. The absolute area convulsed at one earthquake epoch, varies within indeterminate limits, and is related apparently in its extent to the maximum force of the shocks.

Instances are recorded of very violent single shocks having been felt which were limited to very small areas, and here usually the direction of the shock has been nearly vertically upwards. This has been most remarkable in observations made at sea; and slight shocks, however numerous, do not appear to actuate large areas, but in the greater earthquakes the total space shaken is enormous; thus, in the great Lisbon earthquake of November 1755, an area of the earth's crust more than four times the surface of all Europe was shaken.

It was felt in the Alps, on the shores of Sweden, in the West Indies, on the lakes of Canada, in Ireland, in Thuringia and in Northern Germany; at Tœpliz (where the hot springs ran dry), and at the Lesser Antilles, the usual tide of two feet or so was one of twenty feet.

Thus, taking the area shaken at 3300 miles long and 2700 miles wide, which is equal to 7,500,000 square miles, and supposing the motion only extended to an average depth of twenty miles, there must have been 150 millions cubic miles of solid matter put in motion, a mass which conveys to the imagination some notion of the enormous power of the originating impulses. Yet let it be remembered that the whole of this mass was never in motion at once, but merely a comparatively small crest or wall of its particles put in motion, which transferred their moving force again to those beyond.

The earthquake in Syria in 1759, extended, says Sir C. Lyell, over a space of ten thousand square leagues, and for three months continuously this vast area was shaken.

Hamilton thinks the main force of the great Calabrian earthquake was comprised within a circle of 44 miles diameter, or 1520 miles area, but that its shocks were felt throughout a circle of 144 miles diameter or over an area of country of 16,286 square miles.

M. Place (Quart. Journ. vol. xvii.) says of the earthquake of 1820, the principal force was exerted in a circle of about 50 miles diameter, the centre a little N.E. of Valparaiso; persons N. of that felt the shocks from the S.W., those to the S. of it from the N.E. The earthquake was felt from Copiabo in the north to Valdivia in the south, distant 900 miles, and convulsed not less than 100,000 square miles.

Sometimes however the area shaken even by a very violent shock is extremely limited; thus the city of Coquimbo was destroyed in great part by a shock in 1820, which produced no alarm and did no mischief in any other part of the country, according to M. Place (Quart. Journ. vol. xvii.). The shock here probably in every case is a vertical one, from directly beneath, and at a small depth as regards centre of impulse.

15th. The shock or earth-wave is a true undulation of the solid crust of the earth.

"The sand in the streets of Port Royal rose like waves of a troubled sea," says the recounter of the great Jamaica earthquake of 1692.

The amount of undulations, and the rapidity with which these succeed each other, differ, but the great mass of earthquake observers concur in describing a distinct undulation of the surface of the ground. In the greatest shocks this undulation has been often visible to the eye, as in the great Jamaica earthquake, where the passage of the wave was said to be rendered visible by the opening and immediate closing in again of fissures (this however needs confirmation). It is indirectly rendered evident by the tops of trees bending over first to one side and then to the opposite, and by various other motions described as communicated to solids and liquids.

Whenever the undulation of the surface has been described as most distinct, the direction of the shock has been also described by being nearly horizontal; where, on the other hand, the shock has been felt as coming up from beneath, the undulation of the surface has escaped observation or not existed.

In the smaller shocks, whatever their direction may have been, the undulation of the surface has not been observed, that is to say, was not directly observable; but it has been inferred from observations made as to the oscillations communicated to fluids, pendulums, &c.; and there is no reason from any recorded facts for supposing that the small jarring and rapidly recurrent shocks are less undulations than the greater ones, though the former may mutually interfere and be incapable of recognition as undulations directly by the unaided senses.

16th. The undulation which constitutes the earth-wave or shock has a real motion of translation.

The shock travels over the shaken country visiting it in succession (where the direction is nearly horizontal, which is by far the most usual case); this is generally obvious, and the cases of simultaneous shock over large areas are rare.

"The motion evidently moves along a line" (*i. e.* horizontally and parallel to itself), "and at the same time moves upwards so as to produce an undulating motion. Any one who has been in the habit of swimming in the sea during a considerable swell, must have felt something of this; the wave comes on and moves the swimmer's body forwards, but not so much as it moves it upwards when under the full influence of the wave." Such is the graphic account of the describer of the New Zealand earthquake of 1848.—(West. Rev. July 1849.)

Thus also at Messina, in the great Calabrian earthquake, the shock was seen to commence at one end of the Faro, and in rapid succession to overturn the houses and buildings of the city, advancing along to the other end, "like a succession of mines rapidly sprung beneath."

So in the earthquake of Lisbon, the distances travelled by the shock were so immense that the ordinary measures of time became sufficient to point out roughly the intervals of its successive arrival at distant places; and from such observations Mitchell has constructed a table, by which, with wonderful accuracy for his time, he has calculated both the time of transit of the shock and of the great sea-wave which subsequently broke upon so many different shores.

But such calculations cannot be precise, because we do not know the exact direction of motion of the shock, which is probably never perfectly horizontal at any given spot.

17th. The direction of translation of the earth-wave or shock varies from vertically upwards, to horizontally, or nearly horizontally in any azimuth.

This is evident from all earthquake narrations; but in carefully discussing these I conceive the following propositions will be found borne out:—

a. In shocks felt after having traversed a long distance, *i. e.* at long distances from the point of impulse, the shock is usually, if not always nearly horizontal.

b. In great earthquakes within a considerable radius, and in all within a certain range of the centre of impulse, the direction of the shocks is sensibly inclined more or less upwards.

c. In some of the greatest and most destructive recorded shocks, the direction of the movement has been nearly vertically upwards, as in the great shocks of Calabria and at Riobamba in South America.

d. The direction of successive shocks often varies during the continuance of the same earthquake. Thus during the Calabrian earthquake, the point from which most of the shocks seemed to come moved northwards, by a distance of eight or ten leagues, at each of two epochs, 5th and 7th of February and 28th of March.

e. It sometimes happens that two shocks, moving in different directions, arrive at the one spot in close succession, or almost together. In this case, it has been stated that one shock is observed moving nearly horizontally, and the other nearly vertically, or very much inclined to the horizon.

f. There is no good evidence of two shocks arriving together, or nearly so, at one point, both horizontally, and from different points of the horizon. Such an occurrence has been often inferred from phænomena admitting of another solution (as we shall see when speaking of vorticose movements); but there is no *à priori* reason why, from two distant centres of impulse, horizontal shocks should not be felt at once; and this seems to have been remarked by Humboldt in Asia.

18th. The motion of translation of the earth-wave or shock is rectilinear and not curvilinear.

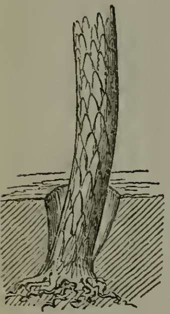
All observers concur in stating, that the general direction of motion of the shock, whether horizontal, inclined or vertical, is rectilinear. Such is the testimony of the unaided senses. It is also the conclusion to be drawn from the motions observed as given by the shock when more or less horizontal, to fluids in bowls or tubs, to pendulums, to candelabra in churches, to furniture, &c.; and from the motions directly given to men, who have felt themselves "jerked upwards," as in New Zealand (West. Review, July 1849); or to articles thrown on to others, as a barrel standing close to a mass of jars, and caused to leap up upon them, as at New Zealand; or to a ship's mast, unshipped by a shock from beneath at sea.

But from a misinterpretation of some such phænomena, authors of the highest ability have affirmed, that there are other shocks which are not rectilinear in their motion of translation, but consist in a vorticose or twisting motion of the ground, a rapid rotation in fact of any given point round some distant centre. The Italians distinguish popularly three sorts of shocks, the *orizontale*, the *oscillatorio* and the *vorticoso*. The twisting of the Calabrian obelisks has been given as the most convincing proof of this; and Humboldt (Cosmos) says, "Circular or rotatory concussions are the rarest, but they are the most dangerous of all. The twisting round of the steeple of the church at Inverness, Scotland, on the 13th of August, in the year 1816, as related in Tilloch's Magazine, vol. xlviii. p. 150, though a little known or noticed instance, is a far more remarkable one than that of the oft-recited obelisks. Twisting round of walls without throwing them down, plantations of trees which had previously stood in parallel rows deflected, the directions of the ridges of fields covered with grain altered, were observed at Riobamba, Feb. 4, 1797, and in Calabria, Feb. 5 and March 28, 1783." He adds, "With the latter phænomenon of rotation, or the transposition of fields and cultivated plots of ground, of which one has occasionally taken the place of another, there is connected a translatory motion, or mutual penetration of several strata. When taking the plan of the ruined city of Riobamba, I was shown a place where the whole furniture of one dwelling-house had been found under the ruins of another. The loose earth of the surface had run in streams like a fluid, of which it must be conceived that it was first directed downwards, then horizontally, and finally upwards."

I maintain that there is no evidence whatever, from any observed facts, for assuming any vorticose motion of the shock, or any other than a rectilinear one. The case of the Calabrian obelisks and of the church of La Merceda at Valparaiso, I believe it is admitted that I have disposed of in my paper on the Dynamics of Earthquakes, read to the Royal Irish Academy in Feb. 1846, and shown that rectilinear motion is sufficient to account for all such cases of twisting. In the cases above adduced by Humboldt, he has fallen into the greater error of mistaking the secondary effects of landslips, and THEIR twistings of the land, for those of vorticose motion, as I shall more particularly explain when treating of the secondary effects of earthquakes.

Lastly, the observer of the New Zealand earthquake of 1848 records, that certain vessels of milk had a movement of rotation given to the fluid they contained, so as to accumulate the cream in the centre. (Westminster Review, July 1849, p. 402.) He appears only to *infer* rotation from the accumulation of the cream in the centre. This accumulation might take place from oscillation in one plane only in a shallow milk vessel; but admitting at once the rotation, there is no ground for concluding vorticose motion in the shock from this. Indeed this observer himself goes much nearer it when he says, "Some of the shocks had a cross motion," &c. It is not easy to say what this exactly means; but one can readily see, that if oscillation be given to a fluid in a circular vessel, first in one plane, and then, while this continues, in another plane forming an angle with the previous one, by a subsequent shock whose direction was different, rotation will be at once communicated to the fluid; and this I believe to have been the solution of this case.

M. Place records, and the same has been done by others, that in some of the South American earthquakes a conical cavity was found worked out in the ground, around the base of the trunks of palms and large trees. This would appear at first sight like a vorticose twisting round and round of the stem, so as to work out this hollow; and such a twisting actually took place no doubt; but any inverted pendulum with an elastic stem, such as a tree is, the centre of gravity of whose head does not coincide with the vertical plane passing through the centre of elastic effort of the stem, will thus rotate from a single impulse given in one right line; and it is the tendency to do this that constitutes the vice of all inverted pendulums as seismometers.



While, however, I consider it proved that there is no evidence whatever for any other mode of propagation or translation of the earth-wave or shock than that of a right line in any given direction towards the earth's surface, or parallel to it, I am prepared to admit that upon this very principle it is *possible* for a most violent wrenching or twisting motion to be given to any spot of tolerably large size upon the surface of the earth. If, for example, from a centre of impulse at a great depth below the centre of a surface comprehended by a circle of, say a mile in radius, and in a direction to meet the extremity of any given radius, a shock be transmitted, and that by rapid and continuous change in the nature and direction of the impulse, a quick succession of such shocks be transferred round the whole circumference of this circle, so as to describe by their path a cone in the solid earth, whose apex is the centre of impulse, and whose base is the circle on the surface before defined, then as each portion of this circle is lifted in rapid succession, it is manifest that all upon and within it, and by connection of parts all for a distance, gradually disappearing around it, will be shaken by a violent wrenching motion, which will make every body upon the surface describe an irregular conical figure in space also.

But while it is thus worth while to show that such a complex movement *may* result from simple rectilinear wave motion, I have been able to find no record that gives the least presumption of any such phænomena having actually occurred, when the facts are rightly interpreted in accordance with admitted mechanical laws.

Let it be noticed however here, that there are, *à priori*, strict grounds of exact science for believing, that in all great shocks of earthquake, besides the transmission of the great wave in the normal direction from the point of original impulse, there will necessarily be transmitted one, if not two sets of transversal waves, of much less dimensions, and whose time of arrival at a given distant point from the origin, will be somewhat later than that of the normal wave; and where the normal is transmitted in a direction horizontal, or nearly so, these transversal secondary waves will be felt as a short tremor, or shaking up and down, and crosswise to the line of translation of the normal wave, and almost at the same time with it. (See Poisson, Mem. Acad. Scien., 1816, 1817, 1823.)

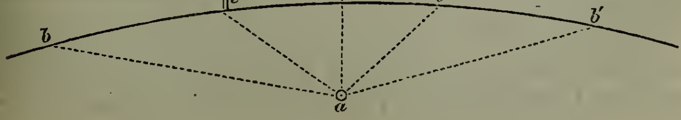
This combination of motion is clearly described by Aristotle; and when experienced by alarmed persons, unused to precise observation, may well give rise to the extraordinary and perplexing accounts of the nature of the movements which abound in earthquake narratives.

19th. The earth-wave or shock has in all cases a true wave form upon the surface of the earth, and when its direction of translation is *quam proximè* horizontally along the earth's surface, the crest of the wave advances along a given line and parallel to itself.

For this more perfect evidence is desirable. In the case where the shock comes up vertically, or nearly so, from beneath, we have evidence that the demolition of buildings, &c. has been greatest where the shock has been felt most vertical, as under the town of Oppido in the great Calabrian earthquake, and that all around this the destruction became less and less as the direction of the shock was more inclined, yet not diminishing with a very strict regularity.

Now as in such a case the mere change of direction of shock from vertical to inclined would have the directly opposite tendency, if taken alone, as the inclined shocks all around would, if equal in extent of movement, throw down buildings, &c. more effectually than a vertical one (as is evident), the change in destructive power must have been due to another cause, namely to the actual amount of motion having been greater at the centre under Oppido than in circles receding around it. Hence we conclude that the greatest amount of motion was at the centre, where the shock was vertical at Oppido, and that here the crest of the wave was raised the highest; that, in fact, at the moment of the shock the whole surface was momentarily raised into a very flattened dome-shaped wave (the height of the dome being of course extremely small as compared with its diameter), and again dropped down to its former configuration of surface as the wave passed outwards at all sides.

Whatever differences may be due in such cases to differences in terrene formation, this must never be overlooked, namely, that supposing a shock transmitted through a perfectly homogeneous mass from a deep centre of effort, and the pulses passing outwards in all directions in spherical shells, there will be a circle, upon the earth's surface, somewhere at a determinate horizontal distance from the central point vertically over the centre of effort, in which the *upsetting* or *overturning power* of a shock of given intensity will be greater than at any point within or without this circle; within, be-



cause here the direction of shock is more vertical, and therefore less calculated to overturn buildings, &c.; and without, because the power of the shock, though there more horizontal, has become weakened by distance of transmission. Thus let a be the centre of effort, b, b' the extreme limits of shock, a, c the vertical passing through the centre of effort, then some points, e, e', on the earth's surface, b, e, c, b, will lie in a circle, where the shock will be more potent in overthrowing buildings than in any other within or without.

But when the surface of observation lies much further away from the centre of impulse, so that the shock advances along the surface, apparently horizontally, then there is more distinct evidence that its advancing crest is linear. Thus in the Calabrian earthquake, observers remarked many buildings, or even whole villages, overthrown at the same moment along a distant line of country; and this demolition appeared to progress in a similar way over the country. Similar facts are recorded by Prof. Rogers of American earthquakes. (Trans. Brit. Ass. for 1843–44.)

There is every *à priori* reason to suppose, that the crest of such a wave, being the intersection at the surface of the spherical shell of elastic compression produced by the original impulse of whatever sort beneath, moves upon the earth's surface outwards, from the point immediately above its deep centre of impulse, in lines parallel to themselves, and which are large circles, or several intersecting large circles, or possibly occasionally ellipses, and with the dimensions of the wave itself continually decreasing, but with unaltered velocity of transit, save in so far as this is effected by changes in the character of the formations through which it passes. This has not yet been proved by any direct observation, and it remains still to be found what is the curve or form assumed by the crest of the nearly horizontal travelling earth-wave or shock. But to this we shall more particularly allude when referring to the desiderata of our knowledge of earthquakes. To those lines along which the shock is simultaneously felt in passing outwards from the origin, I have proposed to give the name of *coseismal lines*.

20th. The earth-wave or shock has determined dimensions in height and breadth, or in altitude and in amplitude, and these are dependent upon the force of the original impulse, the nature of the materials through which it passes, and the distance it has travelled.

Here also much evidence remains to be collected. Thus much, however, we know, that in some ratio the shock is greater, in other words, the wave is larger, as the originating impulse is more powerful. The absolute dimensions of the wave have never yet been correctly ascertained, nor is this possible without the aid of well-constructed instruments. All that we know is, that these dimensions vary from waves whose altitude and amplitude are but a small fraction of an inch, to those whose motions were such and so great, as to throw down the heaviest buildings; to detach vast landslips and whole mountain-sides of rock, or even, as affirmed of the great stroke at Riobamba, to throw the bodies of human beings many feet into the air. [This latter case, however, though recorded on the authority of Humboldt, not from his own observation, however, but from testimony given to him, seems much to need confirmation.]

From all these, however, and generally from the narratives of the effects of all great earthquakes, there is good ground for believing that the altitude and amplitude of the great wave of shock may amount to many feet in either dimension. I have in a former publication (Admiralty Manual, ‘Earthquake Phænomena'), stated that "the wave or shock, travelling at the rate of perhaps thirty miles per minute, often takes ten or twenty seconds to pass a given point; and hence that its amplitude must occasionally be many miles."

The fact of *one shock* taking ten or twenty seconds to pass a given point, however, is only derived from the narratives of great earthquakes, and from the extremely loose use by authors of the word *shock*, as confounded with *whole period of motion*, possibly consisting of many rapidly successive shocks (as already adverted to): this conclusion as to dimension of the wave requires to be taken with caution.

21st. The velocity of transit of the earth-wave or shock has never been correctly ascertained for any one locality or occasion.

A loose approximation was made by Mitchell to the speed of transit of the shock in the Lisbon earthquake, from which he deduces a mean velocity of about twenty miles a minute, or 1760 feet per second.

Humboldt states the velocity ('Cosmos') to be from five to seven geographical (German) miles per minute, which is about twenty or twenty-eight statute English miles per minute, and by others various vague and insufficiently supported statements of its velocity have been made; but the truth is, the real velocity has never yet in any one instance been even approximately ascertained. No mean velocity, such as those given by Mitchell and Humboldt, CAN be true, for if it be granted that the shock is a wave due to the elasticity of the materials through which it travels, then the velocity must vary as these alter, and be dependent on their density and moduli of elasticity.

This we do know, however, that its velocity is extreme in passing through some formations, and very great in all. "The ground," says M. Place, speaking of the great Chili earthquake, "rose and fell with inconceivable rapidity like a mine sprung beneath one's feet." Such are his words; and Dolomieu quotes almost the same as the experience of those who had felt the Calabrian shock at Messina. Thus the shock from below upwards upon a British ship at sea, eleven leagues from Manilla, as recorded by De Guignes in 1796, in his account of the Philippine Islands, was so sharp and sudden as to unship and splinter the mainmast; and the Winchelsea, a British ship from Bengal to England, was similarly struck on the 10th of February 1823, in lat. 52° N. and long. 85° 33′ E.; and Dr. Percival states, that in the earthquake felt in Lancashire in September 1777, "a passage-boat upon the Bridgewater Canal was stopped in its course as if it had struck upon a cable or other obstacle" (Ann. Reg. vol. xx. p. 79); and ships have been repeatedly strained so as to leak by such a shock at sea. The velocity of the shock in sea-water is probably about 4700 feet per second. Stones have been observed *projected* out of walls to a considerable distance by the shock, tearing themselves from the mortar-bed; and, what is more direct proof of great velocity, bodies of *great stiffness and small inertia* have been bent or twisted, as for instance, an iron cross and a rod bearing the arms of Hungary, which were both bent by an earthquake at Pesth in the last century, but my authority for which I have been unable to recover. A somewhat similar case is recorded by Professor Ferrara (Silliman's Journal for 1826). "On the 5th of March 1823," he says, "the vane on the top of the palace-gate at Catania, upon which he bent his eyes, was bowed in a direction from N.E. to S.W., and remained so bent 20° from the plumb-line until it fell." "A tall slender palm-tree he saw do the same."

Few better proofs can be found of the amazing force and velocity of the lateral shock than the overthrow of the Rhodian Colossus—a bronze figure, steadied by being filled with stone as to its lower limbs, and cramped with lead into the solid masonry of the mole. "Ante omnes autem in admiratione fuit Solis Colossus Rhodi.........septuaginta cubitorum altitudinis fuit. Hoc simulacrum post quinquagesimum sextum annum terræ motu prostratum, sed jacens quoque miraculo est.........spectantur intus magnæ molis saxa, quorum pondere stabiliverat constituens."—Plin. *Nat. Hist.* l. xxxiv. 18. It was thus overthrown, according to Eusebius, in the second year of the 139th Olympiad, or 221 years before the Christian æra.

In coherent formations, or rocky strata, there seems *à priori* ground to suppose that the velocity of the earth-wave is not less than 10,000 feet per second, but it may be much less in loose and incoherent material.

I trust in a future Report to be able to give the results of some actual admeasurements of the velocity of earth-waves in various formations, coherent and incoherent, the experiments for which are now in progress.

22nd. The direction and velocity of translation of the earth-wave or shock change occasionally in passing from the boundaries of one formation to those of another.

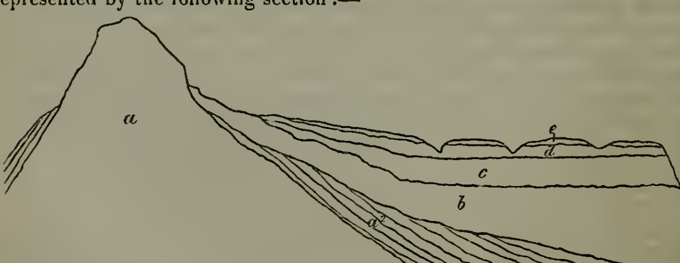
This part of the subject demands much additional careful observation.

It has been long remarked, that buildings have been variously affected in the same earthquake in different localities, which varied in the nature of their subjacent formations, or in their levels or elevations.

The change in destructive effect from the same shock has generally been most evident along the lines of boundary separating different formations. And along such junctions, shocks have been described as succeeding each other in opposite directions, but with a difference in force, with scarcely any interval in time betwixt them, and the second shock being the weaker one. Thus in the New Zealand earthquake of 1848 most of the shocks came from the North or N.N.E., but very few of the shocks appear to have come from the opposite direction, *i. e.* S.E. and S.S.E. " May these," says the narrator, " be a sort of subsidence from the southward after some upheaving from the northward?" He appears, however, to *infer* the directions from the movements of furniture only. The Lisbon shock was felt all over Spain, except in Catalonia, Aragon and Valentia; it is difficult to see why these should be excepted; but the difficulty may arise (assuming the fact) only from our ignorance of the nature of the intervening formations. (Encyc. Londinensis, *in verb.*)

Dolomieu, in his dissertation on the Great Calabrian Earthquake, says, the shocks sustained by the houses and villages situated upon the hills on the solid rock, were less felt and did less damage than those which occurred in the plain.

It is to be recollected that the general formation of Calabria, from the axis of mountains towards the sea, as described by Dolomieu, may be roughly represented by the following section :—



a. Granite.
*a*². Slates.
b. Decomposed granite.
c. Sand, or scarcely coherent sandstone.
d. Clay of great depth.
e. Alluvium; black rich earth.

There is no volcanic rock of any sort, he affirms, in any part of Calabria visited by the earthquake of 1783.

The great plain consists of a vast collection, as it were, of small table-lands, separated by deep ravines, having steep escarpments cut into the clay and sand or sandstone by the action of the rivers and torrents. These ravines are often 500 to 600 feet in depth below the table-land, which is highly cultivated above them, and the sides of these ravines are of the dense clay or scarcely coherent sandstone. All these slope up and abut against the sides of the Apennines, which form the axial line of the country.

This somewhat tedious account is necessary to make the remarks hereafter to be made as to the secondary effects of earthquakes intelligible.

The centre of effort in this earthquake was under the great plain, and probably about under where once stood the village of Oppido, but at an unknown depth.

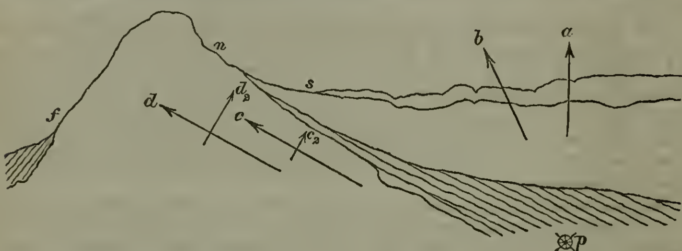
The observations made amount to no more than this; that the shocks did less mischief to structures on the granite or slate rocks of the hills than they did to those on the plain of clay, &c.; that the destructive effects of the shocks were very great along the line of junction of these, at the bases of the hills (from which some of the philosophers of that time concluded that the earthquake came from the mountains), and that along this line, shocks in close succession were felt, not only horizontally and vertically, but also in opposite directions.

Now we may *à priori* account for these facts, on the principle that the velocity of the shock or earth-wave depending on the density and modulus of elasticity of the formation through which it passes, and its velocity being greatest in those whose elasticity is highest, while its range of motion is most limited in the same; therefore the shock here was of less velocity in the plain than in the rocky hills; but had in the former a longer range of oscillation, and hence did most mischief in the plain. Along the line or plane of junction of two formations of different elasticities, &c., the earth-wave will change its course and also its velocity (like light in passing from one medium to another); and here the wave will be divided, part of it will be refracted, and part will be reflected (or total reflexion may take place if the angle of incidence be suitable at the plane of junction); and the latter portion of the wave will in such case double back upon itself, and give rise to a shock in the opposite direction to the first one. Hence along such a line of junction the destructive effects will be very great. Although the direction of transit of part of the shock is changed by thus passing from one formation to another, and its force also modified, yet it often happens that such changes do not arrest much of its main progress or effects.

Even large ranges of mountains abutting on plains of soft material are shaken through and through, and the shock is transferred beyond them. Thus the shock at Lahore in India of 1832, passed through the chain of Hindu-Cutch to the Upper Oxus, and even to Bokhara; and in South America they pass through "the littoral chains of Venezuela and the Sierra Parime." (Humboldt, 'Cosmos.')

Such differences in effects of shock due to situation have been repeatedly observed. Humboldt says that at Quito, which stands at the foot of the active volcano of Rura Pichincha, 8950 feet above the sea, and contains large and lofty buildings, with spires and domes, he has been often surprised at the severity of the shocks which he has felt, and which nevertheless but rarely rent the walls; whilst in the plains of Peru much weaker oscillations injured even lowly houses built of cane; and many other instances might be quoted. To myself the explanation of the facts which theory gives appears, I confess, here sufficient; but the observations made so far, of the facts themselves are too loose and inapposite to say that as yet theory has here been tested by the fact. This truth must never be left out of view, that there are two elements in the problem of destructibility to buildings, columns, &c. in the case of every shock, viz. 1st, its absolute range of motion and velocity; and, 2nd, the direction of its motion, which may be such as to be incapable to overthrow a given building, however great its range and velocity; generally it will probably be hereafter found that, *cæteris paribus*, shocks in a direction nearly but not quite horizontal, with large range and moderate velocity, do the most mischief to all ordinary buildings of masonry.

Another circumstance must be borne in mind also in considering the facts recorded of the Calabrian earthquake, which modified materially the difference in effect upon the plain and in the hills.



Let the above be a rude section of the country shaken, of which we have already given the general geology. Let p be assumed as the place of the centre of impulse at any depth under the great plain, below the bed of soft material, and either between it and the first hard rock, or within the masses subjacent; in this case it is evident the arrows a, b will be the directions of emergence of the shock in the plain, but the arrows c and d will be those of emergence of the same shock in the hills, and buildings situated at n and s along their slopes will be principally exposed to the waves c_2 and d_2, given off at right angles to the normal wave c and d, and therefore less shaken; while buildings at the remote side of the mountains, f, will receive the full violence of the shock. Dolomieu attributes much of the difference of destructive effect on the hills and on the plains to the " motion of the concussions in the latter being more irregular, being modified by communication through the medium of a soil yielding more or less to the force which convulsed it, and consequently transmitting it unequally. In the mountains, on the contrary, notwithstanding that the agitation of the surface was *pretty* considerable, they were less destructive. The rocks on which the towns were built communicated to them a more regular motion, *being better conductors*; the soil after each oscillation resumed its position, and the edifices preserved their fixity." " So," he continues, " a glass full of water will bear a great vibration without a drop being spilt, while it is emptied by the least irregular shake." It is very difficult to see what he precisely meant by this, but it is evident that a solid foundation of rock will favour the preservation of buildings, rather than a yielding one of clay, under shocks otherwise the same.

The great earthquake of the Caraccas (March 1812) is stated by Humboldt to have been everywhere more violent in the Cordilleras of gneiss and mica-slate, or immediately at their foot, than in the plains, and this difference was peculiarly striking in the plains of Varinas and of Casanara. In the valley of Aragua the commotions were very weak, and at Coro, situated upon the coast between towns at either side which suffered much, no shock at all was felt. These differences, says Humboldt, in the direction and propagation of the shock are probably owing to the peculiar arrangement of the stony strata. (Per. Nar. vol. iv. p. 19.)

Again, it is manifest that in estimating the demolishing effects of any shock upon buildings, very much depends upon the direction in which the shock acts upon the building with reference to its particular form and structure, and as this was not sufficiently known or attended to by former observers, fresh information remains to be collected by competent persons as to this part of our subject.

This concludes the first branch of our subject, viz. all that relates directly to the earth-wave or shock; and we now proceed to the sound-waves, which are more or less connected with it.

> 23rd. Earthquakes occur which are accompanied by various sounds, having a subterraneous origin, and which may either precede, or accompany, or succeed, the occurrence of shocks, or precede, accompany, AND succeed, the shocks of some of them; and again, earthquakes occur, even of the greatest violence, unaccompanied by any sound whatever.

The intensity of the sound is by no means in proportion to the violence of the earthquake. One of the most tremendous earthquakes on record, that of Riobamba, occurred, according to Humboldt, unaccompanied with any noise whatever.

The kind of sound has been very variously described, so variously as to induce the belief that there are different sounds on different occasions. Humboldt says ('Cosmos'), "It is either rolling, or rustling, or clanking, like chains being moved, or like near thunder, or clear and ringing as if obsidian or some other vitrified masses were struck in subterraneous cavities." One cannot but imagine that in the latter similitude the ear has borrowed its impression from the preconceived view of the author's mind.

Professor Krashenikoff, of St. Petersburg, in his description of Kamschatka, as translated by Dumaresque (1760), says, "Earthquakes happen here several times in the year. The most violent that was observed, was in the beginning of February 1759, which, during a westerly wind, lasted exactly six minutes; and before it a noise was heard and a strong wind under ground, with a hissing which went from north to south." By some the sound has been directly compared to that of quenching a mass of red-hot iron in water. There was a shock of earthquake at Coningsby in Lincolnshire, in England, on the 6th of February 1817, and also at Holderness near it, when it was heard "like waggons running away upon a road; and so forcible was the illusion, that waggoners on the roads actually drew up their teams to let the supposed runaway waggon pass them safely. While this was heard at Coningsby, they heard also at intervals of about a second of time, sharp and loud noises like the discharges of gunshots; and all gradually died away to a grumbling noise, which shifted from the east to the south." (Quart. Journal, vol. xviii.)

Hollow bellowings is a common expression with narrators. The describer of the New Zealand earthquake of 1848 (West. Rev., p. 397, for July 1849) says, "The earth is in a continual state of tremulousness, and the *dull sound* of the earthquake is continually heard. This sound has been much exaggerated; it is something like the sound of a railway train rumbling through a tunnel, I mean as heard by a person outside and near the mouth. I have also heard nearly a similar sound made by a very large steam ship chimney, except that the earthquake sound is less sonorous. It has been compared with distant thunder and with distant guns, but it is more rumbling in its nature; in short, it admits of no exact comparison. I have noted that when the shocks occur during a heavy gale, this dull rumbling sound is not perceptible: it is overcome by the nearer noise of the wind."

The allusion to the steam ship chimney here relates to a peculiar and most powerful sound, a true musical tone, which is produced occasionally when there are powerful blazing fires under the boilers, with a strong draft, and the furnace-doors are partially shut, in which case the funnel acts as a great organ pipe, to which the furnace-doors play the parts of reeds, and the draft of the fire that of bellows. The note here is about the lowest that the organ is capable of sustaining.

I have myself met a gentleman who had for a long time resided in the convulsed districts of South America, and whose occupation as a mining engineer gave him large opportunities of observation, and who compared the noise most usual to that of steam blowing off into cold water: a low irregular rumble, accompanied with still more irregular, sharp detonations, such as we may hear frequently in travelling by railway, when steam is blown from the engine boiler into the tender to heat the cold water therein; the note however being in the case of earthquakes far graver than in this instance.

In the Caraccas earthquake (April 1812), the explosions of the volcano of the island of St. Vincent were heard at the Rio Apura, like the discharge of the heaviest artillery; the distance in a straight line being 210 nautical leagues, of 20 to a degree, a distance as great as from Mount Vesuvius to Paris. (Humboldt's Per. Nar., vol. iv. p. 27.)

Yet the "Bramidos," however awful and loud, *may* be derived from a very slight original stroke or grinding together of rock surfaces, the volume of sound being multiplied by the vast surface of the earth from which at nearly the same instant it is transmitted to the air and thence to the hearer. Thus, for example, the large blocks of stone on the Breakwater of Plymouth, or on the piers of Kingstown Harbour, Ireland, are some of them so circumstanced, as to oscillate slightly like logan-stones, and to strike together under water by the motion of the waves, with, however, a force and range of motion so slight, that, when left dry at low water, and moved thus by hand, the blow is quite inaudible at a few feet distance; nevertheless, when so moved by the swell under water, the noise and crash sound quite formidable, and would at first lead the hearer to suppose the whole structure was washing away from beneath him, when thus heard on a calm clear day with a swelling sea.

There is a deep mountain tarn in Ireland, Lough Bray, one boundary of which is a steep mural precipice under water; when a stone of a few pounds weight is dropped gently from a boat at this side of the lake, the crash of its descent under water, as it falls over the face of the precipitous rocks which emerge from the dark waters, conveys a most awful impression. So also the ticking of a watch, inaudible even to the holder when held in the hand, becomes distinctly heard across a large room when laid on a table. The signals in use by a blow given to the side of a diving-bell, and clearly transmitted through some fathoms of water, are also in point.

The intensity of the sound heard at a given station will depend in some degree upon the same circumstance that will determine its time of occurrence with relation to the shock, and it will also much depend upon the sonoricity of the media (formations) through which it passes to be heard. Thus, whatever may be the original impulse producing the noise, whether fracturing of strata, falling in of rocks, grinding of masses over each other, or the repercussion produced by steam, evolved by the heat of molten matter under the earth or sea, and again suddenly condensed by being driven into contact with cold water; in any of these cases if the centre of impulse producing the noise, be distant from that producing the shock, or if the two waves, *i. e.* that of sound and of shock, arrive to the ear through different media, they will arrive at different moments. So if the impulse be extended along a line of impact passing away from the listener, he will hear a prolonged sound from a single blow, producing perhaps but a single shock. The general rule, however, *à priori*, is that the sound-wave and the earth-wave of shock travel at the same speed through the same formations, and if they arise from one common impulse will generally reach the ear and observer at the same moment; and accordingly this is by far the most usual case recorded; but innumerable perturbations and complications of this may and do take place, many of which I have remarked upon in my paper on the Dynamics of Earthquakes (Trans. R. I. Acad.), and for brevity here I pass them over as easily predicted by those versed in acoustics.

In most earthquakes perhaps, certainly in very many, a sound is heard before the great shock, and usually a vibratory jar felt also. The earthquake of Tiffliz, in Georgia, of 29th of January 1818, was so. (Quart. Journ. vol. vii.)

Count Mercate, in his account of the earthquake of 20th of December 1820, at Zante, says the sound was heard before the shock was felt. (Quart. Journ. vol. xviii.)

Hamilton says of the Calabrian earthquake, "All agreed that every shock seemed to come with a rumbling noise from the westward, beginning with the horizontal and ending with the vorticose motion." (Phil. Trans. vol. lxxii.) This does not apply to the great shock of the 5th of February, "which was from below upwards."

In the Chili earthquake of 1822–23, the explosive sound and great shocks seem to have arrived simultaneously. (Mrs. Graham, Geol. Trans. vols. i. ii. ser. 2. p. 413.)

Dolomieu says, the Calabrian shocks "were preceded by a loud subterraneous noise like thunder, which was renewed every shock," speaking not however of the great upward shocks. "This great shock," he says (5 Feb.), "occurred without the prelude of any slighter shocks, without any notice whatever, as suddenly as the blowing up of a mine." "Some however pretend that a muffled interior noise was heard almost at the same moment."

The great Lisbon earthquake "began with a noise like the rumbling of carriages, which grew gradually louder until it equalled the loudest artillery, and then the first great shock occurred." (Phil. Trans. vol. xlvi. xlix. lviii.)

In some very great earthquakes it should be remarked that a very loud noise has been heard a very considerable lapse of time after the shock. Thus at Quito and Ibarra the great noise (el gran ruido) was heard eighteen or twenty minutes after the shock. At Lima and Callao, in the great earthquake of October 1746, the subterraneous peal of thunder was heard at Truxillo fifteen minutes after the shock. These great noises could scarcely have been due to the same impulse that produced the original shock, but more probably to a subsequent one, whose shock was delivered in a different direction to the first, and hence not felt at the places where the sound was heard, which may have reached them indirectly and through the air.

The time of transit of the sound-wave will manifestly differ, whether it reach the ear through the sea or through the solid land; in the former case its rate will be about 4700 feet per second, and in air about 1140, and at the following rates for the rocks or formations, given below:—

Lias limestone	3640	feet per second.
Coal-measure sandstone	5248	,,
Oolite	5723	,,
Primary limestone	6696	,,
Carboniferous limestone	7075	,,
Hard slates	12757	,,

For granite and igneous rocks we have as yet no data, but the rate will be greater than in any of the preceding.

Another remarkable fact observed as to sound is, that in some great earthquakes sounds have continued to be produced at comparatively regular intervals for long periods after the shock, but unaccompanied with any sensible motion of the ground. Boussingault informs us, that, after the earthquake of New Granada in 1827, noises like the discharge of cannon were heard in the whole of the valley of Cauca for a long period, at nearly regular intervals of thirty seconds, and several other instances of the same sort are recorded; these, like the slight noises in Perthshire at present, I should be disposed to attribute to the periodic fracturing in cooling of newly-formed igneous rock below or near the country where they are heard.

As there are shocks of earthquakes without any sound, so there are subterraneous sounds heard often without any shocks. Thus in Caraccas, on the plains of Calabozo, and on the banks of the Apure, a branch of the Orinoco, over a region of 9200 square miles, Humboldt informs us there was heard on the 30th of April 1812 an extraordinary thundering noise without any shock, while the volcano of St. Vincent, in the Lesser Antilles, at a distance of 632 miles to N.E., was pouring out lava; this, he adds, was as if an eruption of Vesuvius was heard in the south of France. In the great eruption of Cotopaxi in 1744, subterraneous noises like those of cannon were heard in Honda on the Magdelana River. The crater of Cotopaxi is 18,000 feet above Honda, and separated from it by the colossal mountain chain of Quito, Pasto and Popayan, full of valleys and rents, and in distance 436 miles apart. The sound, he says, was certainly not propagated through the air, but through the earth, and at a great depth. During the violent earthquake of New Granada of Feb. 1835, subterraneous thunder was simultaneously heard at Popayan, Bagota, Santa Marta, and Caraccas (where it continued for seven hours without any movement of the ground); also in Hayti, Jamaica, and on the lake of Nicaragua.

The subterraneous noises of Mexico, which continued without any trace of earthquake at Guanaxuato, for more than a month from midnight of January 9, 1784, and are known there as the bramidos y truenos subterraneos, described as if thunder-clouds lay beneath the feet of the inhabitants, from which issued slow rolling sounds and short quick claps of thunder,—belong to this order also; and there can be little doubt but that Pliny formed his notion of earthquake theory from such sounds, when he says, "Neque aliud est in terra tremor, quam in nube tonitrum, nec hiatus aliud quam cum fulmen erumpit, incluso spiritu luctante et ad libertatem exire nitente."—*Plin.* lib. ii. 79.

After recording many of these singular phænomena, Humboldt ('Cosmos') sums up oddly enough in these words:—"Thus do chasms in the interior of the earth open and close, and the sonorous waves either reach us or are interrupted in their progress,"—apparently forgetting for the moment that the sounds must be conveyed more surely and more rapidly through the solid crust of the earth than through any fissure. These sounds, without shock, must be attributed to impulses given in such directions, and with such a regulated force as is sufficient to affect the air, from some quarter near the hearer, most probably by the vibration of great tabular or mural surfaces of rock, but insufficient to shake the ground under his feet; or sometimes to the impulse of shock, being principally directed by circumstances of formation in one direction, while only enough of the original impulse is enabled to pass in others towards the hearer to affect his sense of sound, without his feeling a shock. Where the resonant surfaces are so vast as in these cases, extending over a whole surface of rocky country, a very slight vibration will produce an overwhelming sound, of which some familiar illustrations have been already given.

In every case it should be borne in mind, that from a distant horizontal centre of impulse, or rather from a point vertically above it, two sets of sound-waves must arrive to the hearer from each shock capable of being heard at all, viz. one coming through the earth rapidly and directly, and the other emerging first vertically upward through the earth to the surface immediately above the centre of impulse, and transferred thence laterally through the air at the usual rate; hence any single blow delivered in the depth of the earth's crust will be heard, if heard at all, at a distance, not as a single, but as a prolonged rumbling sound, or as two distinct sounds.

We now pass on to the consideration of the effects of earthquakes upon the ocean or sea when their centre of impulse is beneath it.

> 24th. Where the centre of impulse of an earthquake is under the sea, and within a certain distance (usually a comparatively small one) of the land, the sea at about the moment that the shock is felt by an observer on the shore is seen to swell and to retire from the beach slightly, and at a certain interval of time after the shock (dependent upon the distance of the centre of impulse), a great sea-wave of translation rolls in upon the shore.

The originating impulse of earthquakes being either 1st under the sea, or 2nd on dry land, gives rise to some difference in the nature and succession of the phænomena constituting the whole *phase* of one complete shock. Thus considered, *à priori*, if the origin be inland, we may, if stationed on the beach, have the following succession of waves for one complete phase of shock:—

1. The earth-wave of shock, accompanied and perhaps preceded and followed by sound-waves through the earth.
2. The sound-waves through the air.
3. The *forced sea-wave*, as I have denominated the small wave produced on the beach at the moment that the earth-wave of shock either plunges beneath the sea, or *vice versâ*, emerges from it when the origin is under the ocean.

If the origin be under the ocean, then the succession for one complete phase of shock will be—

1. The earth-waves of shock and sound together, or nearly so.
2. The *forced sea-wave* lost upon the beach.
3. The sound-wave through the sea.
4. Sound waves (possibly) through the air.
5. The great sea-wave of translation, which rolling in upon shore with immense velocity and violence, completes the catastrophe.

Some of these may be wanting in given instances, or the order of the sound-waves may be slightly different from causes already adverted to, but the above-named order of theoretic succession represents nearly that which has been recorded of most great earthquakes.

In the records of many of these, the peculiar wave phænomenon occurring on the beach, to which I have given the name of the *forced sea-wave* (Dynamics of Earthquakes, Trans. Roy. Ir. Acad.), is mentioned.

Thus Darwin ('Journal of a Naturalist') says, "In almost every severe earthquake the neighbouring waters of the sea are said to have been greatly agitated; the disturbance seems generally, as in the case of Concepcion, to have been of two kinds: first, at the instant of the shock the water swells high up on the beach with a gentle motion, and then as quickly retires; secondly, some time afterwards the whole body of the sea retires from the coast and then returns in waves of overwhelming force." "During most great earthquakes, and especially in those on the west coast of America, it is certain that the first movement of the waters has been a retirement."

Some authors have attempted to account for this by assuming that the water retains its level, while the land is suddenly elevated or thrown up out of it and again dropped down to its former level; but Darwin well says, "surely the waters close to land, even of a steep coast, would here partake of the motion of the land." Darwin views this secession of the water as due to the first action of the great sea-wave formed or forming far out at sea. I have, on the other hand, endeavoured to show that it is due to the traversing along under the sea of the crest of the earth-wave of shock, which moves so fast as to force up a low broad unbroken ridge of water vertically over it, which is imperceptible while the earth-wave is moving under deep water, but becomes visible as it approaches the shallow shore; and the effect of the sudden coming in to land, of this earth-wave, carrying the *forced sea-wave* as it were on its back, is, that at the moment they part company upon the beach, the beach itself is for the instant elevated to the height of the earth-wave and as instantly dropped again, so that slipping from under the sea, the earth-wave gives to the sea for the moment the appearance of having retired and again advanced to its former level. (See Dynamics of Earthquakes, p. 18, 20.) In this Report upon the facts of Earthquakes, it would be out of place to do more than refer to my memoir above alluded to for more detailed speculations of the subject.

Combinations analogous to those which I suppose produce the forced sea-wave, will also account for those strange movements of distant lakes, islands, rivers, &c. recorded as occurring in connexion with distant great earthquakes.

Thus may be produced the oscillations often observed in inland lakes far removed from the convulsed centre, as in the highland lakes of Scotland, on occasion of the great Lisbon earthquake, and of the South Carolina earthquake of 1811, when the course of the Mississippi was temporarily arrested below New Madrid; or as in the Calabrian earthquake, where the course of the river Metramo was thus momentarily stopped, and then began again to run; in the latter cases the crest of the earth-wave, bearing a *forced wave of water* over it, having run up stream like a moving subaqueous or partial dam across the river.

But a far more striking phænomenon is THE GREAT SEA-WAVE which so often rolls in upon land at the conclusion of great earthquakes.

This has never been observed to take place in any earthquake whose centre of impulse was inland, however violent. Thus in the Calabrian earthquake there was no great sea-wave, for the great wave that swept the mole of Messina and drowned the Prince of Scilla and many thousands of his people, was produced by the sudden fall into deep water of an enormous mass of rocky mountain close at hand, detached by a shock. On the other hand, wherever the origin has been at sea, and especially in the great South American and in the Lisbon earthquakes, an immense rolling wave has come in shore some time after the shock has been felt, and this has travelled in from the offing: the height of these waves has never been accurately measured; that of the Lisbon earthquake, at Cadiz, was said to have been 60 feet, and about 18 feet at Funchal in Madeira.

These waves have been repeatedly observed, and from a remote antiquity, as by Thucydides; and in South America some of the shores, or even lands comparatively remote from the shore, still present traces of their violent passage in times very remote, with the same circumstances as at the present day.

They are described as rolling in one long unbroken ridge of water with a steep impending front, and not breaking until after they had rolled some distance inland, overwhelming and sweeping away everything in their rapid and impetuous course. Darwin says, "It is remarkable that while Talcahuano and Callao near Lima, both situated at the head of large shallow bays, have suffered severely during every earthquake from great waves, Valparaiso, seated close to the edge of profoundly deep water, has never been overwhelmed, though so often shaken by the severest shocks."

A good account of the great earthquake of Talcahuano and of the great sea-waves thereof, will be found in the London Geogr. Journ. vol. vi. p. 319; the inundation of the sea, the author says, was similar to that recorded by Thucydides (iii. 89).

The incoming of the great sea-wave, if in water of moderate depth and on a sloping beach, is immediately preceded by a slight recession of the water at the shore.

The first great wave is often succeeded at intervals by others growing less and less; in the Lisbon earthquake there were eighteen such waves on the shore at Tangier.

I must again refer to my 'Dynamics of Earthquakes,' (Trans. Roy. Irish Acad.) for discussion of the theory of these great sea-waves. I have endeavoured to show that they are produced by the actual disturbance of the sea-bottom, directly over the point of original impulse; that a wave is here generated like that produced by dropping a stone into a pond, and is transmitted in constantly enlarging circles, or at least in closed curved figures. This wave translates itself outward in all directions, with a speed dependent upon the depth of the water over which it is passing, and at last reaches the shore, or perhaps many distant shores, its line of motion being widely different at those points, perhaps, from that in which the shock was felt there. Its dimensions depend upon the force of the original impulse and the extent of sea-bottom simultaneously exposed to it, and the depth of the water and its force, time of breaking, &c. upon the form of the shores, depth of water close inland, and so forth. The view I have taken accounts for all the facts that have been recorded, satisfactorily to the demands of the science of tidal and fluid wave motion; but I am thus brief upon this part of the subject because there are extremely few facts as to the dimensions, direction of motion, time of arrival, or other circumstances of great sea-waves that have as yet been observed at all with accuracy.

Navigators have often remarked and been placed in peril by, a peculiar sort of inshore waves called "rollers" coming upon them suddenly and most unexpectedly: I just notice these here, as it remains as yet uncertain whether these are nodal waves produced by the junction of several smaller waves far out on the ocean surface after storms, or be in some way connected with our subject.

It seems probable that in the great ocean such vast nodal waves or rollers are frequently produced and propagated to great distances from the regions of storm where they originate, and may simulate many of the phænomena of earthquake great sea-waves.

A good account of these will be found in Captain Owen's narrative of the surveying voyages of the Leven and Barracouta, on the east coast of Africa, in 1821 and following years, vol. i. p. 288. One of the ships was nearly wrecked off Quilimani by one of these *rollers*, "which burst with fury on the decks, bearing everything before it, nearly swamping the ship, and throwing her on her beam ends."

Capt. Owen says, "The *roller* moves as a precipitous hill of water from 10 to 50 feet in height, overwhelming everything in its course. They are observed on all the shores of the Atlantic south of 30° N. lat., sometimes rising in a perfect calm, probably from past gales in distant parts; but their true cause is not yet known."—Owen, *Voyages*, p. 288.

We now pass to some remarks upon the *secondary effects* produced by the proper phænomena of earthquakes, viz. by those which we have already treated of.

Again let it be observed, that most authors have very confused notions as to the essentially different nature of earthquakes and of permanent elevations or depressions of land. An earthquake, however great, is incapable of producing any permanent elevation or depression of land whatever; its functions of elevation and depression are limited solely to the sudden rise and as immediate fall, of that limited portion of the surface through which the great wave is actually passing, momentarily. Hence, it is inexact, or rather untrue, to class earthquakes as amongst the causes of permanent elevation or depression of the land. But as earthquakes are unquestionably closely connected with volcanic forces, and with those nearly identical forces upon which permanent elevations and depressions without eruption depend, so there are few earthquakes of any magnitude that are not *accompanied* by permanent elevations and depressions of the land. These and the earthquake have a common origin, and are to be regarded as each the symptom of the other; but while the elevation or depression of the land may cause the earthquake, or rather be the immediately forerunning event to the earthquake, the earthquake can never cause the permanent elevation or depression of the land. I dwell upon this because it is important to our future progress in earthquake knowledge, that we should form a clear conception of what it is, and how far its limits extend, and clearly distinguish these from both the permanent elevations and depressions, often of vast extent, that accompany their occurrence due to the great elevatory forces of the interior of our planet, and also from all those secondary, or doubly secondary phænomena, which change the face of the country shaken, but which are only contingent and accidental effects of the earthquake, and which vary with the local conditions of the country in which they occur. The confusion resulting from having lost sight wholly of this distinction is well seen in the extracts I have given from Hooke's discourses of earthquakes in a preceding part of this Report.

In reading over the narratives of earthquakes at large, we are constantly told of mountains being removed from one place to another, of valleys being obliterated, of the course of rivers being altered, springs and fountains spouting up, fissures and chasms of vast depth and extent being formed, with smoke and flames issuing from them, lakes formed where none were before, and so forth; all of which are said in a word to have been produced by the earthquake.

For example:—"Terræ quoque motus profundunt sorbentque aquas; sicut circa Pheneum Arcadiæ quinquies accidisse constat. Sic et in Coryco monte amnis erupit posteaque cœptus est coli. Illa mutatio mira ubi causa nulla evidens apparet; sicut in Magnesia calidas factas frigidas: salis non mutatur sapore. Et in Caria, ubi Neptuni templum est, amnis qui fuerat ante dulcis mutatus in salem est. . . . . .

"Rhodiorum fons in Chersoneso nono anno purgamenta egerit. Mutantur et colores aquarum, sicut Babylone lacus æstate rubras habet diebus XI. Et Borysthenes æstatis temporibus cæruleus fertur, quanquam omnium aquarum tenuissimus: ideoque innatans Hypani. In quo et illud mirabile, Austris flantibus superiorem Hypanim fieri."—Plin. *Nat. Hist.*, lib. xxxi. 30.

Again:—"Sæpe motu terrarum itinera fluminum turbantur et ruina interscindit aquas, quæ retentæ novos exitus quærunt, et aliquo impetu faciunt aut ipsius quassatione terræ aliunde alio transferuntur. . . . . quod accidisse ait Theophrastus in Coryco monte, in quo post terrarum tremorem nova vis fontium emersit."—Senec. *Nat. Quæst.*, l. iii. 11.

It will be necessary to go somewhat into detail, not only to record some of these facts, but to show how they depend upon the accidental features of country as affected by earthquake motion.

These phænomena were presented in great variety and upon a peculiarly grand scale in the great Calabrian earthquake; and we are chiefly indebted to Sir William Hamilton, in his account of them addressed to the Royal Society of London, for first pointing out the true relation that they bore to the earthquake itself.

The general geological features of the Calabrian plain which have been already given, the great tabular surface of clay, sand, and soft decomposed rock, divided by deep ravines and river courses, must be now borne in mind by the reader. The following then are some of the principal secondary phænomena that were there observed, and which are more or less common to all earthquakes on land.

1st. Vast landslips take place.

The shock transferred horizontally through the plain (either as the normal or wave at right angles to this), on reaching the steep escarpments of the valleys, shook down enormous masses of these; the deep clay banks above split into fissures, extending to a great depth, and the weight of superincumbent stuff often forced out the base of the escarpment into the middle of the ravine or valley, so that the upper part of the bank fell nearly perpendicularly (in some cases 500 feet), and was deposited with all its trees and crops growing upon it at the bottom. In other cases, where the escarpments were less steep, landslips in the more ordinary form took place, and the upper lands slid down over a rough inclined plane of previous ruin, sometimes leaving nought but a chaos of upturned trees and crops, with mud and soil and sand at the bottom; and at others, where the thickness of the mass detached was greater, or the surface over which it was launched was more uniform, landing the whole upper surface safely down some hundred feet, with even houses, standing firm on the surface and all the crops uninjured: people descended unhurt on such singular and mighty vehicles; but often the surface over which the slip was launched was not a plane, but curved or twisted, so as to change the direction of motion of the moving mass; and here the mass was sometimes broken to pieces, but at others its surface was only twisted and distorted in rude copy of that over which it had passed and on which it came to rest. Thus, straight rows of elm-trees and of olives became curved, furrows straight from the plough became twisted and contorted.

Childrey, 'Britannia Baconica,' gives several instances taken from Camden's pages, of the effects of great landslips in altering the form and directions of furrows, hedge-rows, landmarks, &c., and one especially of twenty-six acres of land which so moved in Herefordshire in 1571. (Hooke, Dis. of Earthquakes, p. 309.) Another great English landslip is recorded in Baker's 'Chronicle,' p. 419, near Kynaston, in Herefordshire. These are the phænomena that Humboldt appears to have mistaken for evidences of vorticose shocks.

Again, these landslips often took place from both sides of a straight valley at the same moment, or from two projecting headlands at opposite sides, one higher up the valley than the other (when in the latter case the shock passed the valley, not directly across, but diagonally), and then the vast debris meeting in the bottom of the ravine, by the mutual reaction of one side against the other, forced up a huge mass in the middle, often to half the height nearly of the table-land at each side, *i. e.* to 250 feet above the bottom of the valley, and thus a so-called hill or mountain was formed in the valley. Thus, near Terra Nuova, when the whole town of Mollochi di Sotto was detached with many vineyards, and descended into the ravine on whose bank it before stood, "some water-mills that were on the river having been jammed between two such masses as these were lifted up by them in the middle of the valley, and are now seen on an elevated situation many feet above the level of the river." (Hamilton, Calabrian Earthquake, Phil. Trans., vol. lxxii.) And in the plains also wonderful effects of the propagation of pressure to vast distances by superincumbent weight are recorded by Hamilton, Spallanzani and Dolomieu. Thus, says the latter, "In the deep valleys of the rivers Tricucio, Birbo and Boscanio, sand and clay ran like lava, or as if carried away by water; in other places considerable portions of mountains ran for several miles in their way to the valleys, without falling to pieces or even changing their shape." Hamilton says that the loose underlying sand formation, when wetted by the damming up of the rivers, &c., became a sort of fluid rollers, upon which the most enormous masses were moved; in one place, two portions of land, each about a mile long by half as much wide, with all their cultivation, were thus moved bodily down a valley, a distance of more than a mile; and a mountain mass of sand and clay was moved (or at least was affirmed to have been moved) nearly four miles.

2nd. New lakes and river-courses are formed, and old ones obliterated.

In many places the valleys dammed across by these landslips arrested the course of the rivers passing through them, and formed lakes of great size and profound depth. In some places these dams were so stanch from their clayey material, that the lakes, brimful, overflowed the table-land at the sides of the valley, and traced out new river-courses on the plain, which again fell into the old course further down, the new course rapidly eroding the soft alluvial plain, and preparing to form in course of time a new ravine as deep as that that had been dammed so suddenly. These lakes became putrid from the masses of vegetable and animal matter brought into them, and had to be drained at once by public measures to avoid pestilence. But in many cases the dams, unable to resist the pressure of the rising waters above them, burst at length, and the debacle totally altered the form and features of the valley for miles below, overspreading everything with a rounded and fluent mass of mud and slime, imbedding vast numbers of trees and vegetables, animals and men, to become the organic remains of the post-tertiaries to our own remote posterity, should the present œconomy of the earth last long enough.

How well does Hamilton remark of all this!—"What causes a confusion in all accounts of this (and he might have added of all earthquakes) is the not having sufficiently explained the nature and peculiarities of the soil and situation. They tell you that a town has been thrown a mile from where it stood, but without mentioning one word of a ravine on the edge of which it stood (as at Terra Nuova); that woods and corn-fields have been removed in the same manner, when, in truth, it is but upon a large scale what we see every day upon a smaller, where the sides of hollow ways, having been undermined by rain-waters, are detached into the bottom by their own weight;" or he might have added, shaken down by anything causing vibration, as the passage of a waggon or cart.

3rd. New valleys are also hollowed out.

Not only are they hollowed out gradually, as above, by the erosion of newly-formed river-courses, but they are made at once by the slipping of vast masses of soil. Thus, along the bases of the hills, says Dolomieu, referring to those above the great plain along the whole length of the chain, the soil, which adhered to the granite of the bases of the mountains, Caulone, Esope Sagra, and Aspramonte, slid over the solid nucleus, the inclination of which is steep, and descended, leaving almost uninterruptedly from St. George to beyond Christina, a distance along the base of the hills of nearly ten miles, a chasm between the solid granite nucleus and the sandy soil of the plain. Thus a valley was formed of great length in a moment, parallel to the mountain sides and below them; but this cut off the drainage of the mountain slopes from the plain, and hence in after years the ridge of debris forming one side of the valley would become cut through and traversed by streams and torrents descending to the plain, dividing it into isolated masses of hills, and soon destroying all recognition of its singular mode of formation.

A ravine was measured by Grimaldi, which was formed nearly a mile long, 105 feet wide, and 30 feet deep, in the district of Plaisano; another was produced at Cerzulle, three quarters of a mile long, 150 feet wide, and 100 feet deep; and one at La Fortuna about a quarter of a mile long, 30 feet wide, and 225 feet deep; and various others are mentioned which it is needless to detail here.

Without enlarging the list, "what is said will be sufficient to demonstrate," says Dolomieu, "that the singular circumstances attendant on the earthquake were the natural effects of a violent shock acting on a sandy ground previously opened and torn by torrents." "The general effect was, that of heaping together the soil, establishing slopes where there were before steep escarpments, disconnecting masses that had bases insufficient for their bulk, or only supported by lateral adherence, and of filling interior cavities."

These landslips, had they occurred in land reposing upon hard rock, such as clayslate or granite, and more especially if the deep beds of clay already contained pebbles and boulders of hard stone, would in their progress have furrowed and grooved the subjacent rocks, and left thereon permanent traces of their movements, that would have presented to a geologist, thousands of years after, all the aspects of ice or glacier action, and where no other grounds to suspect earthquake origin existed, would probably have been set down to these causes.

Let us remark here the vast difference in effects that these secondary phænomena will give rise to in a low flat country of soft or incoherent material in its formations, and in one of hard, rigid and highly elastic rock, severed by valleys and rising into mountain crests. How different would be the effects in our own country of a great earthquake that should shake at once the London basin, and all the eastern side and south of England, and the Isle of Wight with the mountains of North Wales, and the Grampians! What vast landslips should we record of the southern cliffs of the Isle of Wight, how utterly would its surface and geology be changed in a day; what changes on the face of the cultivated banks of the Severn, the Thames, the Medway, to say nothing of our brick-built cities! Yet how different from the effects in Snowdonia and the Grampians! Here, or in any such regions of hard and elastic rocks, vast crevasses may be rent into the mountain masses, huge blocks may be detached at the instant of the shock (as at Messina, and as seen from the deck of the Volage, when a mighty cliff detached itself, and plunging at once into deep water disappeared), and may fall into the valleys, and be shattered into fragments, vast, angular and without order, such as we see filling the commencement of the pass of the Splüchen above Chiavenna. But the mountain torrents still find their way through or over such debris, the dams formed are not water-tight, their materials are too huge, and interlock too much, to be moved by debacle any great distances; the whole iron frame of the country is too elastic and too strong to be very greatly altered, and the earthquake leaves but comparatively slight traces of its destroying hand, save upon the frail habitations of man, and upon his best and largest works.

4th. Fissures of various sizes are formed in the earth's crust.

These are directly formed in the solid rock. Sir Hans Sloane describes the rocks in the Blue Mountains of Jamaica as greatly shattered in 1687 by the earthquake.

Mrs. Graham describes the granite rock of the beach at the promontory of Quintero in Chili, after the earthquake of 1822, as found rent by sharp recent clefts, very distinguishable from the older ones, *but running in the same direction*. Many of these could be traced to a distance of a mile and a half across the neighbouring promontory, where in some instances the earth parted, and left the base of the hill exposed. (Geol. Trans., vol. i. 2nd series, p. 415.)

Hot springs frequently are found issuing from such clefts in igneous rock. Thus Humboldt tells us that the "Aguas calientes de las Trincheras burst out from a granite rock, split into regular fragments" (Cosmos); and many other similar instances may be found recorded.

Most, if not all writers on this subject have tacitly assumed however that all fissures formed during earthquakes are due to the direct action of the shock; and some accounts, such as that of the great Jamaica earthquake of 1692, affirmed "that the ground undulated like a rolling sea, and that fissures opened as the undulations passed, two or three hundred of which might be seen open at once; that these opened and closed again rapidly, as the undulation rose and fell; and that people were even caught and bitten in two by these Titanic mouths; that some, thus swallowed up, were again cast out." Assuming this narrative veracious, I for some time believed the opening and closing of fissures by the direct passage of the earth-wave to be possible in incoherent formations. On further consideration of the subject, however, I am disposed to reject this solitary and truly wonderful Jamaica narrative, for the present at least; and judging from a connected view of all the other narratives of earthquakes, to state my strong impression, that fissures, at least those of any magnitude, any that are more than rents or cracks in rock or masonry or other coherent bodies, are never produced during earthquakes directly by the transit of the shock, but are solely the result of secondary actions, and due either—

1. To landslips, more or less complete.
2. To subsidences in the ground, due to subterranean action at great depths, of the true elevatory and depressory character, and producing lateral slips by resolution of motion.
3. To elevations of the ground produced in the same way, and producing similar effects.
4. To the action of water, either forced up from beneath, or removing

land or softening it by lateral action, as in newly-formed rivers and lakes, and thus producing slips.

The following are some of my reasons for this conclusion. The limits of elasticity of none of the soft materials of which plains of clay, &c. consist, and indeed of none of the incoherent formations that we are acquainted with, are sufficiently great to permit of the formation of fissures of the width and size upon record. The fissures that have been carefully observed have always been found parallel to great escarpments or to lands that have slipped; thus all the observers of the Calabrian earthquake concur in stating that the great fissures were parallel to the faces of the steep banks of the ravines or valleys, and more numerous the nearer they approached them; and those curious radiating fissures at Jerocarne, which are alluded to and figured by Sir Charles Lyell, are probably no exception, but most likely arose from the ground having fallen away in all directions around, which it would do if circumstanced as an insulated mass, surrounded wholly or on three sides by the usual deep gorges with precipitous sides, of the Calabrian plain. I cannot possibly attribute such " fissures, like cracks in a broken pane of glass," to either subsidence or elevation of such a mass of deep soil, which was nevertheless imperceptible to the eye. Bishop Pocock, in the third book of his 'Travels in Thrace and Greece,' states that " cracks were formed of six inches wide, by an earthquake which occurred at Zeitoun, but that it is situated on the south side or slope of a hill at the foot of a high mountain." So that here there was a supported and an unsupported side to the embankment upon which the town stood. The fissures formed by the first shock of Calabria were greatly widened by subsequent ones; now this would not be the effect of direct action of the earth-wave, an elastic wave; but it would be just that of slow separation, due to subsiding away, from any cause which left gravitation to act; in fact, in a common slip upon a railway embankment may be seen in little, if the soil be favourable, all the phænomena recorded of earthquake fissures in incoherent material. The first great fissures are produced when the slip occurs; others are formed in its mass after it has assumed a state of comparative repose. These, like the crevasses of a glacier, are all transverse to its general line of motion, just as they are in the earthquake transverse to the line of motion of the shock, *or may be*; but every new vibration, every passing train widens the mouths of these fissures, until the whole mass of the slip has gained its position of final repose.

Again, some of the widest of these chasms, recorded as fissures, are of comparatively very small depth in relation to their width. Thus one at San Fili, the government Calabrian Commissioner, Grimaldi, found was half a mile long, two and a half feet in breadth at the surface, and only twenty-five feet deep; and the deepest fissure I can find any record of, does not exceed five hundred feet, and this does not seem to have been measured, and is probably exaggerated. Now as the wave of elastic compression and extension, or shock, traversed miles in depth of the earth's crust at these places, it is inconceivable that these fissures, if produced by its passage, should not correspond with it in depth, or at least much more nearly than these comparatively shallow dimensions represent.

Moreover, many of these fissures were crescent-shaped, as that near Soriano, and figured in the government account of the earthquake, and the curve was extremely short and excentric; it is difficult to conceive such a form of fissure produced by *fracture*, *i. e.* by a shock of any sort or degree of violence; while the excessively irregular figure of some others of the fissures, as that at Polistena (also figured), makes them quite as irresoluble on the fracture theory; and indeed the gradual closing in of all these fissures by the slow subsidence of the soil, as noticed by the Government Commission of the Neapolitan Academy, and also by Sir W. Hamilton, is alone sufficient to show that the elasticity of the formation in which they occurred was far too small to permit their formation by *fracture*.

Of the extent of these subsidences at the time of the earthquake various instances have been recorded, such as the cylindrical lining of the well of the convent at Terra Nuova, being left projecting out of the soil like a tower, nine feet above the surface, and the lateral motion of the mass of soil in which it was dug, also evidenced by the whole well having got an inclined position from the vertical. That these subsidences produced often hollows of a cup form is not wonderful.

In conclusion, I conceive the formation of all fissures, where effecting soft or incoherent formations, to be due to varieties of subsidence due to one form or another of landslips or land removal by water; that they may be and are produced in hard rock, and in buildings, &c., directly by the transit of the shock, I also conceive there is no doubt of, and this leads me next to a singular fact often recorded, viz.

5th. At the moment the fissures open in the earth, fire and smoke (apparently) have been observed to issue.

On this matter much new and exact observation would be most desirable. The narratives generally affirm that flame made its appearance momentarily at the mouth of the fissure, and that a volume of smoke, or some say dust, was vomited forth and hung for some time above the mouth.

That some earthquakes have been observed from points situated so directly above and so close to the focus of volcanic action beneath, as to make all this quite possible in its most literal sense, cannot be doubted, when we call to mind the Volage's chain cable having been made incandescent, and even partly melted, as she swung by it at anchor on the coast of South America; or Captain Tilland's narrative in the Philosophical Transactions for 1811, of the submarine volcano, which he actually saw rise, upon the surface of the sea, near the island of St. Michael's, when laying to, within a few cables' length of the spot. Within four hours after the first visible commotion, the summit of the crater was 20 feet high above water, and 400 or 500 diameter; and before he left, it had raised itself to 80 yards in height. Volumes of steam were discharged, the sea was violently agitated as though boiling, lightning-flashes were emitted from the clouds above, and water-spouts formed in various places around showed the violent disturbance of electric equilibrium. A continuous noise like musketry mingled with discharges of cannon stunned the ear, and the shocks of earthquake felt were sufficient to shake down part of a cliff upon which some observers stood. Many such records show how closely men may sometimes approach the "Atri janua Ditis," and live in the midst, as it were, of the smoke and fervent heat of the unknown regions within; but when the occurrence of flame and smoke is recorded of fissures in non-volcanic lands, and in territories suffering from earthquakes whose origin is manifestly far away, as in the Lisbon one for example, some different solution must be sought for.

The following suggests itself as at least worthy of future investigation.

The experiments of Becquerel and other electricians have shown, that when fracture in a solid takes place, a powerful electrical disturbance is the consequence. This will be great in proportion as the surface and mass fractured are themselves large. When therefore a fracture of a mile long and of many feet in depth is formed, whether by subsidation and slipping, or in any other way in soft material, and yet far more when one of those greater fractures in hard rock takes place, such as have been described when a whole mountain mass has been rent in two at a blow, the disturbance of electric equilibrium may be expected to exceed that of a heavy thunder-storm, and may, *quoad* this particular part of earthquake phænomena, realize the dreams of the older philosophers, who thought an earthquake was a thunder-storm under ground.

In this then I believe is to be found the usual source of the flame or flash, seen suddenly to appear and vanish at the mouth of the rent, and the identification of the supposed flame or flash with electricity in an analogous case, was made by Sir W. Hamilton, who alludes to its violent disturbance always in the cloud above the crater of a volcano in eruption, though he suggests no origin for such disturbance in the case of fissures opening, from which he had satisfied himself by subsequent examination, that there was no evidence of flame or volcanic exhalations of any sort having issued from their mouths. And as to the smoke which has even been *described* by some authors *as dust*, I fancy it has been none other in almost all cases, if not in all.

Eye-witnesses of the falling of towns and cities by earthquakes describe the volume of dust that rises from the shattered buildings as instantly obscuring the scene of desolation from view; thus Catania in 1692 disappeared in an instant in a cloud of dust; and any one who has seen a large blast fired in a quarry of hard rock will remember the dust that rises through and over the falling and shattered masses. There can thus be no doubt that the rending of a mountain mass of rock must be attended with similar volumes of dust, and that the same must attend the fracture of earthy materials, such as the clay of the plains of Calabria or that of Lisbon, which from the dryness and heat of both climates must be for many feet down in a friable condition. But there is another cause yet for the cloud of steam, or dust and steam, even when the walls of the fissure may be perfectly wet. By the sudden yawning of one of these vast chasms a void space is instantly opened, into which of course the surrounding atmosphere immediately rushes; a partial vacuum is thus for the moment produced just above the mouth of the crevasse; the great mass of air suddenly rarified or expanded has its capacity for heat increased, its sensible temperature is therefore as suddenly lowered, and a deposition of vapour, in form of a great cloud, takes place above the crevasse, which is greater or less in proportion as the dew-point is higher or lower at the time and place.

Conversely, if the crevasse be wet and suddenly opened to a considerable depth, the temperature of its sides and of the water dripping from them being that due to the depth, and therefore above that of the air at the surface, will instantly fill it with steam or vapour; this will rise and mingle with the air above in the form of steam clouds at every breath of wind that enters the chasm and disturbs its repose, will be slowly driven out by the descent of the colder surrounding air of the surface, or may be wholly expelled if the crevasse close again, as it often does; and these sources of change of state in the air and vaporization of water, or condensation thereof, are themselves powerful causes of electrical disturbance.

Whether therefore the formation through which a fissure or crevasse is cloven during an earthquake be hard or soft, dry or wet, on the mountain or in the plains, whether it be due directly to the earth-wave or shock, or secondarily to subsidence or slipping, I conceive that there is abundant evidence of sufficient meteorological and electrical disturbance to account for the clouds of steam or supposed smoke, flashes or sudden flame, and dust, so often mentioned as occurring far from volcanic active centres.

Smoke in the true and ordinary sense of this word, it may be remarked in passing, has never been observed by any competent authority actually issuing from even any volcanic vent. The gaseous products are almost wholly vapour of water, holding some acids, as SO^2 and $Cl+H$, in suspension, and various solids in the form of fine dust or sand; but bodies in that peculiar intermediate state between mechanical suspension as sand, and chemical diffusion as vapour, such as constitutes common carbonaceous smoke, and whose peculiar characteristic it is to deposit a portion of its mass as a soot or sublimate of some sort, and the remainder to float for days or weeks permanently in the air in an uncondensed and unprecipitable state, do not seem ever to issue from the interior of true volcanic vents; so that there is *à priori* the strongest improbability of smoke having ever been really seen to issue from an earthquake fissure.

Compare the younger Pliny's account of the eruption in which his uncle perished, where his graphic account of the thick darkness that in a moment overwhelmed them in absolute obscurity and almost choked them, cannot be mistaken for smoke, though he calls it "a thick cloud."

6th. Water often spouts from fissures, wells and springs, or bursts up in unexpected spots from the ground at the moment of the shock; and it also is rolled out of the mouth of great fissures or crevasses, often in a turbid and discoloured state, and sometimes for a considerable time after the earthquake.

These phænomena, various and singular as they are, and apparently perplexing, as we find them recorded in earthquake narratives, all arrange themselves into order and become of simple solution when once we have got the key to the whole, which is this:—They are all cases of reaction, in which the inertia of masses of water lodged in the earth is brought into play by the passage of the shock, through its solid parts, or they are secondary effects of those cases of slippage and subsidence, which, as we have already shown, are themselves secondary effects of the shock.

This will be most rapidly made clear by a few instances.

In the Jamaica earthquakes of 1687 and 1692, Sir Hans Sloane informs us, that "of all wells, from one fathom in depth to six or seven, the water flew out at the top with a vehement motion," *i. e.* at the moment of the shock, which was here a vertical one. The sudden motion of the transmitted wave (the earth-wave) is, to use Humboldt's words ('Cosmos'), "increased at the surface in conformity with the general laws of mechanics, according to which, when motion is communicated in elastic bodies, the outermost free-lying stratum tends to detach itself from the others;" like the last of a train of billiard balls, which alone flies off, when the first is struck; or to illustrate the fact (not this principle), if one hold a cylindrical tumbler (the well) nearly full of water, and suddenly raise it up a couple of feet vertically and there suddenly arrest it, the water will in great part leap out of the glass.

The water of springs and natural wells is contained in the earth chiefly in two forms; it either lies in plates or bands of fluid in the crevices of rock formations, which are mostly either vertical or inclined to the horizon, and are usually of great length and depth and of constricted width, or the water lies in beds of sand and gravel, lying stretched out over large spaces, following sometimes the contour of the surface, and at others cropping out here and there, where the springs themselves bubble out to the surface; or again they lie in the vacuities which have been washed out between the beds of stratified rocks; or lastly, in the caverns and sinuous apertures that have been dissolved out of calcareous rocks, as about Trieste and in Ireland, &c.

Now, in the first case, when the earth-wave passes nearly horizontally through a formation of rock, bearing vertical or inclined plates of water, each of these will be powerfully compressed at the moment of the passage of the shock, for it is by the compression of the water only, that the shock itself can be transmitted onwards to the rock beyond the plate of water; and as fluids transmit in all directions equally, any pressure communicated to them in one, so the water in each such plate will press upwards at the moment of the shock, and will fly upwards, because in this direction resistance is least; and as the pressure, though but for an instant, and even often acting through a very restricted range, yet acts on an enormous surface, namely, on perhaps the whole length and depth of the water plate, each amounting to miles, at the same instant, its total effect, *quoad* the volume of water displaced, is very great, for it is as though a piston of very short stroke but of enormous surface suddenly expelled water through a comparatively very small aperture. But furthermore, the spouting fluid has acquired a certain velocity which it does not lose at once, and has further an elasticity of its own, as well as the solid walls that compress it; hence it spouts higher, and a rather greater volume of water is expelled from the fissure than is due merely to the diminution of its capacity by the passage of the shock and to the speed with which this is effected. Shocks in a vertical direction will affect such plates of water, if vertical or nearly so, precisely in the way already described for open cylindrical wells.

Proceeding now to the case in which the water lies in a water-bearing bed or in several, of sand or gravel, overlaid by rock or by clay, or any other impervious material: if the direction of shock be horizontal, as before, the water in such reservoirs will, by its inertia, oscillate first in the opposite direction to that of the shock, and then again in the same direction as the shock moves; and if in either of these directions its bed crop out to the surface, or it can find vent to it any other way, it may suddenly emerge in vast volumes, and from the principle just alluded to, of quaquaverse pressure, such pourings out of water are not confined narrowly, to the line of direction of shock or its opposite, but may occur at any angle to it, laterally, or upwards, or downwards.

But let us now take the case in which a country underlaid by such a water-bearing bed or beds is exposed to a vertical shock or one nearly vertical. Here, on the principles already stated, every open well, or natural fissure or duct communicating with the water-bed through the impervious strata above, will spout out volumes of water; and if there be considerable tracts over which there are no such artificial or natural vents, or whose combined areas are insufficient to ease off the sudden pressure of the water upwards, it may break through the retentive stratum above, whether of rock or of clay, &c., at the points of least resistance, and there spout out where water had never been known before, and may bear with it volumes of gravel, sand, and mud from the beds below.

Now these were just the conditions of the great Calabrian plain, and of that of Lisbon and of Port Royal. In Calabria, as we have seen, a vast deposit of clay forms the surface of the plain, described by Dolomieu as consisting of "a stratum of vegetable earth, argillaceous, black or reddish, very strong, very tenacious, and from four to five feet in thickness," beneath which lie various formations resulting from the decomposition of granite, and under this "a white micaceous clay rather unctuous and ductile;" and beneath all, the deep bed of sand and scarcely coherent sandstone, which he informs us is a water-bearing stratum in most places, and to which he says "the roots of the trees penetrate to a great depth in search of the humidity always contained in the lower part of the sand."

Sir William Hamilton also describes the "swampy plain of Rosarno" as "consisting of clay," and the higher grounds reposing on the sides of the hills above it (*i.e.* the under stratum), as "of a gritty sand."

Now the great shocks of Calabria, three in number, were almost vertical, and spoutings of water, both out of wells and crevices, and out of spots where before there was neither aperture nor water, were numerous. And these conditions give me the means of explaining the very curious circumstance of the *sand-cones* and circular hollows found in the plain of Rosarno, as described by the Calabrian Government Commissioners, and also figured and described by Sir C. Lyell (Principles of Geol. p. 465). They say, "in the plain of Rosarno were found numerous circular hollows, for the most part about the size of a coach-wheel, but some larger and some smaller; these, like wells, were full of water within a foot or so of the surface; on digging down, they were found to be funnel-shaped cavities in the clay, full of sand, and some which were dry presented nothing but an inverted cone of sand in the clay-bed, concave in the centre on the top, and rippled off at the edges. Eye-witnesses had seen these hollows suddenly formed by the spouting up of water mixed with sand during the earthquake, which was thrown to a considerable height. In the great Chilian earthquake of 1820, M. Place describes similar sand-cones as formed on the banks of the river Concon, fifteen miles from Valparaiso, each, he says, with a crater-like cone in the inside; and he describes the plain there as clay with a substrate of sand." (Quart. Journ. vol. xvii.) And Mrs. Graham, in her description of the Chilian earthquake of 1822–23, says, "In all the small valleys the earth of the gardens was rent and quantities of water and sand forced up through the cracks to the surface. In the alluvial valley of Veña a la Mar, the whole plain was covered with cones of earth about four feet high, occasioned by the water and sand which had been forced up through funnel-shaped hollows beneath them, the whole surface being thus reduced to the consistence of a quicksand." (Geol. Trans. vol. i. 2nd ser. p. 414.) Similar sand-cones, under similar conditions, are recorded in the 'Philosophical Magazine,' vol. ix. p. 72, as having been formed during an earthquake at the Cape of Good Hope on December 5, 1809.

Thus this phænomenon is seen not to be an isolated or peculiar one, but common to several earthquake-shaken countries resting on water-bearing sand beds. Sir W. Hamilton "thinks the phænomenon easily explained;" thus, "the impulse having come from the bottom upwards, the surface of the plain suddenly rising, the rivers which are not deep would naturally disappear, and the plain returning with violence to its former level, the rivers must naturally have returned and overflowed, at the same time that the sudden depression of the boggy grounds would as naturally force out the water that lay hid under their surface." He says he observed that "where this sort of phænomenon had been exhibited the ground was always low and rushy." His explanation is scarcely intelligible, and certainly not true. I am not aware that any other writer has attempted a rigid explanation of the spoutings of water and sand, &c. in earthquakes, but from what has preceded, I think I may lay claim to having, for the first time, done so; and we may now see that the Calabrian sand-cones were simply the ajutages through which in the lowest places, and where the swampy clay offered the least resistance; the bed of water, reposing in the great sand-formation beneath, broke forth at the moments of vertical shock, sweeping up more or less of the sand, along with the water.

The form of these cones, as figured in section by Sir Charles Lyell, is precisely that which an issuing fluid would shape to itself. We may readily see now what prodigious secondary effects in dislocation and removal of masses, such violent and sudden hydrostatic pressure brought to bear under a large surface of undulating country and of soft material may produce, and what shattering and breaking up into blocks, it may be capable of when acting thus from beneath upon countries consisting of stratified rock in a tolerably level and unbroken bed.

Lastly, from crevices formed during an earthquake, water has been observed to pour out in vast volumes for a considerable time after their formation, at which moment they were dry, and within them the water slowly welled up at first.

This case is not to be confounded with the obvious one of a crevasse having some underground communication with a higher source, then opened to it as a mouthpiece, for the first time, and the explanation of which is obvious; but the following seems to be its solution: the crevasse, if formed in deep clay, as in Calabria, or Lisbon, or Jamaica, and rent down to a water-bearing stratum at its lowest parts, will have the base of its sheer sides soon sapped by the water at bottom and by that dripping from its walls, and there beginning to slip, its sides will gradually bulge inwards, first at the bottom, and this rising upwards slowly, the whole chasm will close in and gradually eject and press out over its lips, the whole of the water it had before contained, though this may have at first stood fathoms below the surface; and as the whole capacity of some of the crevasses we have seen is immense, and the closing up gradual, a large stream may thus be kept running from many of them for a long period.

This gradual closing in (and no doubt from this combination of circumstances) was remarked in many of the great crevasses of the Calabrian plain; the enormous force with which the sides closed together, was remarked with wonder by those who dug out the remains of buried habitations, and found beams and masonry, furniture, utensils, and bodies of men and animals pressed together and compacted into one undistinguishable mass; but such a result will excite no wonder in those who have had an opportunity of carefully examining the phænomena and effects of any great landslip, or even slip of heavy embankment, or of the effects of the "creep and crush" in our deep coal pits.

To such a subsidence taking place suddenly, no doubt, was due the dreadful disappearance of the quay of Lisbon in 1755, which became suddenly perched as it were upon the very brink of a vast crevasse, formed under the waters of the Tagus, which rapidly softening the blue clay upon which Mr. Sharp (Geol. Proceed. 1838, p. 36) informs us the lower part of the city is founded, soon caused the banks of the rent to yield under its overwater load; and to a similar cause must the sinking of the quay or mole at Messina be ascribed, which was built upon a submarine bank of clay and sand, sloping rapidly off into profoundly deep water close by. The water poured out from these spouting apertures or from large crevasses, has often been described as impregnated with foreign matters; these have chiefly been described as "hepatic, or sulphureous, or bituminous," and have mostly been recorded as coming from the overflow of crevasses some time after the earthquake; of course water-bearing beds full of soluble mineral matter will eject more or less of these with their fluid contents; but when such crevasses affect deep incoherent formations containing sulphurets and organic matter together, rapid decompositions will give rise to all those horrible evolutions of foul water and poisonous gases that have been recorded so often, and especially in the Jamaica earthquake of 1692.

If, for example, such wet crevasses as we have been considering were to be opened in the deep carboniferous formations of Westphalia or Lower Saxony, or even in some of our own coal-measures, with what rapidity the coal and pyrites of the latter, and the strange mixture of pyrites and vegetable matter, which Mitscherlich describes as used in Saxony for making copperas from, and which only needs to be dug out and moistened to heat and decompose spontaneously, would give rise to black and fœtid water, saturated with sulphates, evolving torrents of sulphuretted hydrogen and carbonic acid, and mingled with red mud of oxides of iron! Again, should such crevasses affect a country such as that of the salt formation of Cheshire, and stretch also into some of the neighbouring coal-measures, what rapid and important chemical action would result from all the above, brought into contact with saturated solutions of common salt, with gypsum, with limestone and with clays dissolving into a paste at the first approach of moisture! What enormous evolutions also of carburetted hydrogen from the coal-beds would the sudden relief of superincumbent pressure give vent to!

Before proceeding to another branch of our subject, it will be proper here just to notice some few *unusual and ill-ascertained phænomena*, of which the facts are doubtful or incomplete, and for which no perfect explanation can be offered:—

1st. Fixed objects are said in a few instances to have been inverted; thus by the "sbalzo" or leap into the air, fixed pavement is affirmed by the Neapolitan academicians to have been thrown upwards, and found afterwards in its own place, but with the stones inverted.

2nd. In the midst of the universal ruin and prostration of a whole town or village, a single edifice, and often one not remarkable for strength or for humility, has stood quite uninjured. Thus at Radicina, in Calabria, a single small square house of one story remained standing, all the rest of the town being prostrated; similar events have been noticed in South America, where—

3rd. "Nodal points or lines" occur, namely, isolated portions of country which constantly escape the shocks which convulse the parts all round them; these portions are so well known, Humboldt says, that the Peruvians say "the rocks form a bridge," "rocas que hacen puente" in Spanish.

4th. Shocks felt in deep mines, as in the Marienberg in the Saxon Erzgebirge, not felt at all at the surface, and *è converso*, shocks at the surface not felt at all underground, as at Fahlun and Presberg in Nov. 1823.

It would be easy to speculate on the probable causes of such phænomena, on the known grounds of reflexion, refraction and total reflexion of elastic waves at certain angles, but the facts themselves are too doubtful to make it at all useful. But we must leave this subject, fertile as it is in consequences, having, as I trust, developed the nature of secondary effects from the earth-wave itself, sufficiently for the purposes of this Report, and proceed to a few remarks upon the secondary consequences of the great sea-wave.

7th. The great sea-wave, when it comes ashore, after the earthquake, produces all the effects on land of a great debacle.

It does not appear needful to enlarge much upon this, as everything remains to be done in the way of accurate collection of facts, of which we have very few, principally due to Mr. Darwin, to W. Parish (see Geol. Soc.) and to Virlet (Bull. de la Soc. Géol. de France, tom. iii. p. 103), who has recorded some curious facts as to the effects of a great sea-wave that broke over Santorin and the island of Sikino, seven leagues off, after the earthquake of September 1650.

Mr. Parish, in a memoir presented to the Geological Society of London in November 1835, has collected all the historical notices of great sea-waves which he was then able to discover accompanying earthquakes on the coasts of Chili and Peru; in 1590 the sea rose over Chili for some leagues, leaving ships, dry far inland; in 1605 such a great wave swept away the greater part of Areca. In 1687 Callao was similarly overwhelmed, and ships were carried from the roadstead a league into the country; the shock of this earthquake was felt by Wafer 150 leagues from the coast out at sea. He also saw at Santa, three miles from Callao, three rotting ships in a valley, where they had been carried inland over a low intervening hill in 1687. In 1746, Callao was again swept away, and vast heaps of gravel and sand left where it stood; large ships were thrown far inland by this wave. Lima has suffered in the same way with Cavallos, Guanape, Chançay and Guara, and the valleys of Barranea, Sape and Patevilca; when Penco was thus destroyed in 1751, a similar but less wave reached Juan Fernandez and overwhelmed houses along the shore.

Mr. Alison (Pro. Geol. Trans. 1835) describes similar waves of the earthquake of Chili of Feb. 1835; but it is unfortunate that no precise levellings or sections were made of the land swept over in any of these cases, or observations of gravel boulders, &c. moved, which would have been highly important.

This dearth of facts is the more to be regretted, because our theoretical knowledge is more perfect of liquid waves than of those of elasticity, as respects this our subject, and observations of the effects in denudation, transport, and effects on vegetable and animal life, producible by their agency, would have important bearing upon other extensive regions of geology; and when facts and observations as to the precise effects produced by great sea-waves shall hereafter have been collected, it may provide geologists with a new instrument of investigation by which to trace upon many distant shores the evidences of ancient earthquakes, whose origin was below the ocean, and of which no other record remains capable of being investigated.

In examining the many meagre notices of earthquakes which I have had occasion to collate in reference to this Report, I have been struck in several instances with notices of sudden recessions, and as sudden subsequent unusually high risings of the sea, in various places where there was no account of any accompanying earthquake, either there or anywhere else at the same time.

Thus of the Thames at London in 1762, and in 1767, of the sea at Malaga and at Leghorn in 1774, and in several other tidal rivers and estuaries, small but unusual fluctuations have been recorded; some of these occurred in great earthquake years, but there are no recorded shocks occurring anywhere at the times given for these fluctuations.

I am disposed therefore not to attribute such to earthquake shocks at all, but to the sudden slippage under water of large masses of submarine banks of sand or mud. Where such banks accumulate in large masses, often, indeed generally, with one steep side next deep water, the progress of accumulation upon the top is equilibrated either by slow and gradual subsidation of the whole mass, or by sudden and partial slippages into deep water of portions of the mass; such a circumstance occurring upon a very moderate scale would be sufficient in a narrow estuary to produce a wave of translation liable to be mistaken for the effect of an earthquake.

In thus examining in a more detailed and systematic manner than has previously been done, the secondary effects of earthquakes, I have been able, I trust, to cause the geologist to bear constantly in mind the broad distinction between the great cosmical forces of permanent elevation and depression, one of the secondary efforts of whose paroxysmal efforts is the production of earthquakes, and the secondary effects of earthquakes themselves. The distinction is most important to the clear conception of both. While to the former is reserved the mighty task of perpetually yet so gradually (as on the whole not to interfere with the inhabitants of our globe) lifting fresh land from beneath the ocean bed and dropping others below its waves, so that the earth, which has already "waxed old as doth a garment," shall be renewed again and "changed like a vesture," and its fitness for the support of man and animals ever preserved, the geologist becomes convinced that as the volcano is itself but insignificant in all its results taken by themselves, when compared with the totality of the mighty cosmical law of which it is at once the superficial index, and also the most striking evidence; so the earthquake, great and formidable as are its effects upon man and upon his works, is as nothing when compared with the enormous forces in whose throes it receives its birth.

Yet as in our estimations of the united effects through time of the sum of all the forces acting upon the surface of our planet, we are compelled to take large account of those directly due to volcanic foci, active and extinct, so the secondary phænomena that we have pointed out and endeavoured to systematize, produced by the transient yet violent passage of the earthquake shock, cannot be neglected in their continual and reiterated effects upon our earth, but should form an element in all our attempts to estimate and explain the past revolutions of its surface.

So far as our knowledge yet enables us to judge, the *office* of earthquakes, the general resultant geological effect of their secondary action, *is not one of elevation but of depression*, of degradation and of leveling, although always probably preceded and accompanied by the proper forces of elevation to whose action it is referable.

Perhaps the most remarkable of the secondary effects of earthquakes to a remotely future supposable posterity, may be the prodigious mass of organic remains of men and animals mingled with many of the least perishable of man's works which will be found entombed in our existing, most recent, or at least most superficial formations, when these may have become depressed, heated, consolidated and altered in texture and re-elevated to become the pleistocenes of future races of mankind. To estimate the numbers of men only that have perished by earthquakes within the period of history is impossible; thousands have repeatedly been in a few moments entombed; 60,000 persons at Lisbon, 10,000 at Morocco, 40,000 in Calabria, 50,000 in Syria, and probably 120,000 in the same country in the time of Tiberius and Justin Elder, A.D. 19 and 526.

In the reign of Justinian earthquakes shook the whole Roman world repeatedly; Constantinople shook for forty days; an impulsive and vibratory motion was felt, enormous chasms opened, huge and heavy bodies were discharged into the air, and the sea advanced and retreated beyond its usual margins; a part of Libanus was thrown into the sea and became a mole for Botrys in Phœnicia. At Antioch 250,000 persons perished, May 20, A.D. 526, and at Berytus all the students of civil law there collected, July, A.D. 551. (See Procopius, Agathias, and Theophanes, as quoted by Gibbon.) On the 21st of July 365, in the second year of Valentinian, a fearful earthquake shook almost the whole Roman world; and the retreat and subsequent rolling in of the great sea-wave of the Mediterranean is described as tremendous, sweeping two miles inland and carrying ships over the tops of houses, so that at Alexandria 50,000 persons lost their lives. (See Libanius, Sozomen, Cedrenus and others, as quoted by Gibbon.) In the earthquake of Messina, 1692, 74,000 persons are said to have perished, some accounts raising the number to 100,000 (Practical Reflections on Earthquakes, by John Shower, 1750, 8vo). In the year 602 a second earthquake of the country about Antioch slew 60,000 persons. (Cluverius.)

In the earthquake in the province of Quito of 1797, notwithstanding the thinness of the population, 40,000 natives are stated by Humboldt to have been buried in crevasses or under the ruins of buildings, or drowned in lakes or ponds temporarily formed. (Per. Nar. vol. ii. p. 237.)

Such are the numbers to be met with in narratives; and if we suppose but one great earthquake in three years over the whole earth, and that this involves the entombment of only 10,000 human beings, and that such has been the economy of our system for the last 4000 years, we shall have a number representing above 13,000,000 of men thus suddenly swallowed up, with countless bodies of animals of every lower class. Sir Charles Lyell then with good reason suggests that even in our own time we may yet find the remains of men and of their habitations and implements thus buried deep and embalmed as it were, by earthquakes that occurred in the days of Moses and the Ptolemies.

But such entombments extend also largely to the vegetable world; masses of vegetable matter, entangled beds of broken branches and leaves and single trees, with all their peculiar insect and other inhabitants, have with man thus found a common grave. And at the present moment, short as has been the lapse of time, were excavations carefully made in the deep clay and sand of the Calabrian plain, there can be no doubt but that evidence would be discovered throwing much light upon the nature of those obscure processes by which vegetable and animal forms are mineralized and preserved, and that we should already find many of the trunks of trees buried in the sand, converted into brown coal or lignite, and thus presenting us with an explanation of that puzzling fact we so often see in the sandstones of our own coal-measures, as for instance at Gascube Quarry near Glasgow, where in the midst of perfectly clear undiscoloured beds of sandstone of enormous thickness, we now and then find a trunk of a single tree buried and fossilized, but bearing no traceable relation, either to the direction of the beds in which it is found, or to any conceivable process of their deposition. How readily may such facts be brought to bear upon the heterogeneous gathering together of multitudes of forms, such as those of the fish of Monte Bolca, at one spot! and again, reflectively, the occurrence of such remains thus thrown together, may become the indices to us, of the loci of ancient earthquakes, as erratic blocks are assumed to be of ancient ice. Nor must the effects of great sea-waves, in entombing beneath the sea in littoral deposits, the various natural and artificial productions of the land, be overlooked. "The great sea wave," says Caldcleugh, "in its reflux brings everything to sea along with it." (Phil. Trans. 1836, p. 21.)

Large however as thus would seem to be the gross effects of earthquake action upon the organic world, they are probably insignificant in comparison with the aggregate entombment even of man alone, due to the every-day progress of accidental events; and shipwrecks alone will probably disclose a vaster mortality, "when the sea shall give up her dead," than all that have perished by earthquake and its effects.

It only remains now for me to make a few observations upon the assumed and presumable CONNECTIONS BETWEEN ASTRONOMICAL AND METEOROLOGICAL PHÆNOMENA AND EARTHQUAKES; and first as to the former. Numerical discussions of earthquake catalogues have been made by several persons, as the Abbé Scina of Palermo, Von Hoff, Merian, Hoffman, Cotte and Perrey, for the purpose of discovering their frequency at any one particular period of the year, or during the lapse of some centuries; but always upon insufficient bases, generally confined to some one district, so that none of their conclusions can be received as certain or even very probable yet.

The three last of these authors come to the conclusion, that in the tropics at least, the periods of the equinox are rich in earthquakes.

"Ideoque post austros noxii præcipue terræ motus. Noctu Auster, interdiu Aquilo vehementior. . . . . Et autumno ac vere terræ crebrius moventur, sicut fiunt fulmina. . . . . Item noctu sæpius quam interdiu; maxime autem motus existunt matutini vespertinique: sed propinqua luce crebri, interdiu autem circa meridiem. Fiunt et Solis Lunæque defectu, quoniam tempestates tunc sopiuntur. Præcipue vero cum sequitur imbrem æstus, imbresve æstum."—Plin. *Hist. Nat.*, l. ii. 49, 84. These, like many of the opinions of the ancient learned upon similar questions, are but the *ex cathedrâ* repetition of popular and ill-founded notions.

Perrey's large catalogue (Mem. Cour. des Scav. Etran. de Belgique, tom. xix.) applies to central Europe or to the basins of the Rhine, Rhone, Danube, and to France and Belgium, only, and extends from the 9th to the 19th centuries.

As we purpose returning to this part of our subject upon an extended base, it is scarcely worth while here to extract his tables, merely stating that his general result shows a preponderance of earthquakes in the winter, *i. e.* in the months of January, February and March, for the whole, which seems again confirmed by the discussion alone, of the results of the 17th, 18th and 19th centuries, during which the accounts are more to be relied on than at remoter dates.

Perrey's Table, in which he seeks to deduce the resultant direction of all shocks in a given region, and the *intensity* of the shock, on the assumption that this intensity is proportional to the number or reiteration of shocks at a given point from one direction, is probably of doubtful value, from the more than uncertain hypothesis on which it rests.

On the Influence of the Season of the Year and Time of Day upon Earthquakes.—Von Hoff remarks, "As we have already noticed, a dependence of the earthquake upon the time of year has occasionally been supposed to have been remarked. In the equinoctial regions earthquakes have been thought to occur more frequently during the rainy season than at any other time of year. Sometimes they have been supposed to be peculiar rather to the period of the equinoxes, sometimes to the winter months; with many other similar opinions. Indeed examples are not wanting which appear to favour such views; as for instance, the observation, that of all the earthquakes which occurred in Sicily from 1792 to 1831 (Hoffman in Poggendorff's Annalen, b. xxiv. s. 52), double as many took place in March as in any of the other months. Still however an almost more profound obscurity hangs over the question, whether earthquakes and volcanic eruptions are more peculiar to one time of the year or day than to another, than over the consideration of the other connections of these phænomena with those of the atmosphere. This subject has also been treated of in an elaborate manner in another paper on the causes of earthquakes (Mémoire couronnée, Utrecht, 1820–28, and enlarged, Leipzig, 1827–28) by Herr Kries, who has brought forward instances in no small number, which prove that earthquakes, even of the most violent kind, have occurred at every time of day and in every season of the year."

"I myself (says Von Hoff) have in another place (Poggendorff's Annalen, b. xxxiv. (110) s. 99 f.) made the experiment of collecting and arranging all the instances of earthquakes which occurred during ten years, in order to find whether any one time of the day or year presented a greater number of these phænomena than the others. The result of these researches however seems to be, that with respect to this relation of earthquakes also, no law can be laid down. We must consider it as an established fact, that both earthquakes and volcanic eruptions *may* occur at any time of the day or year, since experience has shown this with respect to almost every time. The only question which remains on the subject is, whether we can ascribe to any one or other season or time, a greater tendency to produce or favour the production of such phænomena. A mere collection of facts, even though embracing a long period of time, would of itself hardly supply an answer to this question ; since, in order to draw tolerably accurate conclusions from such a collection, many other circumstances would have to be taken into consideration. We ought not to content ourselves with collecting and arranging a mere successive list of these phænomena, but on the contrary, we should compare with one another only the most considerable, and those which occurred in the same climate, with other precautions of a similar nature. That, however, the motions (Bewegungen) which are always going on, in the inner portions of the earth, are at certain times much more energetic and more continuous than at others, numerous examples testify. There have been periods of many years in which these motions remained continuously violent and widely spread, as from 1666 to 1694, 1749 to 1768, &c.; and others in which for several years they seldom manifested themselves. On the whole, however, if it be probable that the idea of any influence exercised by the atmosphere upon the volcanic process should be considered as overturned, the opinion of the influence of the time of day or year upon the occurrence of earthquakes, &c. will retain but little probability." (Von Hoff, Gesch. Verand. Erdober, Th. iv.)

Seneca, 'Quæst. Nat.' vi. c. 1 ; a writer in the 'Annal. de Chim.' vol. xlii. p. 416 ; Cotte, in 'Journ. de Phys.' for 1807, p. 161 ; and Hoffman, 'Hinterlassene Werke,' Theil 11, have discussed the question as to whether earthquakes are more frequent at one season than at another. Kant, in his 'Phys. Geogr.,' vol. ii. p. 199, thinks they occur chiefly in the spring and fall of the year. Smith, in his 'Memoirs of Sicily,' p. 6, states, that thirteen earthquakes occurred there betwixt the 10th of January and the 28th of the succeeding March. Shaw, in his 'Travels in Barbary,' p. 152, comes to the conclusion that they are most frequent there at the end of summer and in autumn. All these however are observations on far too narrow a basis.

Hoffman, 'Hinterlassene Werke,' xi. 357, and Kries, 'Ursachen des Erdbeben,' p. 8, have given a large catalogue of earthquakes during the Christian epoch. Arago, in 'Annal. de Chim.' xlii. p. 409, has discussed the earthquakes of forty years at Palermo. Pouqueville has given a list of sixty-three earthquakes at Joannina from 1807 to 1825. Cotte gives a list of 338 earthquakes in the 'Journ. de Phys.' for 1807. Hoffman has compared these with the forty years' earthquakes of Palermo (Poggen. Annal. xxiv. 52, and xxxiv. 104), and Von Hoff (whose great 'Chronik der Erdbeben' has never yet been fully discussed) has compared all these with those for the years 1821 to 1830, occurring in the northern hemisphere. And Merian ('Uber die in Basil Wahrgenommenen Erdbeben') has given a list of those occurring at Basil. All these the author of the able article Erdbeben (L. F. Kämtz) in the 'Allgemeine Encyklopadie der Wissenschaften und Künste,' von Ersch und Gruber, Theil 36, has arranged in the following table by months, adding the sum in another column :—

Month.	Cotte.	Hoffman.	Merian.	VonHoff.	Total.
January	24	4	12	31	71
February....	25	5	14	36	80
March	23	13	6	31	73
April	26	4	5	29	64
May........	16	1	11	33	61
June	28	6	3	33	70
July........	42	4	7	20	73
August	34	6	8	31	79
September ...	25	6	12	24	67
October	38	2	11	41	92
November ...	22	4	14	26	66
December ...	35	2	15	34	86

And discussing these by the common seasons, the result shows, in—

Winter 237
Spring 198
Summer 222
Autumn 225

These approach so near to equality, that upon this limited induction there is no ground for supposing one season more plentiful in earthquakes than another.

This branch of the subject however cannot be deemed complete until from the largest possible catalogue of earthquakes, extending over the whole historical period, a similar deduction with suitable precautions shall have been made.

A singular work, now very scarce, was published in 1729, by a professor at Lima, entitled 'L'Horloge Astronomique des Tremblemens de Terre,' in which he undertakes, from a discussion of 108 earthquakes occurring in his own time, to predict that of their recurrence; the period of tide and state of the moon are the immediately influencing causes, according to him, as well as the moon's place in the zodiac; the critical time is confined to six hours and some minutes of the horary circle, within which the moon is on the meridian of the place; and he says he has confirmed his results by 143 observations in 1729, and 70 in the subsequent year, which proved correct.

Mr. Edmonds, in the Cornwall Polytechnic Journal, has also endeavoured to connect the occurrence of earthquakes with the period of the moon; he shows that several of the most disastrous have occurred the day after the first quarter.

I mention these latter authors, not as attaching any importance to their conclusions, but as showing to those who will consult the originals, the wrong direction in which such researches have been made.

As respects observed direct connexion with meteorological phænomena, the following comprises most of the information to be had:—

1st. *The Weather generally.*

Although in numberless accounts we read of peculiar appearances before the earthquake, as red lurid skies, red and blue suns, &c., and during the continuance of earthquakes, of strange appearances and threatening portents in the sky, yet, judging from all the narratives of the best observers, there seems to be no ground for supposing that there is any connexion between the state of weather or appearance of air and sky immediately before earthquakes.

In the south of Europe a general belief prevailed that calms, oppressive heats and a misty atmosphere, were the usual preludes of earthquake. Hamilton says he found it a general observation in Calabria, " that before a shock the clouds seemed to be fixed and motionless, and that immediately after a heavy shower of rain (during the earthquake), a shock quickly followed." And in the Philippine Islands, De Guignes informs us that " a calm, the sky gray and cloudy, the atmosphere heated and heavy, occasional gusts of wind, and at intervals gentle showers of rain, are the prognostics by which earthquakes are anticipated there." After recording a number of vague opinions held by the South Americans, as to the weather prognostics of earthquakes, Humboldt says, " These are however very uncertain, and when the whole of the meteorological variations at the times when the globe has been most agitated are called to mind, it is found that violent shocks take place equally in dry and in wet weather, when the coolest winds blow, or during a dead and suffocating calm." (Humboldt, Per. Nar. vol. ii. p. 223.) Again, the veteran philosopher says that " even in Italy this belief is dying away ;" and expresses his own conviction, strengthened by that of those who have lived long in the great shaken countries of South America, that earthquakes are independent of the weather or appearance of the heavens immediately before the shock. He says he has felt earthquakes when the air was clear and a fresh east wind blowing, and also when there was rain and thunder-storms ; and this has been very recently confirmed by the continuous observations made at New Zealand during the earthquake of 1848, which began in a gale of wind.

On the relation of earthquakes and volcanic eruptions generally to the condition and phænomena of the atmosphere, Von Hoff remarks ; " The question, whether any relation or causal connexion exists between the various movements of the earth and those occurring in the atmosphere, has for a long time remained unanswered. The intimate connexion which subsists between the earth and its atmosphere, and which manifests itself in so many phænomena, has always induced people to presuppose a similar connexion between earthquakes and volcanic eruptions, and the condition of the atmosphere. They believed that the influence of the latter might be engaged in the volcanic process, and that, on the other hand, earthquakes and volcanic eruptions might produce some effect on the condition of the atmosphere. The proof of the first of these opinions, it has been thought, was to be found in great falls of the barometer, in remarkable calms, in dry mists, and unusual gray or red colouring of the sky, and especially in great heat.

" Amongst the effects supposed to be produced by the earthquake on the atmosphere, were reckoned tempestuous winds, thunder-storms, meteors, coldness of the air, severe winters, heavy rain, miasmata, producing diseases and affecting vegetation. A very remarkable instance of the latter is quoted, namely, that in Peru ; after the earthquake of 1687, wheat and barley would not thrive at all, though formerly the country was remarkably favourable for them.

" There can be no doubt that an answer to the question, whether a connexion exists between these phænomena of fixed terrestrial bodies and the condition of the atmosphere, is of the greatest importance to a thorough knowledge of both. But from the multifarious conditions which have here to be taken into consideration, from their complication, and from the difficulty of distinguishing, amongst many recurring at the same time, between the indifferent and those which are really important, an extended series of successive observations, made with the utmost care and circumspection, will be required, in order even to approach the object which is aimed at in researches of this sort." (Von Hoff, Gesch. Erdober, Th. iv.)

2nd. *Effects on Animals.*

Hamilton says that during shocks, horses and oxen extended their legs widely to avoid being thrown down (an evidence of the velocity of the shock), and that hogs, oxen, horses and mules, as also geese, appeared to be painfully aware of the approach of the earthquake of Calabria; and the neighing of a horse, the braying of an ass, or the cackling of a goose, even when he was making his survey, drove the people out of their temporary sheds in expectation of a shock.

All birds appear sensible of its approach, but geese, swine, and dogs more remarkably than any other animals; the geese quit the waters before the earthquake and will not return to it. Can it be that with their heads immersed they are able to hear the first distant mutterings, while these are yet inaudible to those who hear through the air, and not as in their case through a liquid?

Von Hoff notices "a presentiment (vorgefühl) which it was thought had been remarked in particular species of animals shortly before an earthquake. Even men have sometimes, a short time before such occurrences, felt a tendency to headache, giddiness (vertigo), and an inclination to vomit.

"It has been remarked, that at such times domestic animals showed a decided uneasiness, dogs howled mournfully, horses neighed in an unusual manner, and poultry flew restlessly about. These latter phænomena might easily be produced by mephitic vapours, which often ascend to the surface of the earth before the breaking forth of the earthquake."

The Cirricelli, (possibly our Sand-eels,) a little deep-water fish, like our white bait, which usually lies buried in the sand, Hamilton says, "came up to the surface with many others, and were caught in multitudes;" this might arise either from actual heat of the sea-bottom and water close to it, or from its being fouled by the commotion or by exhalations into it; or they may have been startled by the vibrations, as trout are when one stamps violently on a river bank.

There is unquestionable evidence of earthquake shocks (and not of great intensity) producing nausea and vomiting in men and women; sometimes, as in a school at Philadelphia, numbers were so affected, at the same instant awakened from sleep by the shock; whether this arise from sudden dread produced by the unusual and fearful visitation, or be analogous to sea sickness, has not yet been determined.

These few particulars constitute nearly all that has been observed of this point of our subject.

3rd. *The Barometer.*

There does not seem to be any ground for supposing that the period of occurrence of earthquakes is marked by any very remarkable rise or fall of the barometer just before, nor certainly by any remarkable fluctuations during the continuance; on this the New Zealand observations are peculiarly important, as during the days from the 7th to the 15th of October, before the earthquake, the range of the barometer was from 28·97 to 29·25; and during the remainder of that month, whilst there were continual shocks, its limits were from 28·37 to 29·58; and during the immediate subsequent period of eighteen days in November, free from shocks, the barometer remained steadily at about 29½ inches; the limits of variation being from 29·53 to 29·10 only.

Humboldt (Relat. Hist.) has shown that the horary oscillations are not affected during or after earthquakes in South America; and Erman has shown the same for Asia.

At the moment of the two first shocks of the earthquake of Cumana of 1799, Humboldt says there was a strong electrical explosion at a great height, and a few minutes before a violent blast of wind, succeeded by rain. The barometer was a little lower than usual, but the progress of the horary oscillations was in no way interrupted; the shock took place just at the moment the height was a minimum. (Per. Nar. vol. iii. p. 319.)

Cotte thinks the barometer rises during earthquakes. Hoffman (Poggen. Annal. xxiv. 56) says it fell at Palermo.

It has been asserted, that at Cape Francois a water barometer fell $2\frac{1}{2}$ inches at the moment of the shock of 1770; this would correspond to about one-fifth of an inch of mercury. No general or well-authenticated facts of falls or rises of the barometer on such occasions could be traced however by Humboldt, and if there be any, he is disposed to attribute them to evolutions of gaseous matter from the shaken earth. (Per. Nar. vol. ii. p. 225.)

It however must be borne in mind, that at the moment of shock, if it have any vertical element of motion whatever, some motion must be produced by mere inertia, in the mercurial column, and this fact does not seem hitherto to have met any attention from earthquake observers.

Von Hoff says, " Since the condition of the barometer on the occurrence of an earthquake has been attentively observed, before, during, and after the shock, both at the place where the earthquake took place and at others more or less distant from it, these observations seem to convince us that no fixed rule with respect to the behaviour of the barometer during an earthquake has been up to the present time proved." There are examples of falls of the barometer before or during earthquakes, and there are also instances of the mercurial column rising during similar occurrences, as well as others where perfect absence of motion prevailed during very violent shocks. The same observations have been made with respect to volcanic eruptions. We are indebted to Herr Kries (De Nexu inter Terræ Motus, &c. et Statum Atmosphæræ,' Mém. cour. Leipsic, 1832) for an excellent memoir on these barometrical changes, supported by numerous examples. As the view given by him does not come down further than the year 1826, we add here some examples of more modern date, and also some not in Kries's collection.

Examples of Falls of the Barometer preceding Earthquakes.

1720, 1st July.—A great fall of the barometer *two days before* the earthquake in the Erzgebirge.

1744, 3rd June.—*Before* the earthquake in North America, the mercury fell 3 lines.

1826, 23rd June.—*At the moment* of the shock at Trient, there was a fall of 1 inch 3 lines.

1828, 29th January.—Immediately *after* the shock in the Swabian Alps, the barometer fell 3 lines.

1828, 8th February.—At the same place, on *the day following* the earthquake, there was a fall of 3 lines.

1828, 23rd February.—*Before* the earthquake in Belgium, there was a very great fall of the barometer through the whole of Germany and even further. It rose however *during* the shock.

1828, 22nd March.—*On the repeated shock*, a much more widely-spread low position of the mercury.

1830, 9th September.—On the occasion of the earthquake in the Swabian

Alps, the barometer fell 6 lines *immediately after* the shock, and in the evening of the same day rose again 4 lines.

1834, 15th October.—*During* the earthquake in Hungary the barometer fell 1 inch, as also in Vienna.

On the other hand, in the following examples the mercury had a high position or ascended:—

1683, 28th September.—*During* the earthquake at Oxford.

1822, 19th February.—*During* that in Savoy.

1825, 23rd December.—At Strasburg.

1828, 2nd February.—*At the time* of the very violent earthquake in Ischia.

1830, 23rd September.—In the Swabian Alps, the barometer reached its lowest position in this month, 6 lines below the average. From the 22nd to the 23rd (the day of the earthquake, and consequently *before* the shock), it suddenly rose 4 lines, and on the following day fell slowly.

1834, 2nd February.—In Silesia.

In the following instances the barometer remained perfectly quiet:—

1826, 26th March.—At Kremsmünster.

1829, 26th November.—During the widely-extended earthquake in Transylvania and Russia.

1829, 30th November.—At Innspruck.

1834, 22nd March.—In Mexico.

1835, 20th February.—During the extremely violent earthquake in Chili.

1836, 9th May.—In Dalmatia.

Here therefore we find twelve instances in which, on the occurrence of earthquakes, the barometer did not fall, against nine cases in which it did. The number of these examples is doubtless very small as contrasted with that of the earthquakes which occurred in the period of time from which they are selected; but they are the only ones which we have found in that period, since in the accounts of the numerous remaining ones, nothing is noticed with respect to the position of the barometer before, during, or after the earthquake. Here also they are very much divided, and in this respect can prove nothing, or at least can only confirm the fact, that, as already mentioned, no more sufficient foundation as yet exists upon which to base a law with respect to the behaviour of the barometer during earthquakes. This is also proved by a very instructive comparative view of the position of the barometer in fifty-seven earthquakes which have been observed at Palermo from 1792 to 1831, which we owe to Frederick Hoffman (Poggendorff's Annal. Physik und Chimie, bd. xxiv. (100), s. 49–64), whom we have already had occasion to make honourable mention of.

4th. *The Thermometer.*

I can find few observations of this recorded. Those of the New Zealand earthquake show no remarkable fluctuations of temperature either before or during the earthquake. The range during the days from the 7th to the 15th of October, before the earthquake, was from 42° to 52° morning, and 48° to 62° night; and during the remainder of the same month of continual earthquake, its range was from 45° to 62° morning, and 48° to 66° at night; while for the eighteen first days of November, the range in the morning was from 48° to 64°, and in the evening from 56° to 73°. (West. Rev. July 1848.)

During the earthquake which took place in Piedmont in the year 1808, the thermometer experienced a slight fall on the occurrence of each shock.

Von Hoff remarks, "Observations have as yet failed to lead us to any rule, as to whether changes in the degree of warmth of the atmosphere have any connexion, whether close or not, with earthquakes and eruptions of volcanoes. It has certainly been sometimes remarked that great heat has preceded an earthquake, but there have been fully as many examples where very violent earthquakes have occurred at all degrees of atmospheric temperature, and at all seasons of the year; so that heat preceding an earthquake can by no means be considered as a regularly occurring phænomenon; which likewise in the work of Herr Kries, already quoted, is clearly proved.

"It must also be admitted, on the other hand, that changes in atmospheric temperature may be a consequence of earthquakes, since there are undoubted instances where, after violent and widely-spread earthquakes, such changes in the condition of the atmosphere, and especially in its temperature, have manifested themselves, which may with probability be ascribed to the forces which produced the earthquake, at least until some other cause for them be observed.

"On the whole, it is more probable that earthquakes, volcanic eruptions, and the whole of the fiery process carried on beneath the surface of the earth, may exercise some influence on the atmosphere, than that the foregoing phænomena occurring in the atmosphere, react upon this process, which belongs to the earth and manifests itself in such an energetic manner. In all relations between this earth and its atmosphere, the former is to be considered as the principal (principale); and the latter only as its appendage (accessorium). The atmosphere is the child of the earth and is supported by it. *Its* influences do not extend beyond the actual surface of the earth, but the internal operations (einwirkungen) of the latter appear solely to determine the condition of the atmosphere, with the exception of the influence which the sun and moon exercise upon it, which however with respect to terrestrial bodies, at least as far as relates to meteorological phænomena, is only superficial. Of the great cosmical influences, as attraction and such like, we naturally do not speak here."

On these observations of Von Hoff I would remark, that when we consider the powerful effects in heating or cooling of the air which the earth's surface is capable of; as manifested to our senses, in the oppressive feel and closeness, &c. of an overcast or clouded summer night, when free radiation is greatly impeded, or conversely, of the dew produced by the free radiation of the earth's heat outwards, we readily perceive what great meteorological changes, in fog, heat, vapour, rain, meteors, &c., may be producible by the *local overheating* by only a fraction of a degree of a vast supravolcanic district of the earth before, or during, or after an earthquake; and thus violent perturbations of season and weather, followed by pestilences and failures of crops, cease to be wonderful, as doubly secondary effects of earthquakes, especially within the tropics, where the natural limits of every sort are so wide and so suddenly passed into.

"It follows," says Dolomieu, "that the atmosphere is not so immediately connected with the interior movements of the earth as has been so incessantly maintained; and it is probable that the tempests (in the Calabrian earthquake) experienced in the Strait of Messina and in other parts of the coast, may have been due to other causes." Perhaps so, but certain it is that the earth acts far more energetically upon the atmosphere than the latter can ever react upon the earth as respects earthquakes.

If several, or even but a few, surprising phænomena once manifest themselves at the same time (or still more if this occur several times), or follow close upon each other, the world is only too much disposed to look for a connexion, or even a relation of cause and effect between them, so as to make them forget the more commonly occurring events which accompany these phænomena. Hence, perhaps, but a few instances in which earthquakes followed great heat, sufficed to produce amongst the Greeks and Romans the opinion that earthquakes occurred more rarely in the cold season of the year than in the warm. How little this opinion of the older naturalists is founded in reality, may be gathered from the fact that directly the contrary is asserted and believed by those of more modern date, namely, that a greater number of earthquakes happen in winter than in summer. In different countries also different opinions have been entertained on this subject, which perhaps always arose from some few, but great, and therefore striking phænomena.

5th. *The Rain-gauge.*

Torrents of rain have often been noticed as falling during earthquakes, and they have also often begun in heavy rain, and sometimes have been concluded with rain, and this has in each case often been accompanied with thunder, lightning and wind; but, on the other hand, so many earthquakes have occurred with serene skies, before, during, and after the shocks, that we must conclude there is no necessary connexion established between them. I can find no numerical observations as to rain, in relation to our subject, recorded.

As secondary effects after earthquakes, disturbances in the usual fall of rain may be almost certainly anticipated in a degree greater as we approach the volcanic centre; but this branch of seismo-meteorology is as yet untouched.

6th. *The Electrometer.*

Eandi observed a Volta-electrometer much agitated during the long-continued earthquake movements of Pignorol in 1808 (Journ. de Phys., t. xlvii. p. 291.); but even were these experiments more copious and refined, it by no means follows that agitations of instruments, at all times in activity, and whose extraordinary activity at any moment may depend upon a passing cloud, have any necessary connection with earthquakes.

"Thunder-storms," says Von Hoff, "have undoubtedly on some occasions burst forth at the same time with earthquakes. Examples of this are to be found in his Chronicle in the years 365, 1138, 1570, 1627, 1680, 1704, 1711, 1715, 1720, 1752, 1821, 1824, 1828. But how many earthquakes took place during this lapse of time without the occurrence of storms, and what innumerable storms to the production of which no earthquake contributed!" (Gesch. Veran. Erdober, Th. iv.)

On the theory of probabilities only, it would be strange were it not so, amidst the numbers of earthquakes of which some record exists.

But here again we are without any facts (to be truly so called) as respects regions visited by earthquakes far beyond the range of the volcanic centres; within these, or in proportion as they are approached, of course this, like other atmospheric perturbations, may be expected.

7th. *The Magnetometer.*

Humboldt found, in the great earthquake of Cumana (4th Nov. 1799), the declination and magnetic intensity unaffected, but to his surprise the dip was diminished by 48 minutes. He had no ground to suppose an error.

With this solitary exception, in all the other earthquakes he experienced on the high lands of Quito and Lima, all the magnetic elements remained unaffected. (Relat. Hist., t. i. pp. 515, 517.)

These movements are of course totally different to those which have been observed by Arago, Biot, and repeatedly at Dublin by Dr. Lloyd, in their magnetic observatories, viz. oscillations suddenly affecting the magnetometers, and most probably due to the transmission of very small impulses from a distance through the earth, and having their origin in very distant earthquakes. Such must have been the cause of the simultaneous movements of the magnetometers of Arago at the Observatoire, and of Biot at the Collège de France some years since. Indeed it was found that at the moment a slight shock had been felt in Switzerland and southern France. Capocci, Director of the Observatory at Naples, relates that at the eruption of Vesuvius of Jan. 1st, 1839, the declination-needle was moved. (Poggend. Annal., b. l. p. 192; Comptes Rendus, t. ix. p. 735.) It is questionable, however, in all such cases, whether the motion be due to magnetism or to pulses communicated to the needle through the shaken ground; and hence special instruments would be desirable, formed to make the distinction.

"In many instances," says Von Hoff, "in which an opportunity of observing the magnetic needle during an earthquake has presented itself, an alteration in its direction for the time has been observed. The usual periodical oscillations (Abweichungs-Schwingungen) are quicker, or take place in a different direction, or are altogether interrupted. It is only in very modern times that great and regular attention has been devoted to the observation of the magnetic needle; consequently good observations of it made during earthquakes are as yet but few in number. The suddenness and unexpectedness of earthquake phænomena certainly render it difficult to obtain accurate observations made at the place where the earthquake occurs, if even the necessary preparations for such observations should be ready, which is to be expected from very few places. The greatest care and the most perfect and accurate instruments also are required for magnetical observations made at the place of the earthquake; the more especially since the shock itself, in proportion to its violence, may mechanically put the needle in motion, which motion is quite independent of that produced by magnetism.

"More remarkable however are the changes in the direction of the dip- and variation-needles, which take place at a distance from the place where the earthquake was observed, and at a place where the shock itself is not perceptible; as, for instance, in Paris, on the 19th of February and 31st of May 1822, simultaneously with an earthquake which occurred in Savoy and some of the southern parts of France. If this observation should be established by others carefully made, the existence could not be denied of a connexion between terrestrial vulcanism (Erd-vulcanismus) and terrestrial magnetism." (Gesch. Veran. Erdober, Th. iv.) It may be here remarked, that without self-registering seismometers and magnetometers, any correct or sustained observation of a connexion between these forces is impracticable.

8th. *The Wind.*

"The opinion, that surprising calms precede earthquakes, is also supported by some evidence, as in the earthquakes of 1704 in England, 1754 in Asia Minor, 1759 at Aleppo, and several others noted. But, on the other hand, earthquakes are sometimes preceded by high wind and tempestuous weather; and with respect to this also no law can be laid down. Violent storms, which raged at the same time with earthquakes, are mentioned as having occurred in the year 359 in Asia Minor; in 1703 at Rome; 1827, 30th of November; 1828, 21st and 23rd of March; 1829, 13th of April. Storms burst forth immediately after earthquakes, in 893 in India; 1703, at Abruzzo; 1824, 26th of October; 1829, 23rd of April; 1833, 9th of October; 1836, 18th of November; 1837, 24th of January. The few instances here adduced, laboriously sought for out of such a long period of time, during which innumerable earthquakes occurred, at least prove nothing in favour of a constant law with respect to any connexion between these phænomena." Such is Von Hoff's view. (Gesch. Veran. Erdober, Th. iv.)

9th. *Meteors.*

"A somewhat nearer connexion may be supposed to exist between earthquakes and phænomena of this kind. These meteors belong to a class of phænomena proportionally seldom displayed by the atmosphere; yet they have been tolerably frequently observed to occur at the same time with earthquakes. To this class belong the so-called globes of fire, and other extraordinary lights and illuminations (Entzündungen) in the regions of the air, which cannot be considered as belonging to the ordinary methods of electrical discharge."

Such meteors have been observed to occur contemporaneously with earthquakes in the years 95 B.C., and A.D. 893, 1001, 1325, 1640, 1674, 1683, 1703, 1737, 1752, 1756, 1810, 1820, 1821, 1822, 1824, 1828, 1829, 1831, 1833 and 1835.

Humboldt states, that just before the great earthquake of Riobamba, a great shower of meteors was seen at Quito (4th of Feb. 1797); that he was informed at Cumana, that just before the earthquake of 1766 a similar display had been seen; and on the 11th of November 1799, he and Bonpland witnessed such a phænomenon in close connexion as to time with the earthquake which then afflicted Cumana. (Per. Nar., vol. iii. p. 331; Cosmos, notes 44, 45.)

10th. *The Aurora.*

This phænomenon, now so well ascertained to be in direct sympathy with terrestrial magnetism, has been often observed before and after earthquakes. I have found no instance in which it was remarked during an earthquake-shock, but it might then easily escape observation.

On the 19th and 20th of October 1848, during the New Zealand earthquake, the aurora was very bright in the south-east (the direction nearly towards which the shock travelled); but there was nothing to show any connexion, in this or in any other case, with the forces concerned directly in the shock.

If there be any real reaction upon the magnetometer for declination hereafter discovered, as due to volcanic action, and not traceable to secondary, electrical or other disturbance close to active vents (and nothing can be more possible than that the sudden movement beneath of great masses of fluid igneous rock, usually rich in iron, shall be found to have such reaction), then it may also be found that the aurora, that most airy and evanescent of all visible meteors, may have some direct, though probably slight relation to the most tremendous agency that the mechanism of our planet possesses.

11th. *Other Atmospheric Phænomena.*

Under this head Von Hoff has placed together some curious facts. "I have already mentioned," says he, "that it seems to me more probable, that the changes going on in the interior of the earth exercise some influence on the atmosphere, than that the latter should in any way influence that process which seems to have its seat deep in the inner portions of the earth. As the globes of fire before spoken of may have their origin in peculiar gaseous exhalations, so it seems probable that other changes in the condition of the atmosphere may be produced by these terrestrial forces. Indeed, alterations in the ordinary state of the atmosphere have not unfrequently been remarked, which ought not too boldly to be ascribed to the influence of the earthquake. We have already noticed the observation, that the earthquake in Peru, in the year 1687, for a long time prevented the success of certain crops. There have also been strange colourings of the heavens and unusual fogs noticed as occurring at the same time with earthquakes; such as the unusual colour of the sky at Lisbon on the 1st of November 1755, and the dry fog (*Nebel*), which was so thick as to produce darkness, during the earthquake in Calabria in 1783. Since observations upon phænomena of this kind, made in modern times, deserve more confidence than those which are preserved in the older accounts, I do not consider it altogether superfluous to quote some instances in modern times of remarkable conditions of the atmosphere existing during earthquakes:—

"1824, 12th August.—In Tuscany. The sun appeared as it were veiled, and was more like the moon.

"1824, 30th November.—In Martinique. After the earthquake, the temperature of the air (which before had been very high) fell very considerably.

"1825, 19th January.—At St. Maura. Extremely heavy showers succeeded the earthquake, and lasted for several days.

"1826, 23rd November.—In the Tyrol. The violent wind which had existed before the earthquake, ceased during its continuance, and rose again after its termination.

"1827, 1st February.—In Naples. On the day of the earthquake, the air, which before had been very cold, suddenly became pleasantly warm.

"1827, 3rd June.—In Martinique. Rain immediately succeeded the earthquake, although none had fallen for sixty-six days before.

"1828.—In Peru. The most unusual and extremely violent rain, lasting four days, succeeded the earthquake in the district which had been most severely visited by it, namely at Truxillo, Lambeyeque, Chiclaya, Puira, and in the desert of Sechua.

"1830, 8th February.—At Agram. A fog, having a very bad smell, spread itself abroad, and lasted for three hours.

"1831, 3rd December.—At Martinique. Heavy showers of rain fell after the earthquake.

"1832, 18th October.—In Saxony. After the earthquake, the thick yellow fog, which had existed there for several days, suddenly dissipated itself, and the air, which before had been harsh, became mild.

"1834, 4th October.—At Bologna. After the earthquake, the air became suddenly cold.

"1835, 27th October.—In the Pyrenees. During the earthquake there rose clouds of hot air, which gave out a distinct smell of sulphur." (Von Hoff, Gesch. Verarl. Erdober, Th. iv.)

Further observations on this whole branch of our subject are imperatively called for. Meanwhile we have provisionally concluded, with great probability, that earthquakes occur in all times, seasons and weathers, and have no very immediate relation with meteorology, in the epochs just before and during their occurrence.

But it is a very different question how far their occurrence or frequency may be influenced,—1st, by the climate; and 2nd, by the meteorological conditions prevailing in a given large district for a considerable time before their occurrence; and again, a totally different inquiry is, what are the immediate and remote reactions of earthquakes upon the climate and meteorology of the country affected.

It cannot be too often insisted on that earthquakes are not motive agents of elevation and depression on the globe, for we find this confusion perpetually, even in the highest authorities, such as Sir Charles Lyell, who frequently alludes to "their upheaving or depressing force," and to land elevated by them (Principles of Geol. pp. 431, 433, 435, 439, 689); but whatever be the ultimate nature of the elevatory and depressive forces to which earthquakes are due when in action, these forces manifest themselves to us in the reaction of the inner portions of our planet, acting through their exalted temperatures upon its outer crust. The term volcanic *fire* has been so long used, and so loosely, and become so habitual, that its abuse has produced in almost every mind, a conception of chemical interchange of elements, *of fire in its popular sense*, in which something enters into combination with something else and *burns* with a true combustion (like that of a metal in chlorine, or of coal or wood in the air), as a true representation of the heat of the inner portions of the earth, the external manifestations of which we behold in the volcano. Yet nothing probably can be further from the truth; the main phænomena of volcanic action, so far as we know them, are those of *ignition, up to liquefaction of solid bodies incapable of any combustion*; nor is there any evidence of this ignition being produced or maintained by the consumption of a fuel, *i.e.* by chemical combination, in which a body, or part of a body, before solid, becomes gaseous.

For as the explosive energy shown in volcanic eruptions is but the by-play, and not of the same nature with the enormous and quietly-acting force by whose (hydrostatic) action from beneath the great elevations are effected, so are the local evidences of combustion at the crater of the volcano, but the by-play also, and not of the nature of that rise of temperature up to ignition without the consumption of a fuel, which is the main phænomenon.

In a word, let us not be dazzled by the glare of the volcano itself, grand, and to us vast, as may seem its forces and their phænomena, so as to confound these, the true combustions, gaseous explosions, and all the other superficial actions at the crater, with the mighty and quietly-acting forces deep below, of which these are all but symptoms, and perhaps as slight ones, as some cutaneous disorders are of deep-seated and all-pervading inflammatory action in the human frame.

This error is not fallen into by the greater observers amongst continental cosmologists: hear Von Hoff (Gesch. Veran. Erdober, Th. iv.):—

"In the great mountain-chains of Europe there exists at present no volcanic energy. It seems to have ended by the great act of the upheaving of these mountains, and since then to have been turned into other channels.

"The same seems to be true, at least for the most part, with respect to the mountains of Asia. Only some portions of the Andes are remarkable as being continually affected by volcanic eruptions. Such are parts of Chili, Quito, and Guatemala. Here we cannot avoid making the remark, that the Andes pass along and close to the great Pacific ocean, whereas the great chains of mountains of Europe and Asia constitute the inmost centre of great continents, whose whole condition of surface has been determined by them. This is especially true with respect to Asia, and perhaps this want of volcanic openings has been the reason of the upheaval of such a large extent of land.

"These volcanic springs are the outlets for the violent efforts of the subterranean vulcanismal processes; and it is remarkable that in countries where there are these outlets, and especially where they exist in large numbers, the inner forces never increase sufficiently in strength to upheave large tracts of land, or to alter the character of the sea-bottom, whilst in places where these outlets for the vapours and gases produced by the subterranean processes are wanting, their concentrated force is able to upheave whole countries. Hence probably the neighbourhood of the sea to the most active volcanoes, of which by far the greater number are found on coasts and islands.

The opinion, that active volcanoes are only the outlets for these internal workings, or as it were, the chimneys, not of particular fires scattered here and there, but of enormous volcanic furnaces existing in the depths beneath, has of late been distinctly enunciated by the most eminent geologists and observers of volcanic phænomena."

Again, hear Humboldt:—"It is only by considering these various relations under a general point of view, and following them on a large extent of the surface of the globe, through formations of rocks the most different, that we are led to abandon the supposition of trifling local causes, strata of pyrites, or of coal set on fire." (Per. Nar. vol. iv. p. 47.)

Steffens, on the other hand, in his 'Geognostich. Geologische Aufsetze,' p. 325, finds in such combustibles "the condition, *sine qua non*," of volcanic action; and it is strange how the same *crude notion of the necessity for a combustible* besets almost every author down to the present day, forgetful that *cosmical fire needs no fuel*, that the perpetual evolution of heat from the interior of a planet (without anything being burnt away) is no more wonderful, than (nay, is only in analogy with) the perpetual evolution of light and heat from the fixed stars and sun, which no one supposes to be flaming fires. See on this Humboldt in his 'Pers. Nar.' vol. i. p. 257.

The whole question of the chemical reactions, conjecturable as *occurring within* the active volcanic foci, has been ably discussed by Gay-Lussac, in his 'Reflections sur Volcans,' in Annales de Chim. et de Phys. tom. xxii. p. 415, which paper contains the germ of nearly everything that has been since advanced upon the subject, clearly and succinctly given.

Thus, then, ignorant as we are of all within the outer surface or skin of our globe (and of how much of its exterior, for the ocean shrouds two-thirds of it from our eyes!), we are compelled to see the close connexion of these mighty heating powers in which *ignition* is present on the vastest scale, yet *without combustion*, with the forces of terrestrial electricity and magnetism; forces which are those alone, that within range of our observation are mutually convertible, and both convertible into heat.

Currents of both we know are ever passing with variable activity through enormous volumes of the earth's crust, the different parts of which possess very different conducting powers. Can it be that these currents, constrained to pass through narrow and bad conductors, at vast depths, in some formations, ignite them in their progress? Will it be found that the great lines of volcanic activity (as dreamed of by Bylandt) are in some way connected with those of terrestrial magnetism? are possibly normals to the surface curves of equal magnetic intensity? A glance at one of Gauss's magnetic maps, and at another of the great bands of active volcanoes on our planet, almost forces the mind into such conjectures.

If, then, as seems at least possible, there be a direct connexion (still more, if this be one of cause and effect) between volcanic action and those forces of electricity and magnetism whose cosmical relations we are just beginning to get glimpses of; and if, again, these are modified and possibly determined in their extent and laws of action by the astronomic motions of the earth, and by its variable reception of heat from the sun, and dissipation thereof again in the celestial spaces; it must result that the volcano and the earthquake *are not* independent of the laws which determine climate and regulate the vicissitudes, and the limits of perturbation, of the seasons.

It is perhaps the most wonderful circumstance in the history of our globe, that its mightiest agencies interdepend, upon a balance so precise, that perturbations in any one of the forces, so small as to appear to us at first sight perfectly insignificant, would, if continued or not corrected, be sufficient totally to alter or disarrange the vast machine. We can prove this in some degree in the exacter branches of cosmical science; we can show it to be so as respects the establishment of the tides, of the great currents of the ocean and of the atmosphere, of the relations of land and water to climate, and of the astronomical conditions of our planet to its mean temperature; but as yet we can only guess from their analogy, as to what and how great may be the total effect, of perturbations of climate, and season, and weather, within the limits known to us, upon the molecular forces acting beneath the surface of the earth, upon which the great agency of elevation depends, and with it the volcano and the earthquake.

But again, we may view it thus: granting that perturbations of climate, season and weather, may not be the appointed agents in determining the local play of the all-present force of elevation, may it not be that their disturbance may be the sufficient and immediately anterior cause, of their being brought into play within a given region, where before they were in equilibrium, but nearly ready to break forth; the last drop as it were to cause the cup to flow over?

To take (in our ignorance) a rude example; suppose a widely-extended tract of sea-bottom, beneath one portion of which, or of adjacent land, the ignited or fluid materials of the inner earth have approached the surface by thinning of the solid crust, or in a word, by any such play of forces as have been well imagined by Mr. Babbage and Sir J. Herschel. Let this portion be under the dry land; and suppose the ordinary rise and fall of tide at the place to be 15 feet or so, that by any of the combined causes which are known to affect the local establishment of tides this becomes a 20-foot tide, and that at the same time a rise of 2 inches of the barometer takes place over the sea, and a corresponding fall over the land. The conspiring effect of all this would be equivalent to a tide of about 80 feet in total rise, brought at once to bear upon the already thinned crust of sea-bottom; this, taking the specific gravity of fluid and porous lava at about 2·0, being equal to a bed of this of 40 feet in thickness, or to a dead pressure of nearly 20 tons per square yard, and acting over hundreds of square miles of surface, it is conceivable that the combination of circumstances might at once bring on an active eruption and earthquake, felt far away upon the land, which otherwise had reposed in safety on its molten base. Compare Von Buch, 'Descript. des Iles Canar.', p. 334, and Hoffman, in Poggendorff's Annalen, band xxiv. s. 8.

Nor yet may the changes in the organic world of life upon the earth be without influence upon these, the most formidable forces that exhibit themselves in nature. Who has yet determined, for example, what meteorological effect is produced, by the wonderful change that takes place during the year in the vegetable covering, upon the surface of the plains of the Pampas, where over thousands of square miles of country covered with scorched and embrowned grass and lowly herbage, a forest of gigantic thistles grows up, and in a few weeks makes the plain impassable for man or beast, and the earth no longer reached by the sun's rays? What may be the co-exercitive effect within the tropics of the changes of the vegetable world at the commencement and end of the rainy season, at the vernal and autumnal equinoxes, and at the changes of the monsoons, at which times popular belief has long asserted within the tropics some connexion with earthquake? and long-held popular belief usually contains some deformed truth, misinterpreted and overlaid with a mass of error, but yet a truth within.

On this branch of our subject we literally know nothing; and in the observations upon it just concluded, I have been anxious rather to suggest the directions in which future investigation may run, than to advance any connected speculations where there is at present no certain basis for them.

But before quitting the region of conjecture, I would add a few words upon the probable nature of that force, or mode of application of that force, upon which the earthquake shock, the actual stroke, depends. We have seen sufficiently that this force must be *an impulse*, it must be of the nature of *a blow, percussive*; hence it is not produced by the direct action of the elevatory force itself, which acts slowly, liftingly (*erhobenlich*), as Humboldt says, and hydrostatically. It may result occasionally from *fractures*, produced by the steady pressure of this evenly acting agency, yet these cannot be the usual or principal action, but only subordinate.

Now the almost universal succession of phænomena recorded in earthquakes is, first a trembling, then a severe shock, or several in quick succession, and then a trembling, gradually but rapidly becoming insensible. It would be possible to fill page after page with accounts of earthquake shocks, which all ring the changes, on a tremor beginning gently and increasing rapidly, then one or more violent shocks, like blows, and afterwards a trembling again, gradually dying away, rarely indeed the shock first. Thus to take one example for all, from Dr. Patrick Russell's account of the earthquake in Syria, on 25th November 1759:—"About half-an-hour after seven at night the earthquake came on; the motion at first was gently tremulous, increasing by degrees until the vibrations became more distinct and at the same time so strong as to shake the walls of the house with considerable violence; they again became more gentle, and thus changed alternately several times during the shock, which lasted in all about two minutes."

In general the average of numerous narratives seems to give from three or four to fifteen seconds as the duration of the great shocks; from two to ten or fifteen minutes for that of the powerful vibratory shakings; and an unlimited, or at least uncertain time, for slighter tremors afterwards. What sort of impulse then will be competent to account for this general order of succession? I believe it will be found either in the sudden bringing into contact under pressure of large ignited surfaces with cold water, or the blowing, through and into, cold water, of volumes of steam under pressure, and this steam suddenly condensed therein.

When an irruption of igneous matter takes place beneath the sea-bottom, the first action must be to open up large clefts or fissures in its rocky material, or to lift and remove its incoherent portions, such as mud, gravel, &c. The first portions of water that gain access thus to the ignited surfaces, repelled by their heat, are brought into that peculiar state which Boutigny and others have called *spheroidal*. While in this condition their intestine motion may be great, but little steam is generated; and while this is the case, no impulses will ever be conveyed to a distance, but only those tremblings or vibrations which precede the shock, and which with wonderful acuteness Aristotle calls *βράσται*, ebullitions like those of a boiling caldron; but no sooner has the surface of lava become cooled to the point at which repulsion ceases, and the water, altering its state, comes into close contact with the heating surfaces, than a vast volume of steam is evolved explosively, and, blown off into the deep and cold water of the sea, is as instantly condensed; and thus a blow or impulse (or several of these), of the most tremendous sort, is given at the volcanic focus, and being transferred outwardly in all directions, is transmitted as the earthquake shock; but the surfaces of ignited material, now cooled down below the point at which steam can be generated rapidly, merely keep up a gentler ebullition, which is transmitted as the trembling after the shock, dying away as the mass grows cold, or again repeating all the phases, as the surfaces again become heated by conduction from the fervid magazine in the interior of the lava mass.

Of course this may be endlessly varied. The first great blow may break up and shatter the bottom, and scatter the molten matter, or may provide the conditions for successive shocks; but the above seems to account for the general facts.

Again, if the eruption occur under land communicating with the sea by rents and fissures, and steam be generated therein, or be blown continuously for a longer or shorter time from them into the sea-water, its unequal and *per saltum* condensation under pressure, will produce all that trembling and repercussion, which, transmitted, will form the earthquake. The phænomena of fluids in the spheroidal state, first systematized by Boutigny, though observed in part long before, seem to remove the great difficulty that Gay-Lussac found in admitting the possibility, of access of sea-water to volcanic vents, viz. that it could not gain access against a pressure capable of sustaining columns of fluid lava 7000 or 8000 feet deep. Let us now remember that water and white-hot lava might be stirred up together in a huge caldron, as one would shake oil and water together, and there would be no repulsion, no explosions, until the lava had cooled down nearly to blackness, when the whole mass would be suddenly and with explosion shattered into fragments from the steam evolved in all its cells. Compare Dolomieu, 'Descr. Calab. Earthquake.'

I do not regard these views as wholly conjectural. I conceive the facts known are sufficient to enable us to say, that they are a true, though probably most incomplete statement of the operations in nature; and it is remarkable, that not only that most accurate observer, Aristotle, was struck with the similarity of the sound and trembling motion to the ebullition of steam in water, but we have seen a long-practised observer compare his experience of South American earthquake sounds and shocks to the blowing of steam through the tender of a locomotive engine; and that some have compared the first noise of the coming shock to that of a large piece of red-hot iron quenched in cold water; while Mrs. Maria Graham, in her account of the earthquake at Chili, in 1822 (Geol. Trans. 2nd ser. vol. i. p. 414), says she felt "a general tremor and a sound like that of vapour bursting out, similar to the tremor and sound which she remembered to have observed at each jet of fire while standing on the cone of Vesuvius during the eruption of 1818."

Briefly, then, it seems to me, that, however modified, the immediate impulses producing earth-waves of shock are due—

1st. To the sudden formation of steam from water previously in a state of repulsion from the heating surfaces, (spheroidal state) and which may or may not be again suddenly condensed under pressure of sea-water.

2nd. To the evolution of steam through fissures, and its irregular and *per saltum* condensation under pressure of sea-water.

3rd. To great fractures and dislocations in the rocky crust, suddenly produced by pressure acting on it from beneath, or in any other direction.

4th. Occasionally, but rarely, to the recoil from mighty explosive effects at volcanic foci, as when a mass of rock weighing 200 tons was shot from the crater of Cotopaxi to the distance of nine miles (Humboldt), or when nearly one-half of the crater of Vesuvius was blown away.

In such cases the shock from recoil must have been far greater than upon any occasions when powder magazines have been blown up. Yet during the last century, when a powder-mill at Waltham-abbey exploded, the inhabitants of districts so far removed as not to know the true nature of the case, felt the shock, and had their furniture and houses, &c. so shaken, as to conclude that it was the shock of an earthquake due to natural causes. (Annual Reg.) And numerous instances will be found in the pages of the 'Gent. Mag.' of explosions of powder being first recorded as earthquakes, and, subsequently, the shock ascribed to the true cause; for example, the blowing up of the Amphion frigate at Portsmouth about the end of last century, was taken for an earthquake over all the south of England. On occasion of the explosion of the powder-mills at Hounslow this year, 1850, it was stated in the papers that the shocks, corresponding in number to the explosions (three in all), were distinctly felt at Sussex, a distance of between 50 and 60 miles from Hounslow; and at Petworth, 40 miles off, the people ran out of their houses, supposing it to be an earthquake; yet here the weight of powder fired was not very large. The same circumstances were remarked when the great Spanish powder magazine was purposely blown up during Sir John Moore's retreat, said to have contained 1500 barrels of powder; it was felt as an undulation of the ground for miles away; and again, in a less degree, when early in last century one of the great lintel stones of Stonehenge fell down upon the ground, it was felt all over Wiltshire, and thought at first to have been an earthquake. In fact all these were earthquakes, though not originating in natural causes*.

Finally, it remains to make a few remarks upon the directions in which it is desirable that earthquake inquiries should be in future extended, and what are the chief desiderata of the subject. In the article drawn up for the Admiralty Scientific Manual, and published in that volume, on the observation of earthquake phænomena, the general character and classification of earthquake observations will be found, and to this I refer.

But altogether the most valuable and important additions that this branch of physics can now receive, must come—

1st. From a large and careful determination of the moduli of elasticity of rocks and of the other substances forming our geological formations, and of the changes due to increase of temperature, upon such moduli.

2nd. From systematic and connected observations of the direction, dimensions, and other conditions of earthquake shocks or waves by self-registering instruments suitably placed in countries which are subject to very frequent shocks.

3rd. From the co-ordination and comparison of such self-registered observations, with those of self-registering meteorological and magnetic instruments.

These observations must be continued for a considerable period, and those at distant points of observation must be in connexion as to time, &c. The island of Zante, as being almost hourly shaken by earthquakes, almost all of which are of a manageable degree of force, and capable of exact registration, would be an excellent station for a first trial of such instruments, in connexion with some other Mediterranean station; but when a complete self-registering seismometer shall have been constructed, it would be most desirable that every astronomical and magnetic observatory on the globe should be furnished with one, and this kept constantly in action, and its indications systematically recorded in connexion with those of meteorology, electricity, &c.

I have to regret that in the latest edition of his work on volcanoes, Dr. Daubeny has discouraged the employment of such instruments, by an ob-

* While these sheets have been passing through the press, an explosion of some tons of gunpowder, effected at Seaford on the south coast of England, for the purpose of removing seaward a large mass of chalk cliff, produced so real an earthquake, that a chimney was thrown down in an adjacent village, and houses shook at a distance of three miles, yet no sound or shock was transmitted through the air.—See 'Times,' Sept. 1850.

jection to that which I have proposed, namely the supposed difficulty of keeping a galvanic battery constantly in action to ensure that of the seismometer. One would have thought that the thousands of miles of electric telegraph now kept in hourly activity, would have shown the groundlessness of such an objection.

The observations heretofore made with seismometers, constructed on the solid pendulum principle, are worthless, by the nature of the instrument, even if they were not much too few and too ill-connected to be of any service. A seismometer must give the direction of emergence of the earth-wave at the station, the time occupied by the passage of the wave, and the form of its crest, *i.e.* its altitude and amplitude. The transit velocity at the station must for the present be assumed as that due to the modulus of elasticity of the formation upon which the instrument stands.

Upon this subject I would refer to my memoir on a self-registering seismometer, Trans. Roy. Irish Acad. for 1846.

It has been objected to the value of determinations of elastic moduli as respects our subject, that they will only give us information as to the purely superficial substances of the earth's crust. This is however not a valid objection. The Belgian coal-measures dip as far below the sea-level as Chimborazo rises above it, so that it is in our power to get measures of the elasticity of formations extending in actual depth to $\frac{1}{435}$ of the earth's radius, and by obtaining a series of moduli for the same rock, descending in depth, to get the law of its variation, and so to arrive at conclusions as to rocks which we can never see or examine by the senses; and again, it is not philosophic to refuse to investigate to the depth we may, because we are limited to a certain depth; to refuse the aid, as Locke says, of the sounding-line, because we cannot always strike the bottom with it.

To be truly serviceable however to the physical geologist, the elastic modulus of any given rock should be ascertained in the three directions as it lies *in situ*, of depth, breadth, and length. Those desirous of entering more fully into this part of the matter, I refer to the Rev. W. Haughton's Memoirs on Elastic wave Motions (Trans. Roy. Irish Acad. 1849).

Direct experiments for admeasurement of the transit rate of elastic waves in the solids of the earth's crust, and especially through its loose and incoherent formations, clay, gravel, sand, &c., are of great value to this inquiry, and may be made by the explosion of small quantities of gunpowder in a suitable manner.

These investigations, involving expensive instruments and the devotion of much time and conjoint labour, can only be attempted with the aids and support that bodies such as the British Association can bestow; and probably no branch of cosmical science would better reward efforts judiciously made to advance it, a reward which would not be confined to geology, but would enrich many other departments of physics and natural science.

I have now concluded the Report upon the facts of earthquakes, so far as time and other avocations would permit, but I do not view the subject as completed.

In a second part of the present Report, therefore, I hope, with permission of the British Association, to present—

1st. A complete catalogue or chronology of earthquakes from the earliest times to the present day, discussed with reference to time and to distribution over the earth's surface.

2nd. Earthquake maps founded upon this discussion.

3rd. As complete a bibliography of earthquake literature as I have been able to collect.

4th. An account of my own experimental admeasurements, now in progress, of the rate of earthquake-wave transit through some of the rocky and incoherent formations of the earth's surface.

5th. An account of the progress made in the construction of a self-registering seismometer, with the aid of the British Association.

NOTE (page 8).

The obscurity of some passages in the original and the extreme difficulty of grasping the meaning of the author almost throughout, with other reasons, have made it appear desirable to subjoin a very literal translation of the passages of Aristotle quoted in the text.

The Greek seems unquestionably corrupt in two or three instances. The text is from the Oxford Edition of 1837, in 9 vols. 8vo, an amended reprint from Becher.

"The shakings and movements of the earth are next to be spoken of. For the cause of this affection of the earth is closely connected with what we have been treating of (namely, the wind).

"Three theories on the subject have been handed down to us by three different persons; namely, Anaxagoras of Klazomene, before him Anaximenes the Milesian, and later than these Democritus of Abdera.

"Anaxagoras says that the æther by nature rises upward, but that when it falls into hollow places in the lower parts of the earth, it moves it (the earth); because the parts above are cemented or closed up by rain, all parts being by nature equally spongy or full of cavities, both those which are above (where we live) and those which are below. Of this opinion it may perhaps be unnecessary to say anything, as being foolish; for it is absurd to suppose that things would thus exist above and beneath, and that the parts of bodies which have weight would not on every side be borne to the earth, and those which are light, and fire rise; especially since we see the surface of the earth to be convex and spherical, the horizon constantly changing as we change our place, at least as far as we know. And it is also foolish to assert on the one hand that it remains in the air on account of its great size, and on the other to say that it is shaken when struck from beneath upwards. And besides these objections, it is to be remarked that he has not treated of the attendant circumstances of earthquakes, for neither every time or place is subject to these convulsions.

"But Democritus says, that the earth being full of water, and receiving much also by means of rain, is moved by this. For when the water increases in bulk, because the cavities cannot contain it, in its struggles it causes an earthquake. And when the earth becomes partially dried up, the water being drawn from the full reservoirs into those which are empty, in passing from one to the other, by its movements it causes an earthquake also.

"Anaximenes, however, says that the earth when parched up and again moistened, cracks; and by the masses thus broken off falling on it, is shaken; wherefore earthquakes occur in droughts and again in times of rain; in droughts, because, as we have said, it cracks when highly dried, and then when moistened over again it cracks and falls to pieces. Were this the case, however, the earth ought to appear in many places subsiding. Why then is it that hitherto many places have been very subject to these convulsions which do not present any such remarkable differences from others? Yet such ought to be the case. And moreover those who think thus must assert that earthquakes constantly become less and less, and at last cease altogether. For the continual condensation of the earth would cause this. Wherefore if this be not the fact, it is plain that this is not the correct explanation."

"But since it is manifest that exhalations must arise both from moist and dry places, when this is the case, earthquakes must necessarily occur. For the earth itself is by nature dry, but receiving much moisture on account of rain, when it is heated both by the sun and also by the fire which burns within itself, a great quantity of vapour must be produced both inside and outside of itself, and sometimes the whole of this flows uniformly inwards, sometimes outwards, and sometimes it is divided.

"If this then be necessarily so, the next point to consider is, what kind of bodies is most easily moved. But it is inevitable that what can go the greatest distance and what is most vehement should be specially of this nature. Therefore the most vehement is of necessity that which is borne along most rapidly, for it strikes with greatest violence on account of its velocity. For that naturally moves over the greatest space which can most easily move through everything, and such is the property of that which is most subtle. Wherefore since this is the nature of wind, it of all bodies is the most mobile. For fire, when it occurs along with wind, causes flame, and is rapidly borne along. Therefore neither water nor earth is the cause of earthquakes, but the exhalation of wind, when having flowed inwardly it has chanced to be exhaled outwardly.

"Therefore the greater number of earthquakes and the most violent ones have taken place during calms; for the exhalation being uniform, follows for the most part the impetus of its commencement, wherefore either all flows inwards together or all outwards. But that some earthquakes should take place during a wind is nothing unreasonable, since we sometimes see several winds blowing at the same time, of which, if one be borne into the earth, there will be an earthquake while the wind is still blowing. But these are of less magnitude, since their origin and cause are divided.

"But earthquakes are also more numerous and greater in the night, and, of those in the day, about the middle of the day. For the middle of the day is in general the calmest part of it. [For when the sun has most power it keeps the exhalations bound in the earth, and it has most power in the middle of the day.] And the nights are even calmer than the days, on account of the absence of the sun, so that then the flow of wind is again inward, as if a regurgitation in an opposite direction to that in which the effusion took place; and this especially towards dawn, when the winds usually begin to blow. If therefore the origin (or direction ?) of them shall be changed within, as at Euripus, on account of their great mass the earthquake will be the more violent.

"Earthquakes also seem to have been most violent about such places as are loose and full of cavities, and where the sea has many tides. Such are the places about the Hellespont, and Achaia, and Sicilia, and Eubœa, for about these places the sea seems to flow beneath the earth on account of the narrowness of the passage. For the same reason the hot baths near Œdipus were formed.

"Near all these places which we have mentioned the earthquakes are very violent on account of the narrowness; for the wind being rendered violent on account of the great mass of the sea, which is borne to the land in great quantity, is repelled again back upon the earth, though naturally it should blow out from the earth. And thus those countries, the earth below which is spongy and therefore capable of containing much vapour, are more violently shaken.

"In spring and autumn also the greatest earthquakes take place, both during drought and rain; but the winter and summer, the one by its cold, and the other by its droughts, produce immobility, for the one is too cold, and the other too dry. But even in droughts the air contains vapour (*πνευματώδης ἐστὶ*), for this *is* a drought when more dry than moist exhalations are produced. But during rain the wind causes a greater amount of exhalation within, and by this kind of secretion (*ἀπόκρισιν*) being intercepted in narrower places, and the same mass being driven into a smaller space, the hollow places of the earth being full of water; when it begins to have power, on account of a great mass being forced into a small space, the wind moving and striking produces violent motion.

"For it is necessary to be understood, that as in our bodies the force of the wind which is intercepted is the cause of tremors and throbbings, so also the wind produces similar effects in the earth, and one earthquake appears like a tremor and another like a throb. And as it often happens after a discharge of water (for then a certain tremor is produced through the body, when a quantity of wind is necessarily transferred in a mass fiom without inwards), so also it happens with the earth.

"Such strength has the wind that we need not look for it only in the effects which it produces in the atmosphere (for there, on account of its great magnitude, any one would presuppose that it could do such great things), but also in the bodies of animals. For spasms and convulsions are some of the other motions produced by wind, and such strength have they, that many people, at once trying to restrain the movements of the person afflicted, are unable to do so.

"So also we must suppose it happens in the earth, to compare a great thing with a small.

"Several signs of it also have taken place under our own observation. For in several places, when an earthquake has taken place, it has not stopped until the wind which caused it burst forth like a storm upon the part of the earth above. This happened in the earthquake which took place lately about Heracleia in Pontus, and formerly in the island Hiera, which is one of those called the Æolian Isles. For in this island a part of the earth swelled, and rose like a hill, the motion being accompanied by noise, until at length rending, much wind came forth, and threw up cinders and fine ashes, which burnt the whole city of the Liparæi, which was not far off, and reached even to some of the cities of Italy; and where the swelling took place is visible to the present day. *For this is to be supposed to be the cause of this fire produced in the earth, that when cut off it burned, the air being first divided into small particles* (? Greek).

"But an infallible sign that winds flow beneath the earth, is afforded by that which takes place with respect to these islands. For when the south wind is about to blow, it is known beforehand by particular signs, for noises are heard at those places from which the eruptions take place; because the sea being forced forwards already from a distance is again repelled from the land where it happens to come upon it, by the eruptive force. But it produces a sound without a shock on account of the great size of the place (for the sea is poured into an immense space without), and also the small quantity of the repelling air.

"Besides these signs, the sun becoming dull and obscure though without clouds, and calms and great cold before earthquakes happening in the morning, are signs of the cause we have been speaking of. For it is a necessary consequence of the wind (which dissolves and separates the air) beginning to return into the earth, that the sun should be obscured and gloomy, and that in the morning, towards dawn, there should be much cold and calmness. For it is necessary that the calmness should for the most part happen when the wind returns inwards, as we have said before, and more so before the greater earthquakes, for then that which is within and that which is without are not separated, but the whole being borne along, it necessarily produces great effects.

"But the cold happens, because the exhalation, which is in itself of a warm nature, now goes inwards. But the winds do not seem to be warm, because they move the air which is full of cold vapour, in the same way as the air which is breathed through our mouths. For that which is near is warm, as when we exhale, but on account of its small quantity it is not equally manifest; but that which is at a distance is cold, for the same reason as the winds. Such force therefore being wanting in the earth, the vaporous emanations coming together, on account of the moisture, produce cold in the places which are thus affected.

"The same is the reason of a phænomenon which generally occurs before an earthquake, namely, that either during the day or a little after sunset, the weather being quite serene, a little cloud appears, narrow and stretched out to a great length, and quite straight, the wind being weak on account of its change of place. For the same takes place in the sea round the coast; for when rising in large waves it is flung in upon the shore, deep and irregular ripple-marks are produced, but when it is calm, less effects are produced, and these are small and straight. What then the sea does on the coast, the wind does on the cloud which is in the air, so that when there is a calm the cloud is left altogether straight and narrow, being as it were a ripple-mark in the air.

"For the same reason also earthquakes often happen about the time of eclipses of the moon. For when now the interposition is near, and the light and heat derived from the sun are not entirely removed from the air, but just decreasing, a calm takes place, the wind returning again into the earth, which causes the earthquake before the eclipse. For winds also often happen before eclipses, blowing in the beginning of the night before those which take place in the middle of the night, and in the middle of the night before those which happen in the morning. This occurs because the heat diminishes which is derived from the moon, when now the path (φορὰ) is near in which the eclipse takes place. That therefore being removed which detained the air and rendered it calm, the wind is again put in motion, and blows previous to the eclipse. But when a violent earthquake has taken place, the shocks do not cease suddenly and at once, but in the first instance they often continue for forty days, and after that are in force for one or even two years in the same place. But the cause of the greatness of the earthquake is the great amount of wind and the configuration of the places through which it flows, for where it is repelled and cannot easily pass through, there it produces the greatest shocks, being retained in narrow places like water, not being able to pass through. Wherefore, as in the body throbbing pulsations do not cease suddenly and immediately, but gradually, as the malady spends itself, so also it is with the beginning of the exhalation and the original impetus of the wind; for it is manifest that the material is not at once consumed from which the wind is produced which we call an earthquake.

"Until therefore the remains of this be consumed, the shocks must necessarily continue, but continually becoming less and less until the exhalation is too slight to produce any perceptible shock.

"But the wind also produces those noises under ground which are heard before earthquakes. And in some places subterranean noises are heard unaccompanied by earthquakes, for as the air by being struck produces every kind of sound, so it does also when it is itself the striking agent, for it makes no difference, since when it strikes against any object, it is itself stricken. But the sound comes before the shock because it consists of more subtle parts, and can therefore penetrate through everything better than wind.

"But when it is unable to move the earth, it is on account of its subtlety, which enables it to pass through without moving it. But when it strikes against bodies whether solid or hollow or of whatever figure, it produces every species of sound, so that the earth often appears, as those who utter portents say, to bellow.

"Water also is often thrown out during earthquakes. But we are not to conclude from this that water is the cause of earthquakes, for whether it be on the surface or below, the wind it is which supplies the force, which is the moving power, as the winds are of the waves, and not the waves the cause of the winds. Since else any one might attribute this convulsion to the earth itself, for when shaken it is overturned like water (for pouring out is a sort of overturning). But both these causes are causes as matter is (passive not active causes), but the wind is as an inceptive cause.

"But when a wave occurs at the same time with an earthquake, it is owing to two winds acting in opposite directions. But this happens when the wind which is agitating the earth cannot altogether repel the sea which is borne along by another wind, but propelling and driving it together, it collects a large body of water. Then when this wind is overcome, it necessarily follows that a great impetus is given to the opposing wind, and a deluge is produced. And this took place in Achaia, for without the south wind was blowing, but there the north; but a calm taking place, and the wind flowing inwards, a wave was produced, and an earthquake at the same time, and the rather because the sea did not give an outlet to the wind acting under the earth, but opposed an obstacle to its egress. For of the two forces in action, the wind produced the earthquake, and the remains (ὑπόστασις?) of the wave the inundation.

"*Earthquakes are confined to particular parts of the earth, and often to a small part; but the winds are not so. But they are so when the exhalations which are in the place itself and the neighbouring place, flow together, since the rains and droughts are so too, as we have before said, and the earthquakes take place in this manner, the winds do not. For these have their origin in the earth, so that they all flow together into one. But the sun has not a similar power, but the lofty exhalations rather so as to flow into one, when they receive an impetus from the path* (φορὰ) *of the sun* (? Greek).

"When a great deal of wind is present, it shakes the earth, producing a sort of tremor sideways, but it occasionally and in some few places happens that it appears like a violent throbbing from below upwards. This seldom occurs, for it is not easy for much motive power to be collected in this way, for there is a much greater evolution of this sideways than upwards. When such an earthquake takes place, a multitude of stones are thrown up as if shaken up in a sieve. It was by an earthquake of this sort that the parts about Sipylos were overthrown, and the plain called Phlegræan, and the Ligurian country.

"But in islands far out to sea, earthquakes are less felt than in those which are near shore. For the great mass of the sea cools the exhalations and keeps them down by its force and weight. And besides, the sea is in constant motion, and is not shaken, overcome by the winds. And because it occupies a great space, the exhalations are not produced into, but out of this, and those which are produced in the earth follow these.

"But those islands which are close to the main land are in fact part of it, for the intervening water on account of its small size has no force. But islands far at sea cannot be moved but with the whole sea which surrounds them.

"Concerning earthquakes therefore, and their nature, and causes, and all other circumstances concerning them, we have here treated of the principal things."—*Arist. Meteor.*, Lib. II. cap. 7–8.

"It often happens, however, that a similar wind, hidden in the earth, when these (i. e. means of exit) are absent, when it has insinuated itself into hollow places and dark passages in the earth, as if breaking out from its proper resting-places, produces a vibratory motion in many places round.

"And it often happens that when much wind from without has got into these hollows, all means of exit being cut off, in turning itself within it shakes the earth with immense force, in vain seeking a place of exit, from which arises that convulsion of nature which we call an earthquake.

"But those earthquakes which shake the earth obliquely at an acute angle are called 'Epiclintæ,' as acting in a transverse direction.

"But those which toss the earth up and down at a right angle are called 'Brastæ,' from their likeness to the motion of boiling water.

"But when the sinking of the ground leaves hollows in its subsidence, they are called 'Chasmatiæ,' from their gaping.

"But those which produce chasms by an eruption are called 'Rhectæ,' that is breakers forth. Now some of these in their eruption carry forth blasts of wind, others stones, others mud. There are some also which produce springs where before they did not exist.

"Those are called 'Ostæ' which with one thrust overturn what they move.

"But those which with much shaking, and inclining, and vibrating to either side, always throw the objects they shake upright again, are called 'Palmatiæ,' that is vibratory, as producing an affection very like a tremor."—*Arist.*, *De Mundo*. cap. 4.

A mere regard for the verbal construction of the preceding passages would, on the whole, lead the reader (especially if unaided by reference to the Greek) to the conclusion, that Aristotle meant to convey that wind simply in some form or another, was the efficient cause of earthquakes; after careful consideration, however, I am still disposed to adhere to the view given in the foregoing report, and to believe that in so far as he had in reality any distinct idea, it was that of some intangible, imponderable force or agent present in the earth and above it, acting upon the winds, and acted on by them, though not the winds themselves, and giving rise in such reactions to earthquakes and volcanoes. Perhaps from the want of any distinct ideas as to atmology, and its relations to those forces which we call molecular, and having no clear metaphysics of spirit and matter, an abuse of words is found in the Greek physical writers, which often renders them (as throughout the above passages) almost unintelligible. The word πνεῦμα was used to express pure spirit, and the wind (compare John's Gospel, cap. 3, ver. 8), as well as condensable vapours, and this alike by the philosopher and by the vulgar.

Letter to the Assistant General Secretary to the British Association.

Dublin, July 22, 1850.

My dear Sir,—As the working member of the Committee appointed at last meeting of the Association for the instrumental admeasurement of earthquake waves, I have to report as follows:—A sum of £50 was placed at the disposal of this Committee, the entire amount of which has been devoted to the completion of a self-registering seismometer, upon my construction. In this considerable progress has been made, and we hope to present it in action at the next meeting of the Association after the present one, it being found impracticable to have it completed in time for the Edinburgh meeting.

When so finished and found, as we trust, to answer its purpose, it would be most desirable that a second instrument at least should be constructed, and that both should be sent out and kept at work in whatever earthquake district might appear most favourably circumstanced for registration.

The island of Zante and some other one or more moderately distant stations in the Levant, would seem to offer great inducements to fix on them. I have reason to know that competent persons could be found at Zante to undertake the task of superintending the instruments and recording their indications.

After such a conjoint arrangement for self-registering observations of the peculiarly manageable and almost constant shocks felt at Zante and its surrounding regions, should have been in operation for a year or so, we might expect to arrive at some very definite knowledge as to the position and *the depth below the surface* of the centre of those frequent impulses, in other words, probably, of the actual depth of the great volcanic focus of the Mediterranean basin.

The whole sum of £50 has been drawn, and the whole, with the exception of a small sum, remains as yet to the credit of the Committee, but will very soon be required for payment.

Should a second instrument hereafter be constructed a further grant will be necessary.

Previous to the appointment of this Committee at the last meeting, I had arranged and in part proceeded with a series of experiments for the experimental admeasurement of the rate of transit of waves of impulse (analogous to those of earthquakes) produced artificially in various coherent and incoherent formations of the earth's crust, and at first proposed that the expense of these experiments should be defrayed from the grant made to this Committee at Birmingham; but finding that the cost of the seismometer for self-registration would, as a first instrument, involving alterations, &c., absorb nearly the whole grant, if not the whole, and that the expense of these transit experiments would be very considerable, I proposed to the other members of the Committee that the whole grant should be devoted to the seismometer, and that I would complete the experiments on rate of wave transit, as I had commenced, from my own resources.

I have already completed that class of those experiments that regard the rate of impulse-wave transit in *incoherent* formations, and with very interesting and unexpected results, and am now proceeding with those in coherent or rocky formations. The impulses in the former case were produced by the explosion of rather large quantities of gunpowder. In the latter it will probably be found most convenient to resort to a blow delivered by the fall of a heavy body.

I propose giving an account of these experiments as a portion of a second report on the facts of earthquakes, should I be directed by the British Association, at its approaching meeting, to prepare such report. In this would also be embodied the extended catalogue of earthquakes, and discussion of same by curve-diagrams and maps, which I have in progress, and which I expect to be the most complete ever tabulated—about two thousand earthquakes, new to any previous catalogue, have been already collected, arranged and tabulated.

The bibliographical catalogue of works relating to earthquakes has also been brought to a very forward state, and through the assistance of friends abroad I have been enabled to obtain complete excerpts of the seismological books existing in several of the most important foreign libraries; when finished, therefore, I expect this will form a better index to future students of this interesting branch of physical geology than they have before had access to.

I am indebted to Dr. Robinson for some valuable suggestions as respects my experimental determination of wave transits above adverted to, and to my eldest son, William Mallet, for much laborious aid in the preparation of those catalogues; but these and other such obligations received from other friends will best be fully acknowledged hereafter.

I would beg the favour (as I am myself unable to be present at the Edinburgh meeting) of your presenting this in the proper quarter, as the provisional report upon the above matters, in order that the views of the Association may be ascertained upon the question of a second report, &c.

Believe me truly yours, ROBERT MALLET.

On Observations of Luminous Meteors; continued from the Reports of the British Association for 1849. *By* the Rev. BADEN POWELL, *M.A., F.R.S., F.R.A.S., F.G.S., Savilian Professor of Geometry in the University of Oxford.*

IN continuing my report to the British Association for the year elapsed since the last Meeting, on observations of Luminous Meteors made in various parts of the world, I have been aided by the contributions of many friends, among whom Mr. Lowe, as on former occasions, has been pre-eminent in the number of observations he has kindly communicated. From other quarters I have not received so many as last year, though Dr. Buist has favoured me with a considerable number from India. I have also been enabled to prefix a notice of some older observations which in some instances throw light on those in former reports.

The arrangement of the tables is nearly the same as before, with a slight extension in their form, which it is hoped will add to their perspicuity. The time is usually only common clock time, and therefore open to much uncertainty, unless otherwise expressed; but in all Mr. Lowe's observations it is Greenwich mean time.

I. List of a few Meteors prior to the date of the commencement of the Catalogue for 1849–50.

(i.) 1828 or 1829. At Allport, Derbyshire, about the end of August or beginning of September, at 3 P.M., a bright light was seen to traverse the sky, slowly when it exploded, with a loud noise; pieces fell in a field of mown grass, where persons at work picked them up. A specimen was picked up and preserved by B. Staley, Esq.

It was analysed by Dr. R. A. Smith. It contains oxide of iron, making its specific gravity about 2; also free sulphur, which appears in minute crystals visible to the naked eye as a fine dust as soon as a fresh surface is exposed. Its composition is in these respects totally unlike any other meteorite. It contains also charcoal, which might perhaps be acquired from matter among which it fell. The analysis by Dr. R. A. Smith is as follows:—

"It contained 22·32 per cent. of sulphur in small crystals, 43·59 of carbon and 34·09 of oxide of iron, in which number is included a fraction of a per cent. of silica. It did not contain phosphates, sulphurets or earths."
Communicated by Dr. R. A. Smith, Manchester.

(ii.) Observations of Luminous Meteors prior to Aug. 1849. Communicated by Dr. D. P. Thomson. Extracted from his Introduction to Meteorology, 1849.

1837. Sept. 21, 7^h 48^m P.M.—Cast a shadow; seen at Paris. (p. 305.)

1841. Dec. 21.—Twice the apparent diameter of moon, and exceedingly effulgent; the tail was variegated, and the body burst in a blaze of light; seen at Glasgow and near to Stirling at the same time. (Ib.)

1843. Feb. 5, about 8 P.M.—Passed over Notts, resembling a large mass of fire of a blood-red colour, and assumed various shapes; its course was from N.W.; its apparent height trifling, and its velocity about fifty-five miles per minute. (Ib.)

1846. June 20, about 8^h 30^m P.M.—Witnessed at Marieux near Autun, Saone et Loire; it was of a violet colour, and seemed a yard in circumference. It continued visible about a minute, and descended perpendicularly to the horizon, giving off five other balls, each nearly one-fourth the size of the parent mass, which nevertheless preserved its original volume; before disappearing it burst into sparks, spreading far and wide. (Ib., Evening Mail.)

1846. Aug. 1, about 10^h 30^m P.M.—At Cassel, at an altitude of about 80°, near to the meridian; it burst with a sibilant sound, leaving behind a train of sparks. (Ib.)

1846. Sept. 15.—A bolis appearing as large as an orange, with a train some yards in length, crossed Wrenbury, Cheshire, about 10 P.M. (p. 305). The observer was my brother, Mr. William Thomson, surgeon, Wrenbury, near Nantwich.

1847. Oct. 17, at 6^h 5^m P.M.—A very fine bolis was observed by my friend the Rev. Charles Aldis, crossing from S.W. to N.E. at Wrenbury, with a long train and a faint whizzing noise; another of very large diameter was seen near to midnight on the 23rd of November of the same year, at Birkenhead.

"The finest bolis which the author ever witnessed occurred on the 2nd of February 1848, about 9 P.M. [near Wrenbury, Cheshire]. The night was calm and beautiful,—three hours before he had been testing a reflecting telescope upon the ring of Saturn [then a difficult object]. Returning from a professional visit, his attention was drawn to the south by a sudden and brilliant light not far from [the belt of] Orion. It was a fireball slowly descending at an angle of nearly 20°. Its light was more intense than that of Jupiter, which was then shining in great splendour, and it had a decided apparent diameter. The body of the meteor was coloured grass-green, and it was partially bordered with crimson, in a crescentic form in the direction of the white and tapering tail. The bolis disappeared without sparks, falling seemingly to the ground between the observer and the wood of Combermere Abbey, nearly a mile off. Before sunrise the sky was overcast; the following day was bleak and windy, and rain soon followed." (p. 306.)

1848. March 8.—A luminous meteor shot across the clouded sky at Bath from the S.W.; the nucleus seemed larger than a cricket-ball, and the tail appeared about three-fourths of a yard in length. (Ib. p. 306.)

Query.—Might not this be the same which was seen by Mr. Symonds near to Oxford, at 1^h 45^m on the 9th?

1849. Jan. 9.—A bolis crossed the sky at Edinburgh, seemingly one-third the moon's diameter; passed slowly to the south. (MS. Edin. Advertiser.)

(iii.) Other Meteors up to August 1849.

1846.—"I never saw more meteors than this winter. From October 17th to December 17th they appeared in great numbers almost every clear night, some as large as Jupiter. The most remarkable were between October 17th and 26th, and on November 10th, 11th, and 12th." (J. F. Miller, Whitehaven.)

1847. August. Whitehaven, J. F. Miller, Esq.—Multitudes of shooting stars, and several larger meteors, almost every clear night between the 2nd and 20th. (MS.)

1847. Oct. 24.—A very large bright meteor fell during a grand display of aurora borealis. (Darlington, Durham, by J. Graham, Esq.)

1848. Jan. 27.—Several very brilliant meteors. (Uckfield. C.L. Prince, Esq.) These four communicated by E. J. Lowe, Esq.

Date.	Hour.	Description.	Place.	Observer.	Reference.
1815.	h m				
Feb. 18	....	Explosion; meteorite fell.	Dooralla, India.	Captain Bird ...	Bombay Times. See App., No. 22.
1822.					
Aug. 7	....	Meteorite.	Kadonah	....	Ib. App., No. 23.
1825.					
Nov. 3	....	Elongated fire-ball	Calcutta	Colonel Blacker	Ib. App., No. 24.
Nov. 22	....	Brilliant meteor like a comet.	Ibid.	....	Ib. App., No. 25.
1832.					
June 23	....	Three fireballs united into one.	Delhi	....	Ib. App., No. 26.
July 24	....	....	Meerut	....	Ib. App., No. 27.
Nov. 18	....	Innumerable meteors ...	Bulrampore and Asia	....	Ib. App., No. 28.
1833.					
March 18	5 27 p.m.	Very brilliant in N.E.	Madras.	Mr. Taylor	Ib. App., No. 29.
1841.					
Sept. 10	....	....	Calcutta	....	Ib. App., No. 30.
1842.					
April 11	4 0 a.m.	....	....	Capt. Shortrede	Ib. App., No. 31.
1843.					
July 26	3½ 0 p.m.	Meteorite fell	....	Various observers.	Ib. App., No. 32.
1848.				Capt. Abbot.	
Sept. 4	8 45 p.m. (M.T.)	A very singular luminous streak dissolved in train of sparks.	Wrottesley, near Wolverhampton.	Assistant to Lord Wrottesley.	See Appendix, No. 1.
Sept. 7	6 30 p.m.	Large fireball, from N. to S.; course deviated at right angles; burst into fragments.	Poona	Correspondent to Bombay Times.	Bombay Times. See App., No. 33.
Oct. 29	7 0 p.m.	Large fireball, from W. to E.; horizontal, then fell.	Bombay and Poona.	....	Ib. App., No. 34.
1849.					
July 27	8 30 p.m.	Bright meteor with large train of red sparks; visible about 5 secs.; fell perpendicularly from an alt. about 70°.	Porebunder, India.	Id.	Ib. App., No. 35.
Aug. 25	10 p.m.	A splendid meteor = 2 ♀, followed by train of stars; path marked by a dark cloud	West of Chesterfield.	A Correspondent	Derby Courier. See Appendix, No. 2.
Aug. 12, 13, 14	....	Great numbers of meteors observed, and their tracks laid down on a map; all appeared to originate in Pegasus.	Midhurst, Sussex	M. Bulard	Comptes Rendus, No. 10, p. 269. See also App. No. 3.

II. *Catalogue of Luminous Meteors*

Date.	Hour.	Magnitude or brightness.	Colour.	Train or explosion.	Velocity or duration.
1849.	h m				
Oct. 8...	10 53 p.m. ...	Small	Blue	No tail.....................	Rapid..............
9...	9 45 p.m. ...	=4th mag.	Blue	No tail.....................	Rapid..............
10...	11 55 p.m. ...	=3rd mag.	Blue	Sparks	....
	12 17 p.m. ...	=4th mag.	Blue	Sparks	Rapid..............
12...	9 58 p.m. ...	=1st mag.; round, well-defined disc.	Orange-red......	Train of bright sparks...	Rapid..............
	10 8 p.m. ...	=4th mag.	Yellow	No tail.....................	Rapid..............
	10 12 p.m. ...	=4th mag.	Blue	No tail.....................	Rapid..............
	10 13 p.m. ...	=4th mag.	Yellow	Sparks	Rapid..............
13...	10 30 p.m. ...	=4th; as bright......	Blue	Sparks	Rapid..............
14...	9 29 p.m. ...	=5th mag.	Orange	No tail.....................	Rapid..............
	9 35 p.m. ...	=3rd mag.	Yellow	No tail.....................	Rapid..............
20...	6 20 p.m. ...	=1st mag.	Yellow	No tail.....................	Rapid..............
	6 35 p.m. ...	=4th mag.	Yellow	Sparks	Rapid..............
	8 2 p.m. ...	=2nd mag	....	....	....
	8 7 p.m. ...	....	....	....	....
	8 30 p.m. ...	Very brilliant	....	....	3 or 4 seconds ...
31...	3 00 p.m. ...	No meteor visible ...	....	....	....
Nov. 1...	11 00 p.m. ...	....	....	....	....
2...	5 10 p.m. ...	Bright	....	....	Nearly 20 seconds
	5 30 p.m. ...	Large; round	....	With train	About 8 seconds
	5 33 p.m. ... (G.M.T.)	Globe meteor = $\frac{1}{8}$ of the moon.	Orange-red ...	For the 1st half of course separate sparks extending through 10°, thence without any.	Very slow; visible 30 seconds
	6 5 p.m. ...	Small	Blue	....	....
	7 33 p.m. ... (G.M.T.)	Larger than ♀ when at ☍, and twice as bright.	Orange-red ...	With sparks...............	Moderate ....

(*continued from the Report of* 1849).

Direction.	General remarks.	Place.	Observer.	Reference.
16 Draconis to υ Herculis	....	Highfield House, Nottingham.	E. J. Lowe, Esq.	M.S. com. to Prof. Powell.
γ Equulei to β Aquarii	....	Ibid..............	Id.	Ibid.
Downward through ♂, inclining to N.	....	Ibid..............	Id.	Ibid.
From ϱ to α Urs. Maj.	....	Ibid..............	Id.	Ibid.
From χ to 57 Ceti	....	Ibid..............	Id.	Ibid.
From Delphinus ⊤ down; slightly inclined to E.	....	Ibid..............	Id.	Ibid.
From 29 Vulpec. through 12 Vulpec. and 113 and 109 Herculis.	....	Ibid..............	Id.	Ibid.
From γ Equulei through 3 Aquarii.	....	Ibid..............	Id.	Ibid.
Sagitt. to 1° S. of ϑ Serpentis...	Emitting blue stars in its track.	Ibid..............	Id.	Ibid.
Through ε Lyræ over 15′	....	Ibid..............	Id.	Ibid.
From 5° above φ Aquilæ to N. of τ Aquilæ.	....	Ibid..............	Id.	Ibid.
From 5° N. of Capella, and at same alt. ⊥ down.	....	Ibid..............	Id.	Ibid.
⊥ down from Vega through β to γ Herculis.	....	Ibid..............	Id.	Ibid.
....	....	Ibid..............	Id.	Ibid.
From ϱ to γ Herculis	....	Ibid..............	Id.	Ibid.
Alt. 45°; nearly 1 hour preceding α Aquilæ.	Appearance like a bar of light; then explosion at one end.	Hartwell, Aylesbury.	Mr. Horton	MS. letter from Dr. Lee to Mr. Birt. See Appendix, No. 6.
....	Sound heard; meteorite fell and splintered a tree; buried 13 inches deep.	Farm of H. Post, county of Cabaras, Charlotte, N. Carolina.	Mr. H. Post......	Phil. Mag., March 1850, p. 241.
Descended obliquely from N., diverged suddenly to W. on approaching a dense cloud.	....	Castle Lecky, Londonderry.	Mr. Webb	Astronomical Soc. Notices, x. 24.
From altitude 45°, obliquely, to N.W. through about 30°	Velocity decreased; no explosion.	Near and N. of Mold, Flintshire.	W. W. Smyth, Esq.	Letter to Prof. Powell. See Appendix, No. 4.
From E. to W., considerably below Polaris.	Seemed to decrease as it advanced.	12 miles N.N.E. of Swansea.	Mr. Hill	See Appendix, No. 5.
From between β and γ Lyræ to within 6° of W.N.W. horizon.	In a slight curve inclining towards N.	Highfield House, Nottingham; seen also at Kegworth and at Beeston; between Bramcote and Nottingham.	E. J. Lowe, Esq. and A. S. H. Lowe, Esq., M. Durand, R. Felkin, Esq., C. Wright, jun., Esq.	MS. list.
Between γ Pegasi and ♄; nearly horizontal towards S.; disappeared W. of Pegasi.	Brightness vanish; once or twice nearly extinguished.	Observatory, Richmond Park.	W. R. Birt, Esq.	Letter to Prof. Powell. See Appendix, No. 6.
From 39 Andromedæ to 1° N. of γ Cassiopeiæ.	Auroral glare	....	E. J. Lowe, Esq.	MS. list.

Date.	Hour.	Magnitude or brightness.	Colour.	Train or explosion.	Velocity or duration.
1849. Nov. 5	h m 6 8 p.m.	....	....	....	....
	6 10 p.m. (G.M.T.)	Head composed of 7 or 8 small balls.	Bluish	Vivid train of sparks which seemed attracted together in masses.	5 seconds; train remained about 2 minutes.
		= 1st mag.	....	Train of red light; explosion.	....
	6 20 p.m. (G.M.T.)	Brightness = ♃	Red	Leaving remarkable thin lines of red light through whole path ...	Moderate ....
8	6 30 p.m.	Bright circular defined disc.	Greenish white.	Towards end threw out train of sparks 10° long; visible 3 or 4 secs. after meteor.	....
9	9 p.m.	= 4 times ♀; light = full moon.	....	Burst with loud explosion.	....
10	6 18 p.m.	= 1st mag.	Orange	....	....
11	[illegible] 44 p.m.	= 3rd mag.	Blue	Continuous streak or tail...	Rapidly ....
	9 20 p.m.	= 2nd mag.	Yellow	....	....
	9 21 p.m.	= 3rd mag.	Blue	....	Rapid ....
12	6 20 p.m.	= 2nd mag.	....	....	Rapid ....
	10 37 p.m.	= 4th mag.	Blue	....	Rapid ....
	From 10 30 p.m. to 12 30 p.m.	88 meteors; 1 = ♀; 1 = ♃; 15 = 1st mag.; 31 = 2nd mag.			
13	From 10 30 p.m. to 12 15 p.m.	69 meteors; 1 = ♀; 9 = 1st mag.; 20 = 2nd mag.; 25 = 3rd mag.			
	10 23 12ˢ	A fireball	....	....	....
15	10 29 p.m.	Small	....	....	Rapid ....
	10 31 p.m.	Small	Yellow	Streamers	Rather rapid ....
	10 31 p.m.	....	....	....	Rapid ....
Dec. 4	11 40 p.m.	Globular; three times as large and four times as bright as ♃.	Orange-red ...	Sparks over 1°	8 secs. ....
12	11 30 p.m.	Appeared to increase as it descended to mag. = 4 times ♀.	Greenish white.	Shower of sparks; no noise.	Rapid ....
14	10 35 p.m.	= 3rd mag.	Yellow	Leaving a continuous luminous streak in its track.	Over 4°; rapid ......
	10 36 p.m.	= 4th mag.	....	....	Rapid ....
	10 38 p.m.	= 4th mag.	....	....	Rapid ....
19	5 10 p.m.	= 2 ♀	....	Leaving a streak...........	Remarkably slow; visible 2 mins. 30 secs.

Direction.	General remarks.	Place.	Observer.	Reference.
From 3° above α Urs. Maj. to 8° above β Bootis.	....	Stone, near Aylesbury.	M. V. Fasel	Phil. Mag. Feb. 1850, 115.
From near Pleiades and close to α Arietis, [to 10° above Delphinus (from alt. 13°, azim. N. 68° E. to alt. 60°, azim. S. 8° W.), Glaisher.	....	Chester	R. L. Jones, Esq.	Communication to J. Glaisher, Esq., Phil. Mag. May 1850, p.381.
From azim. N. 7°, W. alt. 30°, to azim. N. 59°, W. alt. 38°.	....	Stone	M. V. Fasel	Ib. Feb. 1850.
From 14 Draconis to *h* Herculis	Mr. Glaisher suggests this may be the same as last.	Highfield House, Nottingham.	E. J. Lowe, Esq.	MS. list. See Appendix, No. 7.
In Pleiades; about 20° alt.; from W. to E.	"The air full of small meteors at present."	Bombay	Id.	Bombay Times, Nov. 3–16, 1849. See Appendix, No. 8.
From E. to W.....................	....	Asseerghur	Id.	Ib. See Appendix, No. 9.
⊥ down; from slightly W. of η Urs. Maj.	....	Highfield House, Nottingham.	Id.	MS. list.
Through 5°; from ι Ceti at an incl. of about 7° to horizon towards S.	....	Ibid................	Id.	Ibid.
From below α Aurigæ; incl. at 45° downwards.	....	Ibid................	Id.	Ibid.
Just under ♂, through 1°......	....	Ibid................	Id.	Ibid.
From 54, 55, 56 Persei to Capella.	....	Ibid................	Id.	Ibid.
From 1° below Capella through 3°.	....	Breslau............	Prof. Boguslawski and Assistants.	Comptes Rendus, Nov. 26, 1849. Phil. Mag. Jan. 1850, p. 75.
From Camelopardalis to Urs. Maj.	....	Ibid................	Id.	Ibid.
From β Aurigæ to η Gemin. ...	....	Highfield House, Nottingham.	E. J. Lowe, Esq.	MS. list.
From under Capella towards S.	....	Ibid................	Id.	Ibid.
Under Pleiades	....	Ibid................	Id.	Ibid.
Horizontal from between τ and Eridani; ½ nearer the former; about 1° beneath σ and χ Ceti; fading away near ω Piscium.	....	Ibid................	S. Watson, Esq. & F. E. Swann, Esq.	Mr. Lowe's MS. list.
From zenith to S.W.; exploded at alt. 20° nearly.	Dimmed the light of stars.	Near Shorapore.	Correspondent to Bombay Times.	See Appendix, No. 36.
From 4° below ♂; in direction of Orion's belt.	....	Ibid................	E. J. Lowe, Esq.	Ibid.
From H. I. Camelopardalis to γ Persei.	....	Ibid................	Id.	Ibid.
From between γ and ξ Draconis ⊥ down.	....	Ibid................	Id.	Ibid.
From α Draconis; slightly above λ Draconis to just above Capella.	....	Beeston, near Nottingham, & at Whitehaven.	M. J. E. Durand, J. F. Miller, Esq.	Ibid.

Date.	Hour.	Magnitude or brightness.	Colour.	Train or explosion.	Velocity or duration.
1849. Dec. 19	h m 5 15 p.m. (G.M.T.)	Bright nucleus = 2 ♂; another estimate = 4 ♃.	....	Train increased in length as meteor advanced; length established from 30′ to 5°; no explosion.	Uniformly through 65° in 30 secs.
		√ ♂	....	Train	Through 76° in 15 secs.
	10 16 p.m.	= 2nd magnitude, but brighter than 1st.	Orange-red ...	No streamers	Slow; 4° in 1 sec....
20	7 58 30ˢ	Size = 4th magnitude; brightness = 3rd mag.	Blue	....	Rapid; ½ sec.........
23	6 36 30ˢ	Size = ♃; brighter than ♂ at ☍; circular disc.	Fine red.........	A few separate sparks......	1½ sec. ....
	7 30 p.m. (G.M.T.)	At first small, but increased to brighter than Aldebaran.	....	Scintillated like a rocket before disappearing; no explosion; left a considerable train.	2½ secs. ....
30	5 21 p.m.	= 2nd mag............	Rather red......	No streak...................	Instantaneous ......
	5 45 p.m.	Brilliant	....	....	Rapid...................
		Globe about 4′ diam.	....	....	....
1850. Jan. 30	6 23 p.m.	Bolide brighter than ♂ at brightest.	Reddish	Bright train; no noise ...	About 3½ secs. ......
	6 50 p.m.	Several small, and one = ♃.	....	....	....
	8 48 p.m.	Much larger than ♃	....	....	....
	9 30 p.m.	Smaller than ♃	....	Oblong form	....
Feb. 3	8 10 p.m.	= 4th mag.	Yellow	No train	Slow ....
4	8 55 p.m.	= 2nd mag............	....	Slight train	....
6	8 15 p.m.	= 1st mag.	Yellow	Train	Quick ....
	8 20 p.m.	= 4th mag.	Orange	No tail.................	Rapid ....
7	7 0 p.m.	Large, = moon	....	....	....
9	6 30 p.m. & at 11	Many shooting stars..	....	Some with streaks	....
	11 15 p.m.	....	....	....	....
10	8 30 p.m.	Brilliant, = ⅙ moon...	....	Tail = 4 times diam. of head.	Instantaneous ......
	8 46 5ˢ	= Sirius, but brighter	Red.................	Tail	Rapid.................
	8 46 50ˢ	= Rigel	Blue	Leaving white streak	Rapid.................

Direction.	General remarks.	Place.	Observer.	Reference.
Alt. 10°; N.W. by N.; horizontally towards E.; disappeared N. by E.	Separated into three or four fragments falling horizontally.	Durham	Mr. Carrington and several Observers.	Letter from Prof. Chevallier to Durham paper. See App. No. 10.
From W. to N.; alt. 15°; burst at alt. 6°.	Separated in two parts which moved on together; these again each separated into fragments.	Edinburgh; through parts of Ireland and Scotland, from N.E. to S.W. 300 miles long, 140 broad.	Prof. Forbes and numerous other Observers.	Proceedings of the Royal Society of Edinburgh, 1850. ii. 309. See Appendix, No. 10.
From near C. H. 117 Leonis Min. to ε Leonis.	....	Highfield House, Nottingham.	E. J. Lowe, Esq.	MS. list.
From direction of Cassiopeia; from β Lyræ to 108 Herculis.	....	Ibid................	Id.	Ibid.
From ξ Tauri through χ and 94 Ceti.	Vanished suddenly.	Ibid................	Id.	Ibid.
From near ψ Persei to 30′ beyond Aldebaran.	....	Castle Donington, Leicestershire.	W. H. Leeson, Esq.	Ibid.
From Pleiades to α Ceti.........	....	Ibid................	Rev. K. Swann...	Ibid.
From Pleiades to α Ceti	Burst in fragments; visible some secs.	Latimer	Rev. G. King ...	Phil. Mag.
S.W. of Andromeda; moved N. by E.; inclination 20° to vertical.	Burst and emitted knotted streak of red light 5° or 6° long.	Hartwell	Rev. C. Lowndes	Ibid.
From about ½ distance from α to γ Urs. Maj.; passed E. of γ; disappeared at alt. = η.	Nearly vertical ...	Cherbourg, 380 metres W., 60 metres N. of Cherbourg Church.	M. Liais	Comptes Rendus, 1850, No. 8, p. 208.
Through 12° between Procyon and β.	....	Headington Hill, Oxford.	Mr. W. Ray	MS. letter to Prof. Powell.
Through about 20° from N.W. of Cassiopeia to 20° alt. N.W. by N.	....	Ibid................	Id.	
Below Sirius; disappeared about 20° above S. horizon.	....	Ibid................	Id.	
From H. 17 Camelopardi to f Cassiopeiæ.	....	Highfield House, Nottingham.	E. J. Lowe, Esq.	MS. list.
From 19 Monocerotis to 9 Argus.	....	Ibid................	Id.	Ibid.
From Rigel to γ Can. Maj.......	....	Ibid................	Id.	Ibid.
Procyon to Sirius	....	Ibid................	Id.	Ibid.
From alt. 40° in E. to alt. 25° in N.E.	Vanished	At sea, lat. 24° 53′ N. long. 66° 16′ E.	A Correspondent.	Bombay Times, March 13, 1850. See App. No. 11.
Chiefly in Ursa Major and Ursa Minor.	....	Highfield House, Nottingham.	M. J. E. Durand.	Mr. Lowe's list.
From Aries to Orion	....	Hartwell	Rev. C. Lowndes	Phil. Mag. May 1850, 363.
From alt. 8° S.S.W. to alt. 2°.	....	At sea, lat. 24° 18′ N. long. 66° 30′ E.	A Correspondent.	Bombay Times, March 13, 1850. See App. No. 12.
Procyon to γ Canis Maj.	....	Highfield House, Nottingham.	E. J. Lowe, Esq.	MS. list.
From 17 Monocerotis to γ Orionis	....	Ibid................	Id.	Ibid.

Date.	Hour.	Magnitude or brightness.	Colour.	Train or explosion.	Velocity or duration.
1850. Feb. 11	h m 5 0 p.m.	Brilliant nucleus......	Reddish	Tail blue	Slow ....

Accounts of the great meteor of February 11 were collected by Mr. J. a large part of England, in the Phil. Mag., March and April 1850. tabular form as the preceding:—

Feb. 11	10 41 p.m. (G.M.T.)	Various estimates from = moon to about ¼; very bright and increasing in brilliancy till disappearance.	Various contrary accounts; changeable.	Long train, emitting sparks according to some, not so according to others; report afterwards at intervals of from 1 to 5 min.	From 10, 41, 16, to 10, 41, 27 at Greenwich = 11 secs.; others estimated from 2 to 40 secs.

Mr. Glaisher institutes calculations on the data furnished which give the
Height at 1st appearance 84 miles, nearly over a point
Height at disappearance 19 miles, nearly $1\frac{1}{2}$ mile S.
Height of luminous sparks at disappearance 10 miles.
Real velocity 30 miles per second.

In addition to the accounts cited by Mr. Glaisher, the

Feb. 11	10 50? p.m.	....	Nucleus brilliant red.	Train bluish; outer edge with rainbow tints; no report.	....
		At first like a star ...	....	Descended with a stream of light of various colours; explosion like distant thunder.	....
	11 42 p.m.	Large; brilliant	Greenish	A succession of sparks; no explosion.	Slow; visible abou 5 secs.
	10 50 p.m.	Round; gradually expanding.	Succession of colours—green, red, violet.	....	....
	10 40 p.m.	Bright light followed by a distant report after 2 min.	....	....	....
	10 30 p.m.	Brilliant	....	Disappeared with sparks	Rapid ....
		Small globe increasing as it advanced, by successive jerks or bursts till it becomes nearly = moon; intensely bright.	Head intensely blue.	Train darting out sparks; disappeared without noise, throwing off bright fragments.	Rapid; 2 or 3 secs...
		....	....	A report afterwards	....

Direction.	General remarks.	Place.	Observer.	Reference.
....	Atmosphere electric; thunder heard.	Holy Moorside, Derby.	A Correspondent.	Derby Courier.

Glaisher of the Royal Observatory, Greenwich, from various observers, over
The following is a brief summary of the main results thrown into the same

From W. to E., slightly inclined, at a mean altitude of about 20°.	....	Numerous parts of England: extreme points Penzance, Brighton, Durham.	Correspondents to Mr. Glaisher	Phil.Mag.vol.xxxvi. pp. 221 and 249. See Appendix, No. 18.

following ultimate results:—
13 miles N.E. of Montgomery.
18° E. of Biggleswade.
Real diameter from 1800 to 2000 feet.
Path, Parabolic.

following have been furnished from other quarters:—

....	....	Southgate House, near Chesterfield.	P. C. Maxwell, Esq., and H. J. Bowdon, Esq.	Derby Courier. See Times, Feb. 13. See App. No. 13.
....	....	Renshaw Street, Hulme, Manchester.	A Correspondent.	Ibid. See Appendix, No. 15.
rom W. to E. by N., horizontal	Undulatory or jerking motion	Holloway, Islington.	F. Barnard, Esq.	Letter to Prof. Powell. See Appendix, No. 16.
rom W. to E.; path curved...	"Seemed to roll over and disappear."	Kennington Lane, Lambeth.	W. F. Whitmore, Esq.	Times, Feb. 13. See Appendix, No. 14.
....	....	Hartwell Rectory.	Rev. C. Lowndes	Mr. Lowe's MS.
....	Light illuminated a room with fire, candles, and blinds down.	Wrottesley, Wolverhampton.	Lord Wrottesley and others.	Letter to Prof. Powell.
bliquely from W. to E.; mean alt. about 20°.	....	New Coll., Lanc., Oxford.	Mrs. Baden Powell.	See Appendix, No. 19.
....	Mean estimate of 5 observers; interval between disappearance and report 2 min.	Oxford	Communication to Mr. R. Wheeler.	Letter to Prof. Powell.

Date.	Hour.	Magnitude or brightness.	Colour.	Train or explosion.	Velocity or duration.
1850.	h m				
Feb. 11	10 30 p.m.	....	....	....	....
	10 48 p.m.	Several globes following in a luminous train.	....	....	....
13	7 45 p.m.	Very small	....	....	....
	7 47 p.m.	=4th mag.	White............	Train	....
	8 0 p.m.	Small	Yellow	No tail....................	Rapid..............
	8 1 30ˢ	=3rd mag ; defined disc.	Deep red	....	Mean ....
	8 6 p.m.	Small	Deep red	Gave out sparks	Slow ....
	9 45 p.m.	$=\frac{1}{2}$ moon; dazzling brightness; pear-shaped.	Bluish white ...	No noise	About $1\frac{1}{2}$ sec. ......
14	....	Several small	....	....	....
20	8 32 p.m.	=1st mag.	Orange-red......	Separate stars	Rapid..............
22	11 50 p.m.	....	....	Explosion with no noise...	....
	11 47 p.m.	Bright, = moon ; became pear-shaped; round end below.	Blue	Anterior part remained round ; back separated into luminous fragments and streaks; no report.	3 or 4 secs. ....
	11 57 p.m.	Large	....	....	....
26	10 32 15ˢ	Bright blue, =3rd mag.; defined disc.	....	....	10 secs. ....
Mar. 4	7 20 p.m.	....	....	....	....
6	9 0 p.m.	=Sirius	....	Train with falling sparks, most numerous about the middle part.	About 15 secs. ....
	9 15 30ˢ	Small, =3rd mag. ...	....	....	About 1 sec. ....
7	9 25 p.m.	=1st mag.	Deep orange ...	Tail	Rapid..............
	9 40 p.m.	Larger than ♃ and brighter.	Red	Continuous stream of light.	Slow, 2 or 3 secs. .
11	8 47 p.m.	....	....	....	....
15	7 25 p.m.	....	....	....	....
17	9 12 p.m.	=4th mag.	Blue	Continuous train of light...	Hardly 1 sec.......
	6 55 p.m.	Brilliant, = ♃.........	....	Train of blue light extending 5°	....
	9 48 p.m.	....	....	....	....
24	8 59 56ˢ	Small, =2nd or 3rd mag.	....	....	Slow ....
	9 3 40ˢ	Small	....	....	About 1 sec ....

Direction.	General remarks.	Place.	Observer.	Reference.
2° above Procyon, just above the head of Hydra, ending near 15 Sextantis.	....	Beeston, Nottingham.	Mr. Butler.	Mr. Lowe's list. See Appendix, No. 17.
....	A drawing taken immediately and an engraving executed.	Paddington	Mr. Wyatt.	Communicated to Prof. Powell.
Horizontally from 42 to H. 35 Ursa Major.	....	Highfield House, Nottingham.	E. J. Lowe, Esq.	MS. list.
....	....	Ibid...............	Id.	Ibid.
From ϵ to below f Cassiopeiæ, through Polaris.	....	Ibid...............	Id.	Ibid.
From υ to χ Orionis	Gave the appearance of a small ball at no great height.	Ibid...............	Id.	Ibid.
Through 2° from 25 Monocerotis, *upwards towards zenith*, at inclination about 70°.	....	Ibid...............	Id.	Ibid.
Obliquely downwards; disappeared before reaching horizon, from about 15° alt. in E.	....	Hincksey, near Oxford.	A. Locker, Esq., Pemb. Coll.	MS. communication.
....	....	Highfield House.	E. J. Lowe, Esq.	MS. list.
From ζ Draconis to α Cephei...	....	Ibid...............	Id.	Ibid.
Towards S.E.	....	Aylesbury	A Correspondent.	Oxford Journal, March 2.
In S.S.E. by S.; alt. 15° perpendicularly down.	....	Albany Road, Camberwell.	J. Wallis, Esq.	Phil. Mag. vol. xxxvi. p. 318.
From W. of Crater to S.; exploded near horizon.	....	Stone, Aylesbury.	Rev. J. B. Read and Mr. Dell, Aylesbury.	Phil. Mag. May 1850, p. 363.
Perpendicularly down from 30′ E. of α Hydræ, and same alt. over 15°.	....	Highfield House, Nottingham.	E. J. Lowe, Esq.	MS. list.
Crossed Orion	....	Aylesbury.	T. Dell, Esq. ...	Phil. Mag. May 1850.
From R.A. 15°, N.P.D. 20°, through 5° from E. to W.	....	Surat	A Correspondent.	Bombay Times, Mar. 13, 1850. See App. No. 20.
From β Comæ Beren. to just under ϑ Leonis.	....	Castle Donington.	W. H. Leeson, Esq.	Communicated by Mr. Lowe.
From H. 35 to α Cassiopeiæ....	....	Highfield House.	E. J. Lowe, Esq.	MS. list.
From α Draconis through α Urs. Maj. to θ Urs. Maj.	....	Ibid...............	Id.	Ibid.
From E. of ♃ towards N.	....	Aylesbury	T. Dell, Esq. ...	Phil. Mag. May 1850.
From α Urs. Maj. to α Hydræ, through Regulus.	....	Ibid...............	Id.	Ibid.
Through 1° perpendicularly down from α Cephei.	....	Highfield House, Nottingham.	E. J. Lowe, Esq.	MS. list.
From above Sirius to 15° S. ...	....	Aylesbury.	T. Dell, Esq. ...	Phil. Mag. ibid.
From ζ Cancri through 30′ ...	....	Ibid...............	Id.	Ibid.
From 30′ to E. of γ Leonis, to nearly 2° below Regulus ...	....	Highfield House, Nottingham.	E. J. Lowe, Esq.	MS.
From γ Urs. Maj. to near Cor Caroli.	....	Ibid...............	Id.	Ibid.

Date.	Hour.	Magnitude or Brightness.	Colour.	Train or explosion.	Velocity or duration.
1850.	h m				
Mar. 24	9 3 40s	Almost at the same instant; another smaller.	....	....	....
28	8 45 p.m.	....	Red	Train of blue light	....
31	9 5 p.m.	....	....	....	....
April 2	8 30 p.m.	Small	Blue	....	Rapid........
May 1	10 31 p.m.	=5th mag.	Pale yellow ...	Small tail........	½ sec........
	10 33 p.m.	=2nd mag........	White........ ...	No tail........	Slow ....
	11 10 p.m.	Small	Blue	....	Rapid........
30	10 38 p.m.	=2nd mag........	Yellow	....	Rapid........
June 1	10 30 p.m.	Defined globe meteor = ♃, but duller.	Red	No streamers	1½ sec. ....
3	10 30 p.m.	Small, ill-defined, =3rd mag.	Blue	....	½ sec.; rapid........
	10 45 p.m.	=3rd mag.	Blue	....	½ sec.; rapid........
5	Evening ...	Lightning-flashes terminating in *squares* and *balls of fire*, whence again *streamers* flew out, sometimes in straight lines and occasionally in spirals.	....	....	....
6	Between 9 & 10 p.m.	Globular, = moon; much more brilliant.	....	Train of gradually decreasing brightness.	Several minutes.....
	9 15 p.m.	Brighter than gas-flames, as if luminous balls formed out of each other successively.	....	Curvilinear luminous track	....
July 4	8 26 p.m.	= ♃ at brightest.	....	....	....
	9 26 p.m.	Increasing brightness from just visible in twilight to 3 times ♃ in size and 6 times brighter; ill-defined.	Pale blue	At first without sparks; afterwards separated into sparks and disappeared.	2 secs........
5	8 45 p.m.	Bright	....	....	Rapid........
	8 54 2s·42 Grantham mean time (disappearance).	Very brilliant; = ♂ at brightest.	White........	Burst, leaving a train 1° in length.	....

Direction.	General remarks.	Place.	Observer.	Reference.
From nearly same point, but inclined slightly downwards.	....	Highfield House, Nottingham.	E. J. Lowe, Esq.	MS.
From α Pegasus to γ Androm.	....	Aylesbury	T. Dell, Esq. ...	[1850. Phil. Mag. May
From γ Virginis to 3° or 4°E.	....	Ibid..............	Id.	Ibid.
Under ♃; downwards	....	Hartwell House Observatory.	E. J. Lowe, Esq.	MS. List.
Nearly perpendicular; inclining slightly to N. from ψ Draconis over 1°.	....	Highfield House, Nottingham.	Id.	Ibid.
From Spica 5° in direction of δ Corvi.	....	Ibid..............	A. S. H. Lowe, Esq.	Ibid.
Perpendicularly from 5° S. of ♃	....	Ibid..............	Mrs. E. J. Lowe	Ibid.
Horizontally towards S. from δ Lyræ.	....	Ibid..............	E. J. Lowe, Esq.	Ibid.
From γ through φ Cassiopeiæ, across the face of Perseus, disappearing 3° E. of α Persei.	....	Ibid..............	Id.	Ibid.
From α Cygni through Lacerta .	....	Ibid..............	Id.	Ibid.
From λ through η Draconis ...	....	Ibid..............	Id.	Ibid.
....	....	Wingerworth, Derbyshire.	A Correspondent	Derbyshire Courier, June 8, 1850.
From S.W. to N.E.; lost behind hills.	....	Havre	Id.	Journal des Débats, 9th June, 1850. See App. No. 21.
....	Explosion heard ½ min. after disappearance.	Rouen	Id.	Ibid.
In S.E. nearly perpendicular; diappeared at alt. 10° or 12°.	....	Haverhill.........	W. W. Boreham, Esq., F.R.A.S.	Letter to Prof. Powell.
Nearly perpendicularly down, inclining to E. from half-way bewteen χ and ϑ Antinoi to 2° E. of α Capricorni.	....	Beeston Railway Station, Nottingham.	E. J. Lowe, Esq. and Mrs. Lowe.	MS. list.
Down towards E. horizon	....	Oxford	....	Communicated to Prof. Powell.
From alt. between 50° and 55°; perpendicularly down for about 25°; direction from 8° or 10° N. of E.; too much light to see stars.	At Boston "left a smoke behind, and a crackling noise was heard;" no smoke nor noise at Grantham.	Grantham and at Boston.	J. W. Jeans, Esq.	Communicated by Mr. Lowe.

APPENDIX,

Containing details from the original Records of Observations, communicated to Professor Powell, referred to in the foregoing Catalogue.

No. 1.—Note communicated by Lord Wrottesley to Prof. Powell from the Assistant at the Wrottesley Observatory.

"September 4, 1848.

"Standing with my back to the south, at the west end of the Observatory, there came a flash of light from the south which completely illuminated the shrubs and the ground around me. I immediately turned round and there saw a beautiful pale yellow streak, about half an hour west of the star α Aquilæ, the vertex of the streak being about the same altitude as that star, and in length about 25°, perpendicular to the horizon; I saw this streak about 10^s, when it began gradually to dissolve (commencing at the vertex) into a beautiful train of large sparks of a fiery red, and disappeared in about 5^s after. On going into the Observatory to note the time, I found it exactly $8^h\ 45^m$ P.M. mean time. This must have been the train of a meteor, and from the flash it emitted (which was equal to the most vivid flash of lightning I ever saw), it must have been one of an extraordinary size. The night was beautifully clear, large dusky clouds very low in the S.W. horizon.—R. P."

No. 2.—From the Derbyshire Courier, August 25, 1849:—

"Meteor.—On Monday evening, August 20, 1849, about ten o'clock, a splendid meteor was seen to the west of Chesterfield. It was about twice the apparent magnitude and brilliancy of Venus, and moved slowly in an almost horizontal line from north to south, leaving *a train of small stars in its track which speedily disappeared. In a few moments afterwards a long dark cloud marked its path.*"

No. 3.—M. Coulvier Gravier *on Shooting Stars, &c.*—Comptes Rendus, 1849, No. 7, p. 179.

The number of meteors, as we have always remarked, has been very small in the first half of the year; but since the commencement of July, the number has progressively increased, and the maximum has been about the 10th of August.

The following shows the increase for the year, taking the observations for the horary number at midnight:—

1849.	July											August				
	10.	11.	13.	14.	15.	20.	21.	22.	26.	27.	28.	6.	8.	9.	10.	11.
Horary number at midnight	6	8	10	7	10	13	13	12	26	28	33	50	60	107	120	80

Ibid.—No. 21, p. 601.

"The maximum of August rises this year to 120 meteors in a hour, and its duration is about fifteen days. The maximum of November rises to forty meteors per hour, and lasts about thirteen days.

"The maximum of August happens invariably about the 10th, while that of November may happen from the 15th of October to the 5th of December. This year it has been observed from the 15th to the 17th of October. Thus the maximum, which we always expect on the 12th of November, took place twenty-four days earlier, so that the 12th of November had only thirteen or fourteen meteors for the horary number.

"This state of the phænomena is not peculiar to 1849. Since 1841, and especially since 1845, the maxima of August and November, as well as the maxima of less importance in February and May, have always an ascending and descending progress more or less marked and gradual; these appearances never being sudden, as is the case with those periodic returns which come at fixed days and leave no trace behind of their appearance."

The meteors of October 15–17 are also mentioned by A. Von Humboldt, Comptes Rendus, November 26, 1849. See Phil. Mag. January 1850, p. 75. To which he adds the following interesting remarks:—

"I think that many apparent anomalies are explained if we admit that the stream (of cosmical matter) is of a certain magnitude,—a variable magnitude; and that the asteroids in the annular zone are unequally distanced and agglomerated. Have we not seen the comet of Biela divide into two comets since December 19, 1845, each having its tail, advancing parallel at twenty minutes distance from one another? Cosmical nebulæ that have so little *mass*, such as comets, fireballs and shooting stars, must be subject to undergo many transformations in form, direction and velocity."

No. 4.—Letter from W. W. Smyth, Esq., M.A., Mining Geologist to the Geological Survey, to Professor Powell.

"Holywell, Flintshire, Nov. 19, 1849.

* * * * * * * *

"On the 2nd of November I was walking westward along the hill of Gwysanan, the residence of Mrs. Davies Cooke, north of Mold; the sun had just sunk behind the mountains of the Clwydian range, which were in front of me, and the sky was so light and brilliant that I could see no stars for some time afterwards: it was ten minutes after five, when my eye was attracted by an intensely bright white speck falling from a point about 45° above the horizon in a north-westerly direction. As it fell its velocity appeared to decrease, and when, after I had watched it through 30°, it disappeared near a light cirrostratus cloud, I think as much as twenty seconds must have elapsed from the moment of my first seeing it. Indeed, towards the conclusion of its course it seemed to be almost floating, as one may see one of the coloured lights of a rocket, almost stationary in the air. Its vivid brightness was so remarkable, that I remained some minutes on the spot, actually trembling from excitement, and expecting to hear a detonation or some sound indicative of its not very distant fall. In this I was disappointed; but shall be curious to learn whether it happened to be observed by any one else.

"Very truly yours,

"WARINGTON W. SMYTH."

No. 5.—Letter from W. R. Grove, Esq., F.R.S. &c., to Prof. Powell.

"London, Nov. 17, 1849.

* * * * * "The following extract from a letter of a correspondent of mine near Swansea may be interesting to you. He writes, 'Have you seen or heard of a remarkable meteor that passed over the earth on Friday evening the 2nd of November? The following is a description of it:—Time, half-past five, evening; direction from east to west, and to the north of the observer at this place; duration about eight seconds; colour bright red; size about 6 inches diameter, with a tail 3 feet long; the body appeared to diminish as it went along.'

"The place whence this was seen is twelve miles from Swansea, in a direction N.N.E. * * * * My correspondent (Mr. Hill of Swansea) * * * * says it was considerably below the Polar star; the weather was cloudy; but he concludes it was near the lowermost conspicuous stars in Ursa Major. It appears his account was gathered from different observers.

"Yours very truly,
"W. R. GROVE."

No. 6.—Letter from W. R. Birt, Esq. to Prof. Powell.

"Observatory, Old Deer Park, Richmond, Surrey, Dec. 5, 1849.

"My dear Sir,—On the evening of my arrival here I observed a shooting star, which in its features bore very materially on the stars *b*, Nos. 4 and 5 in my former communication*. I annex a copy of my original memorandum made at the time.

"'Nov. 2, 1849, $6^h\ 5^m$ by estimation.—Observed a shooting star pass about two-thirds of the distance between Saturn and γ Pegasi; nearest the star and above Saturn the direction was nearly horizontal towards the south. *I particularly observed that this star did not present the same brilliancy throughout its course, being once or twice* NEARLY *extinguished, but not entirely so, so that the identity of the star was preserved.* It disappeared some distance west of γ Pegasi. Colour and magnitude blue, small, and very variable in its brilliancy.'

"Dr. Lee has communicated to me the following very interesting observation of a shooting star, by Mr. Horton, his assistant. I give you it *verbatim*, as I received it:—

"'October 20th, 1849.—Observed a very brilliant shooting star, which was visible three or four seconds, almost due west, about half-way between the horizon and the zenith at $8^h\ 30^m$ P.M. When first seen it appeared thus  it afterwards burst, and at that moment the whole appeared as follows .'

"In a memorandum added by Dr. Lee is the following remark:—'It was about an hour preceding the star α Aquilæ.'

"I have been very unfortunate in observing these interesting bodies since I have been here. On the 14th of November, in the evening, I looked occasionally for them, but saw only two. My son, who was on the roof with me at the same time, saw six. From all the information I have received, it appears that while they have not been abundant at the November epoch, the character of periodicity has been maintained.

"I have the honour to be, my dear Sir,
"Yours very respectfully,
"*Rev. Prof. Powell.*" "W. R. BIRT."

No. 7.—Extract from Mr. Lowe's MS. communication.

"Nov. 5th, $6^h\ 20^m$.—The meteor fell at a tolerable pace, leaving a thin pencil of red light in the sky in the whole extent of its path, which was 50° in length. This pencil of light lasted visible five minutes, becoming gradually fainter, and altering from a straight line, in $2^m\ 30^s$, to that of a series of waves, thus:— , and in another minute these became twice the width 
The width of the line of light when first formed was = to that of Vega, but now, from the apex of the one wave to that of the opposite wave, it was 35′ (or

* See Report, British Association, 1849, p. 50.

larger than the diameter of the sun). It begun to disappear from each end of its path (*i. e.* when first and last seen), the middle remaining visible the longest.

"On this meteor, which seems to be the same observed by Mr. Jones and Mr. Fasel, Mr. Glaisher makes the following remarks:—

'*Jones.*—	Altitude	when first seen	13°	and in azimuth	68° E. of N.
	„	at explosion..	60°	„	8° W. of S.
'*Fasel.*—	„	when first seen	30°	„	7° W. of N.
	„	at explosion..	38°	„	59° W. of N.

"'The path of the meteor was from E.N.E. to W.S.W., and contrary to the order of the planetary motions. The intersections of azimuths at explosion indicates the meteor to have been vertical over a spot fifteen miles from Montgomery and N.E. of it. Its distance from the earth about eighty miles.' (Glaisher.—Phil. Mag., May 1850.)"

No. 8.—From the Bombay Times, Nov. 17th, 1849.

"A beautiful meteor was seen at half-past six on Thursday evening (8th inst.) rushing from west nearly due east. As seen from the Esplanade, it appeared to disappear over Butcher's Island: it was in the constellation of the Pleiades, then about 20° above the horizon. It was of a bright greenish white colour—disc circular and perfectly well-defined—about four times the size and brilliancy of the planet Venus when at its brightest. When near the end of its career, it threw out a mass of red fragments or sparks, and left a train of these behind it about 10° in length, visible for three or four seconds after the disappearance of the meteor itself, which seemed to vanish at once, without altering its form or size. The air at present is full of the smaller-sized meteors, for which October and November are remarkable."

No. 9.—"About half-past nine the previous evening (Nov. 7th) one of the most magnificent fireballs ever witnessed was observed rushing towards the east. Seen from Mazagon, it seemed to burst over Elephanta, and descend in a perfect stream of blazing fragments. All night long the air was filled with shooting stars of lesser magnitude, but after one such as that alluded to, they seemed scarcely worthy of attention."—*Ibid.* Nov. 14.

"*Meteor at Asseerghur.*—A beautiful meteor was seen at Asseerghur about nine o'clock on the evening of the 9th ult. It travelled rapidly from east to west: the natives describe it to have been the size of a small water-ghurree, from which we should infer that it must have appeared at least four times as large as the planet Venus at her brightest. It lighted up the whole sky for some seconds, as if the full moon had been shining. It burst with a loud explosion, the sound being heard over the whole neighbourhood like that of a heavy gun at sea. By some it was supposed an explosion had occurred at Berhampore; by others, that a mass of rock had fallen. We have not as yet heard of any fragments having been picked up."

No. 10.—Letter from Prof. Chevallier to Prof. Powell.

"Durham, Jan. 11, 1850.

"My dear Sir,—With respect to the meteor seen here on the 19th of December last, the account which I have gathered from four intelligent persons, one of them Mr. Carrington, the observer at Durham Observatory, is as follows:—

"'The meteor appeared at $5^h\ 15^m$ Greenwich mean time, December 19th, 1849, in the N.W. by W. quarter, at an altitude of about 10°. The altitude is estimated from the position of the meteor with reference to the star in the tail of Ursa Major, the meteor appearing to have half the altitude of those stars.'

"Its size was estimated by Mr. Carrington as twice that of Mars, as now seen in opposition, both in magnitude and brightness. Another person considered it to be six times larger than Jupiter.

"Its motion was parallel to the horizon from N.W. by W. to about N.E.: its progress was quite steady and uniform, continuing for twenty or thirty seconds of time.

"The bright head was followed by a tail, the length of which is estimated variously. Mr. Carrington considers it to have been 20′ or 25′: the other observers estimate it at from 6 to 10 diameters of the moon, or from 3° to 5°. Before the meteor disappeared, its head broke up into three or four fragments, which followed one another horizontally till the whole gradually disappeared. No sound was noticed after the disappearance of the meteor.

"I have written to several parts of Great Britain and Ireland, with a view of comparing observations of the meteor made elsewhere; but I have not heard of its being seen anywhere but at Edinburgh.

"By a letter dated January 8th, from M. Piazzi Smyth, I find that it was seen at Edinburgh by Mr. James Stirling, C.E., who perceived it pass across the opening of a street, and has since measured the altitude of the part of the house where the body disappeared. He found it about 8° 20′, and is quite sure it could not have been 9°.

"Professor Forbes and Professor Kelland also saw it; and Prof. Forbes published an account of it in the 'Edinburgh Courant' of December 20.

"The altitudes of the meteor, as seen at Durham and Edinburgh, are sufficiently consistent on the supposition that the meteor had but very small parallax; and Mr. P. Smyth informs me that the same conclusion follows from several accounts which Prof. Forbes has collected from various parts of the country.

"As you are the centre to which all information of this kind converges, you will probably have already received intelligence of this meteor.

"About a quarter of an hour before its appearance (that is about 5 P.M.) a bright falling star passed downwards vertically near the Pleiades.

"Believe me, yours very truly,

"*Prof. B. Powell.* "TEMPLE CHEVALLIER.

"P.S.—Since writing this, I have found a copy of the printed account, which I enclose.

"'*Brilliant Meteor seen at Durham*, 1849.—In the evening of December 19, at 5^h 15^m mean Greenwich time, an unusually bright meteor was seen at Durham, in the northern part of the sky. By a comparison of three different accounts, it appears that the meteor was first observed in the north-west by west quarter, and moved slowly in a horizontal direction from west to east, disappearing nearly north by east, thus moving through 65° in about half a minute. Its altitude, obtained by referring the meteor to the tail stars of the Great Bear, was about 10°, half the altitude of those stars. The head was estimated by one observer, accustomed to notice the heavens, to be twice the brightness and twice the apparent size of Mars, as now seen in opposition; and by another observer to be four times as large and bright as Jupiter. The meteor had a tail nearly straight, which became sensibly longer as the meteor advanced. The length of the tail was estimated by one of the observers to be less than the diameter of the moon, about 20′ or 25′: another estimated it at six, and another at ten diameters

of the moon. Such differences of impression are likely to arise in a case where a sudden phænomenon takes place, under circumstances in which the judgement cannot be corrected by even rough measurement, or by subsequent examination. It is probable that the tail of this meteor may have been at least four or five diameters of the moon, or about 2° or 3° in length. Before the meteor disappeared, the head broke up into three or four fragments, which continued to follow one another horizontally, and then the whole very gradually disappeared. There was no sound heard as of any explosion. It would be desirable to obtain accounts of this meteor as seen in other places, and especially in places further north, with a view of determining its altitude.
"'C.'"

Account of a remarkable Meteor, seen December 19, 1849. By Professor J. D. Forbes.

[From the Proceedings of the Royal Society of Edinburgh, vol. ii. No. 39.]

On the evening of the 19th December 1849, whilst walking near the southern part of Edinburgh, about fifteen minutes past five, Greenwich time (as I afterwards estimated), I observed a meteor, fully brighter than Venus at her average brilliancy, moving from W. towards N., parallel to the horizon, elevated 15° above it, and followed by a distinct luminous train. This angle was subsequently taken by estimation by daylight, with the aid of a theodolite; and the compass-bearing of the meteor, when first seen, ascertained in the same way, must have been 47° W. of N. When it bore 29° E. of magnetic north, it was observed to have divided into two, the one part following the other at some distance; and I soon after lost sight of it in the obscurity of the smoke of the town. When it split, its altitude was estimated at 6°. It thus described an arc of no less than 76°, in doing which it occupied, as I roughly estimated, about fifteen seconds, or possibly more.

Having sent a short notice of the appearance of the meteor to the *Courant* newspaper, I received from many quarters accounts of its having been seen under circumstances remarkably similar to those just described. I believe that nearly forty communications on the subject have reached me from places included between Longford, in the centre of Ireland, to near Bervie, in Kincardineshire, a distance of above 300 miles, in a direction nearly N.E. and S.W., whilst in a perpendicular direction, or from N.W. to S.E., the range of observation has been comparatively small; for I have received no information from beyond Renfrew in the one direction, and Durham in the other, being about 149 miles distant in a straight line. The meteor was seen at Longford, in Ireland, 74 miles west of Dublin, but not in Dublin itself. It was seen at Belfast, between Carlisle and Gretna at Stewarton in Ayrshire, at Johnstone, at Paisley, Renfrew, and by many persons in Glasgow and the neighbourhood. It was also generally seen in Edinburgh, in East Lothian, near Melrose, and at Durham, as already mentioned. Further north, I have received accounts from Crail, St. Andrews, Dundee, Perth, and Johnshaven to the north of Montrose.

The greater number of these communications concur in estimating the direction of the motion of the meteor to have been from S.W. to N.E., although, as might be expected, they vary excessively as to its distance and magnitude; being described by some persons as only 50 or 100 yards off, and as large as the moon; by others, as a ball of 9 inches in diameter, or the size of a large egg. One person only professes to have heard a sound. The time during which it was seen was variously estimated. At Longford, by Mr. Curtis, 20 seconds; at Glasgow, by Mr. Stevenson, at 20 seconds; at Johnstone, by Mr. Cunningham, 15 seconds; at Perth, 15 or 20 seconds;

at Durham, by Mr. Carrington, 30 seconds; at St. Andrews, 15 seconds according to one observer, and 18 to 21 seconds according to another; at Johnshaven, $\frac{3}{4}$ths of a minute. The hour of the appearance of the meteor, in most of the descriptions, is stated at between $5^h\ 10^m$ and $5^h\ 16^m$.

The arc of the horizon which it was seen to traverse depended, of course, on the point where the meteor first caught the observer's eye. At Granton, it was traced by Professor Kelland through 125° of azimuth; at Perth, 130°; at St. Andrews, 74°; at Edinburgh, 76°; at Durham, 65°; at Glasgow, from 60° to 70°. The division of the head or nucleus into several parts, and, first of all (in most cases), into *two*, has been noticed with remarkably slight variation; consequently, the explosion of the meteor marks a well-determined point in its path. The separation was specially noticed at Edinburgh, Granton, Glasgow, Renfrew, Melrose, Haddington, Johnshaven, Perth, Durham and St. Andrews.

In a majority of cases a luminous train was observed; and I am confident that the existence of this train, which has been estimated from 2° to 3° long, cannot be questioned. Dr. Adamson, however, especially remarked that no train was to be seen at St. Andrews.

On revising the whole accounts, it does not appear that any of them can be relied upon for ascertaining the position of the meteor in space, except the observations of Mr. Carrington of the Durham Observatory; of Professor Kelland, Mr. Stirling and myself, at Edinburgh; of Dr. Adamson and another observer, communicated by Professor Fischer of St. Andrews; of a young gentleman at Perth, communicated by Thomas Miller, Esq., Rector of the Perth Academy; and of A. D. Stevenson, Esq., and W. Gourlie, Esq., jun., at Glasgow. My inquiries were chiefly directed to the two following points; *first*, the angular elevation of the meteor in the N.W. quarter of the heavens, where it is admitted by all that its path appeared almost horizontal; *secondly*, to the bearing of the meteor at the instant of explosion.

At Durham, Mr. Carrington saw the meteor first when the bearing was true N.W., the altitude (by theodolite) was then 10°, or not exceeding 11°; when it burst, it was due N. (true), and continued to move 10° or 12° further before it disappeared. Professor Chevallier, who obligingly communicated these results, states that the meteor appeared rather to rise as it approached the north, but with a doubt. This supposition, however, appears inadmissible, from the unanimity of the other accounts.

At Granton, near Edinburgh, Professor Kelland caught sight of the meteor a little to the N. of the moon, and several diameters below it. This corresponds, by after estimation, with a theodolite, to 75° W. of magnetic N., and an altitude of 12°. Professor Kelland thinks that it rather rose afterwards. It split into two at 20° E. of magnetic N., having then an altitude of only 5°; it continued for a considerable time bright, then began to fade, as if by the effect of distance, and also to separate into several parts; it was finally lost sight of 50° E. of magnetic N. (this bearing is well-ascertained), with an altitude estimated at only half a degree. The position and circumstances of these observations, made at an elevated station above the Frith of Forth, were eminently favourable.

Mr. J. Stirling, civil engineer, looking up North Hanover Street, Edinburgh, saw the meteor separate into two parts; the bearing he afterwards estimated at 25° E. of magnetic N. (the probable error not exceeding 1°), and the altitude at 8° 30′, certainly not exceeding 9°.

I think we may conclude, that at Edinburgh the meteor attained a maximum elevation of 15° (that mentioned in the commencement of this paper), since it no doubt rose after Professor Kelland first saw it to the S. of the true

W., with an altitude of only 12°. The course of the meteor was evidently such as to be nearest the spectator when in the true N.W. or W.N.W.

The place of the meteor when it burst stands thus:—

Kelland,	N. 20° E. (mag.)	Alt. 5°.
Stirling,	N. 25° E.	Alt. 8° 30′.
Forbes,	N. 29° E.	Alt. 6°.

The average is almost 25° E. of N., or about 1° W. of the true meridian, the variation being nearly 26°. The mean of the three observations of altitude would be 6° 30′; but admitting Mr. Stirling's to be entitled to the greatest confidence, we may suppose it 7°, or possibly a little more.

At St. Andrews, the meteor was seen by Dr. Adamson, when riding in a northerly direction, on the Largo road. Professor Fischer was so kind as to accompany him afterwards to the spot, and to reduce his observations with all the accuracy of which they were capable. It was first noticed when bearing 8½° W. of magnetic N., and disappeared at 42½° E. of N.; the altitude was conjecturally stated as between 14° and 18½°, and it appeared to move horizontally, but rather declining towards the N.

After describing three-fourths of its course, it split into two parts, which went on close together for a little, then broke into four or five, became dull red, and rapidly disappeared; the separate pieces travelling on together until the last.

Another intelligent observer near St. Andrews, whose evidence was taken by Mr. Fischer, first saw the meteor 29¾° W. of magnetic N., and estimated the point where the meteor burst at 44° E. of N.; but this last number coincides so closely with Dr. Adamson's estimate of the point of final disappearance, that it is perhaps allowable to suppose, that this second observer had mixed up these two events in his description. Dr. Adamson's statement, that one-fourth of the arc which he saw was described after the meteor had split, would give an azimuth at that moment of almost 30° E. of N. magnetic, or 4° E. of N. true, as Mr. Fischer determined the magnetic declination to be about 25° 46′. The altitude of the meteor, as seen by this observer, appears not to have exceeded 15° (the same as at Edinburgh); which number we shall therefore adopt.

At Perth, the passage of the meteor was seen from the North Inch, by a young gentleman of intelligence, whose observations were reduced to numbers by Mr. Miller, Rector of the Perth Academy, who was so good as to accompany him to the spot, and take the angles with a theodolite. Its bearing, when first seen, was 46° S. of W. true; its angular altitude was at that time only 3° 30′. This is by far the most southern azimuth which has been observed. Its bearing, when it disappeared, was 6° W. of N., but it was then lost in a cloud. If I understand right, it had by this time separated into fragments. Its apparent altitude in the middle of its course was about 17° 30′. These observations, extending over an arc of 130°, taken along with Professor Kelland's, clearly demonstrate that the meteor appeared with a very low altitude in the S.W. quarter of the heavens, and disappeared in a similar way in the N.N.E., attaining its greatest elevation about W.N.W. (true).

At Glasgow the meteor was very generally and well seen. Mr. William Gourlie, jun., saw it move from S.W. to N.N.E., over an arc of 60° or 70°, and divide into two, when it bore 40° E. of magnetic N. He estimates its greatest elevation at 30°, and that it decreased to between 15° and 17°, or even less, at the time of its separation: he adds, that he is not much accustomed to such observations. Mr. A. D. Stevenson, living in South Portland Street, Glasgow, saw the meteor moving along at a height just sufficient to clear the chimney-tops, on the west side of the street; an elevation which he afterwards estimated, as he states, with considerable accuracy at 28°. I have received further and more minute accounts of the appearance of the meteor from Mr. Stevenson, who has been most kind and intelligent in his communications; and my friend Mr. James Peddie has verified the accuracy of Mr. Stevenson's observations beyond the possibility of mistake. It appears that the meteor passed quite clear of a stack of chimneys on the opposite side of the street, which would give it a well-defined minimum altitude of 25° 41′; but Mr. Stevenson is of opinion that it rose more than 2° higher, or to not less than 28° (perhaps even to 28° 21′); when it was highest, its bearing was $52\frac{1}{2}$° W. of N. (magnetic), and it disappeared from his view when it bore 40° 27′ E. of magnetic N. *It was then decidedly single.* Now this bearing coincides with that at which Mr. Gourlie observed it to become *double*; and, consequently, the limit towards the N. of this event is severely defined.

The following table contains the most definite of these observations, and the azimuths are all reduced to the true meridian :—

	Greatest altitude.	True azimuth when first seen.	True azimuth of disappearance.	Arc observed.	True azimuth of first explosion.	Altitude at first explosion.
Durham ...	10° 30′	N. 45° W.	N. 12° E.	57°	N.	
Edinburgh	15°	W. 11° S.	N. 24° E.	125°	N. 1° W.	7°
St. Andrews	15°	N. 55° W.	N. 16° E.	71°	N. 4° E.	
Perth	17° 30′	W. 47° S.	N. 7° W. (in a cloud)	130°	?	
Glasgow ...	28°	....	....	100°?	N. 14° E.	15°

Remarks on the Observations.

1. On the whole, these observations are not consistent, and cannot (I conceive) be cleared up without additional and accurate ones, which it may now be too late to procure. The central group of stations, Edinburgh, Perth and St. Andrews, are sufficiently accordant, and indicate that the path of the meteor must have been nearly parallel to a line passing through the first and last of those places, or in a direction N. 27° E. (true); which accords well with the observations at most of the individual stations, and particularly with the *vanishing direction* in Professor Kelland's remarkable observation at Granton.

2. The Durham observation is compatible with the above-mentioned group within the limits of error. By the combination of Durham and Edinburgh (the base line perpendicular to the assumed direction of the meteor's motion being 95 miles), I calculated that the meteor passed vertically nearly over the island of St. Kilda, with an absolute elevation of about 88 miles. But this solution seems absolutely excluded by observations at Glasgow which admit of no question, and which I have spared no pains in verifying. Had the position of the meteor been such as I have first assumed, it could not possibly have been seen over even the roofs of the houses from the station occupied by Mr. Stevenson, much less over the chimney-tops. The bearing, at the moment of explosion at Glasgow, also singularly enough corroborates sufficiently well the comparatively small elevation (about twenty miles above the earth) which the combination of Edinburgh and Glasgow gives; and this bearing we have seen to have been also accurately defined by the physical obstacles bounding the observer's view; it would have given a parallax of 15°, subtended by the perpendicular on the meteor's path, referred to Glasgow and Edinburgh respectively. Now, if this calculation were anything like

correct, the Perth observation is entirely wrong; and the meteor could not have risen about 6° above the horizon of Durham, instead of 10° or 11° as estimated. I am unable in any degree to explain these conflicting results.

3. The observations of Professor Kelland at Granton, and those at Perth, through the great azimuths of 125° and 130°, described by the meteor with such remarkable deliberation of motion, lead, when analysed, to the very same results which presented themselves to the mind of the spectator intuitively; namely, that the motion must have been sensibly rectilinear, equable and parallel to the horizon at Edinburgh. Assuming that the greatest altitude at Edinburgh was 15°, and the bearing then N. 63° W. (true), we may calculate that the altitude should have been on this hypothesis, when first seen by Professor Kelland, 11° 47′, instead of 12° as observed; at explosion, 6° 59′ (7° observed), and at its final disappearance 0° 47′ (instead of 0° 30′ observed). Again, at Perth, the observed altitude, when first seen, was $3\frac{1}{2}$°, and the calculated altitude 5° 3′, taking the maximum altitude at $17\frac{1}{2}$°. The coincidence is, on the whole, remarkable, though it would be rash to push it to an extreme, as an error of some degrees may exist in the assumption of the direction of the meteor's course. Some later observations, received from Mr. Curtis at Longford, and a consideration of the effects of perspective at Perth and Edinburgh, incline me to admit that the path might make an angle 3° or 4° greater with the meridian than I have above supposed. These conclusions are independent of the actual distance or parallax of the meteor; which, as I have said, cannot be determined without further observations, which I should be glad to receive from any quarter, but more particularly from Ireland, and from the centre and N.W. of Scotland. If correct, they entitle us to infer that the meteor in question was most probably a body moving in space, in a path little curved, and not revolving round the earth.

No. 11.—From the Bombay Times, March 13, 1850.

"'Palinurus,' at sea, February 21st, 1850.—The following memorandum of meteors lately seen, I hope may prove interesting to you:—Feb. 7th, latitude 24° 53′ N., longitude 66° 16′ E. at 7 P.M., a large meteor, about $\frac{1}{8}$th the diameter of the moon, appeared to the eastward, about 40° elevation, and vanished to the north-eastward, about 25° elevation."

No. 12.—*Ibid.*

"February 10th, latitude 24° 18′ N., longitude 66° 30′ E., at 8·30 P.M., a large meteor, at least $\frac{1}{6}$th the diameter of the moon, appeared, elevated 8° S.S.W., and disappeared again instantly about 2° to the southward. This meteor displayed a most brilliant light, and had a clearly defined short tail, not more than four times the diameter of its body in length."

No. 13.—Meteor of February 11. The following details may be of interest in addition to the particulars given in the table.

[From the Derbyshire Courier.]

"Southgate House, Feb. 14, 1850.

"Sir,—In looking over this morning's 'Times,' there appear two letters, one dated from Oxford, the other from Lambeth, mentioning the appearance of a most extraordinary body in the heavens, which took place between ten and eleven o'clock on Monday last, the eleventh inst. On the same evening, Mr. Henry John B. Bowdon and myself were returning home from Mount St. Mary's, which place we left shortly after ten o'clock, and just before we arrived at home, it being a particularly dark night, the entire atmosphere of a sudden became illuminated with the most brilliant light. Astonished at the circumstance, we all at the same instant looked out of the carriage window, and beheld a most brilliant substance descending towards the ground. It appeared not more than fifty or sixty yards from us. The head of the light appeared of the most splendid and brilliant red colour, whilst the tail was of a pale bluish tinge. It had very much the appearance of a sky-rocket, though much larger and brighter. Just before reaching the earth it seemed to explode, though we could hear no noise. This took place about twenty minutes or a quarter before eleven o'clock on Monday night.

"If you think this curious appearance, which has shown itself at nearly the same time in places so distant from each other, worthy of a place in your columns, it is much at your service.

"I remain, Sir, your obedient Servant,

"PETER C. MAXWELL."

No. 14.—The following account is most remarkable with respect to the mode of disappearance of the meteor.

[From the same Journal.]

"Mr. Whitmore of Kennington Lane, Lambeth, says, 'On Monday night, at about a quarter or ten minutes to eleven o'clock, a very beautiful shooting meteor of dazzling appearance was visible in the heavens, taking, as it seemed to me, a direction bearing west to east. The night in the early part of it had been rainy, with a fair amount of wind, from the westward and southward (as during the day), but at the time of the above luminous appearance it had partially cleared off, and the stars were visible, with only a few light clouds, which served materially to heighten the effect when illuminated. The course the light described was a fine curve, commencing with a small feathery appearance, gradually expanding in width and radiance as it proceeded, and its duration was of some seconds. At first it occurred to me it was a trial rocket of some description, as it dropped precisely as they do when near exploding, but it afterwards lighted up still more brilliantly, and resumed its course with increased splendour, leaving in its track a long train of intense light. It appeared rounded or bulbed at its head or point of combustion, and went off to an elongated taper, as some of the comets have been represented. Its altitude I should judge was not great, as its edges were distinct, and one slight wave in its progress was to me very discernible. As it brightened it displayed the most lovely colours, which could be distinctly traced to the radial colours produced by the sun—at one period green, violet (deep), pale red, &c., and their effects through the thin stratum of clouds which were in its path were most gorgeous. *Before vanishing it appeared to roll over, like to something molten, and contracting all its light at once, suddenly disappeared.* It was perfectly silent, although my expectation was that from its extent and brilliancy a report might possibly be produced.'"

No. 15.—"The following is from Manchester, which also differs from the others in some respects:—In passing along Renshaw Street, Hulme, on Monday night, at ten to eleven o'clock, I saw the most singular phænomena that I ever heard of, in the form of a meteor. I observed what appeared to be a bright star, situate about E. by S., when suddenly it fell straight downwards, leaving a stream of fire of the most beautiful colours—crimson, purple and green. The light was so great from it, that it cast my shadow along the ground, as clear as at noonday. It appeared to burst in the air like a rocket, and made a noise like distant thunder, accompanied by a thick cloud all around the light.

Several parties who saw the light, but not the meteor, supposed that it was caused by vivid sheet lightning, until I undeceived them."

No. 16.—These appearances are further illustrated by the very graphic description contained in the following letter to the author from Mr. F. Barnard:—

8 Cross Street, Islington, London, Feb. 12, 1850.

"Sir,—Since the month of May 1848, when I sent you a short account of a meteor I had seen, I have had no opportunity of repeating any similar observation until last night, when, in common with many others, I had the good fortune to see the phænomenon of most extraordinary size and brilliancy. The circumstances were as follows:—At eighteen minutes to eleven, my sister and self were walking in a southerly direction through Holloway, when we were startled by a greenish white light that suddenly lit up the whole scene in front of us. At first I thought it was lightning; the quantity of light flung round seemed equal to that from a vivid blaze of lightning, but it *continued* with a slight glimmer. This was all conceived before I turned round and beheld a large and intensely bright meteor traversing the sky, almost from west to east, perhaps a trifle to north. The most remarkable feature besides its light, was its duration and slowness. *It appeared almost to struggle with the atmosphere—if it was within our atmosphere—with an undulatory motion, just as the electric fluid is zigzaged by atmospheric resistance, so this meteor appeared to be alternately impeded on this side and on that.* It *meandered*, it *trickled through the sky*; and as it moved, gave off a succession of balls or sparks which stretched out in a tail of some length, and vanished as rapidly as the nucleus proceeded. In fact, it might well have been mistaken for a rocket, but that it was lofty, horizontal and *silent*.

"This was somewhat of its appearance, though it is difficult to form a definite image of such an object. The time that it was visible was, I think, about four, perhaps five seconds. I find that either itself or its light has been seen by a great many; indeed I suppose more have seen it than have not, and from various parts of the metropolis. You cannot fail, I think, to hear of it from numerous correspondents; but from many accounts the *truth* is extracted. So this comes from, Sir,

"Yours very respectfully,

"*To Rev. Baden Powell.*" "FRANK BARNARD."

No. 17.—Mr. Lowe has favoured me with the following details (besides those inserted in the Catalogue).

"February 11th, $10\frac{1}{2}^{h}$.—Tail and all together = size of ☾; much brighter than ☾; colour yellow, with yellow light for tail, excepting round the edge of the tail, where was a purple light. When it disappeared, it broke up like a rocket into separate stars and almost instantly disappeared, leaving a slight stain at the spot for about half a second. The edge of meteor was well-defined. * * * * * I regret I did not see it, though I watched until within a minute of its taking place; but a dense cloud rising rapidly, I left off observing, unluckily too soon, as it occurred before the cloud came over. The cloud discharged much snow. It was seen in Nottingham by G. Allcock, jun., Esq., and at Beeston, by the Rev. J. Wolley."

No. 18.—Mr. Glaisher has collected a large number of details of the observations made on this meteor. The following are a few particulars, both

from that paper and other sources, bearing on the *physical* characters of the meteor. [The numerals refer to those in Mr. Glaisher's paper.]

(iii.) It had a train, besides which it threw off sparks literally.

(xx.) Before disappearance it emitted numerous sparks from the end of the tail.

(xxxv.) At first it was of the size of an ordinary meteor; it increased as it went on.

(xxxvi.) The tail was conical from the head, throwing out sparks before disappearance; it had a wavy motion.

(xli.) Fireballs in profusion fell from the tail.

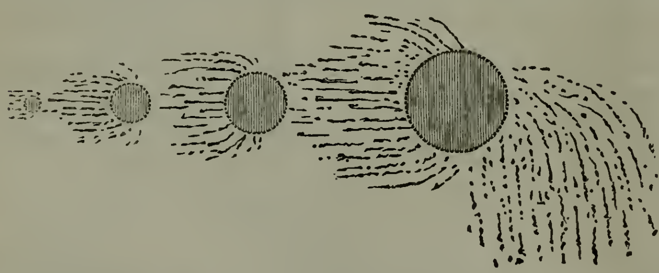
(xliii.) It burst at alt. 30°, but did not disappear till it had descended to 25°; at 2° or 3° above 30° it separated into six bodies, which spread very little laterally.

Mr. Glaisher thinks (p. 271) from the violence of the report that it must have been the bursting of a solid body by expansion of an elastic fluid. Some fragments may probably have fallen near Biggleswade (Bedfordshire). It seems certain it must have come from regions beyond the influence of our vapours: this circumstance, its extreme velocity, and intensity of light, are more conformable to the nature of a solid than a gaseous body.

One of the most remarkable observations is that of Mr. Hind, who says, (x.) "the appearance of its light was such, that in my idea no doubt can be entertained but that it was of *electrical origin*; it moved precisely in the direction in which the *wind* was blowing at the time."

No. 19.—At Oxford, Mrs. Baden Powell described the appearance as of a small globe advancing, and rapidly expanding by three or four successive jerks or bursts, at each burst remaining stationary for an instant, and thus forming successively larger globes—intensely bright and blue, all the while emitting a stream of sparks on each side, till the final globe was nearly as large as the moon, which dissipated into brilliant globules, shot off in all directions, and appearing to fall. It was compared by another person present to an umbrella pushed onwards, and alternately opened and shut rapidly.

The subjoined sketch gives an idea of this peculiar appearance, it being understood that the globes here represented were in reality seen in *succession*.



This peculiarity bears a close resemblance to that represented in Mr. Wyatt's engraving. Also in the accounts collected by Mr. Glaisher several of the observers allude to what was apparently the same appearance. Thus (xxvi.) "A bar of light with sparks issuing on every side, advanced with a jerking motion."

(vi.) After explosion it was followed by three globes in the same direction.

(viii.) The Astronomer Royal saw a brilliant body, followed by two others close behind it.

(xxi.) "Like an enormous flaming umbrella opened and shut alternately."

No. 20.—From the Bombay Times, March 13, 1850.

"Surat, 7th March, 1850.—I send you the following, believing it will interest you. On Wednesday evening, 6th, at nine o'clock, a beautiful meteor burst suddenly into sight in a quarter of the heavens to which my eye was at the instant directed, viz. R.A. 15°, N. P. D. 20° (very nearly). It remained in sight but a moment, and was in brilliancy, size and colour like Sirius; and its appearance and disappearance were quite startling from their suddenness. It passed over about 5° of the heavens from east to west, leaving behind it a train of dull red sparks of the same length, strikingly resembling a comb, the teeth pointing downwards towards the horizon. The train descended very slowly, and the teeth, as it were, gradually shot out from each, and downwards, increasing in length as they approached the centre, until the train assumed the form of the Roman letter V, the angle being composed of large egg-shaped drops, like molten iron, and the intermediate space between the lines forming the letter, filled with parallel vertical lines of sparks. This appearance gradually faded from the sight (without altering in shape), very like the colour disappearing from a piece of heated iron as it cools. It had descended about 5°, when it finally disappeared: it remained in sight full fifteen seconds, I counted fifteen slowly, and did not begin to count till a second or two after the disappearance of the meteor. If the accepted theory is correct, perhaps I shall not be wrong in assuming that the meteor must have cut a chord of an arc through the verge of our atmosphere, the outer surface being fused and thrown off in its passage, the principal body continuing its course through space beyond the limits of the atmosphere, the attraction of some other body acting more powerfully upon it than that of the earth, which, by the way, it is difficult to conceive.—URSA MINOR."

No. 21.—From the Journal des Débats, June 1850.

"On écrit du Havre, le 6 juin:

"Hier, entre neuf et dix heures du soir, un météore lumineux a été observé dans le firmament au dessus de notre ville. Il affectait la forme d'un globe de feu du diamètre de la lune dans son plein, mais brillait d'un éclat beaucoup plus vif. Après avoir suivi la direction du sud-ouest au nord-est, laissant après lui une traînée lumineuse d'une longueur de trente mètres environ, dont la clarté allait graduellement s'effaçant, il a disparu, au bout de quelques minutes, derrière les hauteurs qui dominent la ville.

"Le même phénomène s'est produit presque simultanément à Rouen et au Havre. Voici ce qu'on lit à ce sujet dans le 'Journal de Rouen:'

"Hier soir, vers neuf heures un quart, un brilliant météore a tout à coup projeté sur notre ville une vive lumière, qui l'a entièrement éclairée pendant quelques secondes.

"La journée, qui avait été très belle, pouvait cependant faire craindre un orage, tant la chaleur était forte et tant l'air était raréfié. Chacun ressentait cet alourdissement général de tout le corps, suite du peu de densité de l'atmosphère trop dilatée par un soleil ardent.

"A la fin du jour, quelques nuages parurent çà et là; bientôt ils se réunirent vers le Boulingrin, mais pour se dissiper très promptement. A neuf heures un quart, le ciel était pur et l'obscurité assez peu sensible, lorsqu'un globe de feu éclata sans bruit dans l'atmosphère. Il semblait être à la distance de terre qu'atteignent habituellement les fusées à étoiles.

"Ce météore répandait une magnifique clarté, plus vive que celle du gaz de l'éclairage, et d'une coloration s'approchant de la couleur aurore. A peine eut-il annoncé sa présence, qu'il décrivit dans le ciel une courbe lumineuse s'étendant de l'est à l'ouest. Cette courbe se forma de la manière suivante : de la première boule de feu, grosse comme un œuf, sortit une autre boule qui se détacha sous la forme d'une larme ; de cette larme, subitement arrondie, il s'en détacha une seconde, de cette seconde une troisième, et de la troisième une quatrième ; puis, de ces sortes de larmes qui s'étaient successivement éteintes à mesure qu'elles s'étaient engendrées, la dernière disparut, et la nuit reprit son empire. Une demi-minute après, un unique coup de tonnerre se fit entendre. Rien autre chose n'est venu troubler l'atmosphère, qui toute la nuit a été des plus calmes."

No. 22.—The following details have been communicated by Dr. Buist of Bombay.

Meteoric Stone presented to the East India Company's Museum.—The following is an authentic account of a meteoric stone which was lately brought from India by Lieut.-Col. Penington, and presented to the Hon. E.I. Company, who have deposited it in their museum.

Extract of a letter from Capt. G. Bird, first assistant in the Political Department to Major-Gen. Sir D. Ochterlony, Bart., K.G., C.B., to Major Penington.

"Loodianah, 5th April, 1815.

"My dear Major,—I lost no time, after my receipt of your letter, to take the measures for obtaining the information you desire relative to the meteorolite which lately fell near the village of Dooralla. Accounts of this extraordinary phænomenon had spread over the whole of the Seikh country; and for more than a month before your letter reached me, the account of its fall, connected with a great number of wonders, had been reported to me, and that the people from all the neighbouring villages had assembled at Dooralla to pay their devotions to it, but now, after a very full inquiry, I feel quite satisfied that you may rest confident in the accuracy of the following statement. On the 18th of February last, about noon, some people who were at work in a field about half a mile distant from the village of Dooralla, were suddenly alarmed by the explosion of what they conceived to be a large cannon, 'the report being louder than that of any other gun they had ever heard,' which report was succeeded by a rushing noise, like that of a cannon-ball in its greatest force. When looking towards the quarter whence the noise proceeded, they perceived a large black body in the air, apparently moving directly towards them, but passing with inconceivable velocity, buried itself in the earth, at the distance of about sixty paces from the spot where they stood. As soon as they could recover from the terror with which this terrific vision had appalled them, they ran towards the village, where they found the people no less terrified than themselves, who, though not having seen the stone, imagined that a marauding party was approaching, and, as but too frequently happens, would sack their village. When the brahmins of the village were told what had really happened, they determined to proceed, and were followed by all the people to the spot where the stone fell, having with them instruments for digging it out. On their arrival at the place, they found the surface broken and the fresh earth and sand thrown about to a considerable distance, and at the depth of rather more than five feet, in a soil of mingled sand and loam, they found the stone which they cannot doubt was what actually fell, being altogether unlike anything known in that part of the country. The brahmins, taking immediate charge of the stone, conveyed it to the village, where they commenced a Poosa, and covering it with wreaths of flowers, set on foot a subscription for the purpose of erecting a small temple over it, not doubting from the respect paid to it by the Hindoos, to turn it to a profitable account. As I said before, it fell on the 18th of February, about mid-day, in a field near the village of Dooralla, which lies about lat. 308° 20′, long. 76° 41′, within the territory belonging to the Pattialah Rajah, sixteen or seventeen miles from Umballah and eighty from Loodianah. The day was very clear and serene, and as usual at that season of the year, not a cloud was to be seen, nor was there in the temperature of the air anything to engage their attention; the thermometer of course may be stated at about 68° in the shade. The report was heard in all the circumjacent towns and villages, to the distance of twenty coss, or twenty-five miles from Dooralla. The Pattialah Rajah's Vakeel being in attendance here when your letter reached me, I desired him to express my wish to the Rajah to have this stone, and as it appears that he had been led to consider it rather as a messenger of ill omen, he gave immediate orders for its conveyance to Loodianah, but with positive injunctions that it should not approach Pattialah, his place of residence. It arrived here yesterday, escorted by a party of brahmins and some Seikh horse. It weighs rather more than twenty-five pounds, and is covered with a pellicle thinner than a wafer, of a black sulphureous crust, though it emits no smell of sulphur that I can discover; but, having been wreathed with flowers while in possession of the brahmins, the odour originally emitted may by these be concealed. It is an ill-shapen triangle, and from one of the corners a piece has been broken off, either in its fall or by the instruments when taking it out of the ground. This fracture discloses a view of the interior, in which iron pyrites and nickel are distinctly visible. Since its arrival, all the brahmins in the neighbourhood have assembled at my tents to pay their adoration to it, and no Hindoo ventures to approach but with closed hands in apparent devotion, so awful a matter is it in their eyes. I shall avail myself of the first escort that leaves Loodianah, to forward it to you."—*Original Communication.*

An uncommon phænomenon appeared on the evening of the 14th, between seven and eight o'clock, which has produced a curious sensation amongst the inhabitants of this settlement. A meteoric globe of fire of about the size of a full moon, when seen in the horizon, approached from the south-east, and passed over the town in a north-west direction, at a height not much above the tallest trees. It was followed by a rattling broken noise, somewhat resembling that of thunder, produced, we suppose, by the bursting of the ball, which took place at some distance from the town. The oldest people in Malacca say they never witnessed such a thing before, and many, not knowing its real nature, consider it a portentous omen for evil. Some very sagely prophesy that there will be war; others that rice will be dearer; and others again aver that the world will soon be at an end; the Malays say that it is an *Antoo Api*, or fire spirit, sent to destroy some wicked man's house; and others that it is the serpent of the sun which has got loose and is going its peregrinations. We understand that a Chinaman, who had been sickly for some time previously, was so terrified by the appearance, that he sunk down in a fit and instantly expired.—*Malacca Obs.*, May 20.

A correspondent of the 'Englishman,' at Dinagepore, gives an account of a fall of meteoric stones at that station. The fall occurred at noon, and was accompanied by a rumbling noise, similar to that which precedes an earthquake, with this difference, that the noise was from *above*. Some of the stones were of considerable size, the largest weighing about four pounds. They were all much alike in appearance, with a thin black crust over them, as if they had been intensely heated. The sky was perfectly clear at the time of the fall.

No. 23.—*Meteoric Stone which fell near Agra on the 7th August*, 1822.—At a late meeting of the Royal Institution of Great Britain, a large meteoric stone was placed on the library table, with a particular account of its fall, in the Persian language. This was translated by Dr. Wilkins. The stone fell in the night of the 7th of August, 1822, near the village of Kadonah, in the district of Agra. It descended with much noise as of cannon and of the wind, awakening those who were asleep, and alarming a watchman who heard it fall. On making a search in the morning the stone was found warm, and with a little smoke arising from it. It is to be subjected to examination.

No. 24.—*Meteor of 3rd November* 1825, *observed at Calcutta.*—Colonel Blacker's third communication gives an account of a singular meteor, having the appearance of an elongated ball of fire, which he observed on the 3rd of November, a little after sunset, when on the road between the custom-house and the court-hall. Its colour was pale, for the daylight was still strong, and its larger diameter appeared greater, and its smaller less than the semi-diameter of the moon. Its direction was from east to west, its track nearly horizontal, and altitude about thirty degrees. Col. B. regrets not having heard of any other observation of this phænomenon at a greater distance, whereby he might have estimated its absolute height. As, however, it did not apparently move with the velocity of ordinary meteors, it was probably at a great distance, and consequently of great size. So long as Col. Blacker beheld it, which was for five or six seconds, its motion was steady, its light equable, and its size and figure permanent. It latterly, however, left a train of sparks, soon after which it disappeared suddenly, without the attendant circumstance of any report audible in Col. Blacker's situation. Col. Blacker concludes his paper with some interesting observations on luminous meteors, and considers them of perpetual occurrence, although daylight, clouds and misty weather, so often exclude them from our view. Of their number no conception can be formed by the unassisted eye, but some conjecture may be formed of their extent from the fact mentioned by our author, that in using his astronomical telescope he has often seen what are called falling stars, shooting through the field of view, when they were not visible to the naked eye; and when it is considered that the glass only embraced one twenty-five thousandth part of the celestial hemisphere, it will be apparent that these phænomena must be infinitely numerous, in order to occur so frequently in so small a space.—*Calcutta Government Gazette.*

No. 25.—*Meteor of 22nd November* 1825, *observed at Calcutta.*—A remarkable meteor was visible on Friday night S.W. of the comet and near it. It appeared in shape at first like a ball of fire, which assumed the form of a vividly brilliant comet. This continued beautifully and powerfully luminous for some minutes, but gradually waxed fainter and fainter, until at length it totally disappeared.—*India Gazette*, Dec. 5.

No. 26.—*Meteors of 23rd June and 24th July* 1832, *observed at Delhi and Meerut.*—Delhi, 28th July 1832. An extraordinary large meteor, or rather three balls of fire, at first arose out of the E.S.E. horizon on the 23rd of last month, and after rising to the elevation of about fifteen degrees, joined into one, forming a large ball of brilliant fire, nearly as big as a full moon in the meridian, and passed over an arc of the heavens of about 115° before it vanished in the W.N.W. The light was very brilliant. This took place about ten o'clock at night, and I suppose but few persons witnessed it.—*India Gazette.*

No. 27.—Another, almost equally big, passed over Meerut a few nights ago, and disappeared with a brilliant and dazzling light in the W.N.W. N.B. The first meteor passed over the city of Delhi, and its greatest altitude was about 70°. It passed to the north of the Juma Musjid.—*India Gazette.*

No. 28.—*Meteors of* 18*th November* 1832, *observed at Bulrampore and Agra.*—The 'India Gazette' contains extracts from two letters, one from Bulrampore, in the Jungle Mehauls, the other from Agra, communicating accounts of a very remarkable atmospherical phænomenon.

"Camp Bulrampore, 13th Nov.

"During our march this morning the sky presented a most brilliant spectacle. Innumerable meteors were flying in every direction, and some of them the most beautiful I ever saw. They appeared to burst finer than the finest sky rockets, leaving a long line of various-coloured light in the heavens behind them, which remained several minutes and vanished gradually. I never saw anything like it before, and I should think it not a common thing in India, for I have travelled frequently at different hours of the night, and never before witnessed a similar phænomenon."

"Agra, 18th November.

"Some nights ago there was a most extraordinary appearance in the heavens. The sky was all one blaze, owing to the number of falling stars."

The same phænomenon was seen at the same time at the three presidencies.

No. 29.—*Meteor of* 18*th March* 1833, *observed at Madras.*—"On the evening of the 18th inst., at 5^h 27^m mean time, a meteor of great brilliancy and magnitude made its appearance towards the N.E., in the constellation Cor Caroli, from whence, pursuing a north-westerly direction for about 3°, through the constellation Hercules, it disappeared at an altitude of 35°. The time it remained visible did not exceed two or three seconds. Listening attentively, at about $6\frac{1}{2}$ minutes after the disappearance a report was distinctly heard, which very evidently proceeded from the bursting of the meteor; the distance resulting from this interval is in round numbers about 81 miles.

"Madras Observatory, 20th Mar. 1833." "T. G. TAYLOR, H.C.'s Astronomer."

No. 30. *Meteors of* 10*th September* 1841, *observed at Calcutta.*—About two in the morning on Friday last, innumerable meteors of surprising beauty were perceptible in the heavens. Vast myriads of shooting stars were seen darting through the air in a S.S.W. direction, leaving a long and brilliant train of light. The whole atmosphere was illuminated, and at one period the light was so great, as to have enabled a person to read the smallest print with the utmost facility. This magnificent spectacle was visible during a period of ten or twelve minutes.—*Englishman*, Sept. 13.

No. 31.—Account of a luminous meteor seen at Charka, lat. 24° 06′, long. 81° 02′, on the morning of the 11th April 1842, by Capt. Shortrede, First Assistant G. T. Survey.

"A little before four o'clock this morning I saw a meteor of a singular appearance, of which the following is an account:—

"I was lying awake outside my tent, and about a minute or two before had closed my eyes, intending to have a short sleep before marching, when my attention was roused by some brilliant light before me. On opening my eyes, I saw a meteor having very much the appearance of a rocket: it was situated in the constellation Scorpio, having its middle about 10° to the westward of Antares, and pointing towards the constellation Corvus, the lower star of which was about 4° above the horizon. The meteor was about 10° or 20° long, and equally bright throughout except at the upper end, where it was rather faint. It continued in the same position and of the same brightness for between two and three minutes as well as I could judge, and then gradually became fainter and fainter, till it lost its brilliancy altogether; and as it began to fade, it began also to become crooked and to move towards the west. It became gradually more crooked, and continued to fade till it became like a thin smoke, and at last vanished away at about 3° or 4° from the place where I first saw it. I listened attentively, but heard no noise. From the time I first saw it till its brilliancy ceased, was probably about five minutes, and in about three minutes more it ceased to be any longer remarkable. I was then at Charka, in lat. 24° 06′ and long. 81° 20′."

"Dewra, 11th April, 1842."

No. 32.—An account of a remarkable aërolite which fell at the village of Maniegaon, near Eidulabad in Khandeesh. Communicated, with a specimen, to the Asiatic Society by Capt. James Abbott, B.A., late Resident, Nimaur.

A chemical examination of the above aërolite, and remarks, by Henry Piddington, Curator, Geological and Mineralogical Department of the Museum of Œconomic Geology.

At the meeting of October 1844, Capt. Abbott communicated to the Society the following documents, with two small specimens of the aërolite.

"Capt. J. Abbott, *Artillery, Dum Dum, to the Secretary of the Asiatic Society, Calcutta.*

"Dum Dum, Sept. 16th, 1844.

"Sir,—In July 1843, I received at Mundlaisir, from the Komarder (or native collector) at Asseer, a report of the fall, in that part of the country, of a meteoric stone, together with a few grains, said to be particles of the same. I immediately despatched a karkoon to the spot, to ascertain the truth or falsity of the statement, and to collect specimens of the supposed aërolite. These accompany my letter. They differ so much from the structure of every reputed aërolite I have previously met with, that I should be inclined to doubt the veracity of the reporters, could I discover any other reason for questioning it. I have never heard any other instance of an aërolite in that neighbourhood. The fact is implicitly credited in the neighbourhood of Eidulabad, where it is said to have occurred. These specimens appear to me to resemble masses of friable rock of the quartz family which I have met with in Malwa. But it is evident that a mass of texture so loose could never have borne unshattered the propelling agency of fire, nor has any volcano existed within the memory of man in Nimaur or Mahiswah, nor, I believe, in Khaundes, although fable declares Oojyne to have been buried beneath a shower of mud, and Mahiswah to have been destroyed by the mischievous malice of a demon. The depositions of the observers I have translated and appended. The spot was beyond, my district, or I would myself have visited it. It is probable that the collector of Khaundes may have reported it to the Bombay Society.

"This report, and the note upon granite in the Nerbudda, were prepared many months ago, but restricted leisure and many concurring events, prevented their being forwarded." "J. Abbott, *Capt. Artillery.*"

Fall of a Meteoric Stone in Khaundes.—Deposition taken by a karkoon, despatched from Asseer by Capt. James Abbott, to collect information upon the subject.

"Oonar, Puttail, and Ghubbahjee, Chowdry, of village Maniegaon, pergunnah Eidulabad, Tuppeh Sowdah, Illaquh Dhooliah in Khaundes, depose as follows:

"Taken July 26th, 1843. On Mittee Asarr, Soodie Teei, Goraur ke din.

We were in our house. At half-past three o'clock P.M., whether from heaven or elsewhere, a prodigious ball (ghybee golah) fell. The noise it made was very great, it might be heard twenty miles round. We heard it with our own ears, and in fear and trembling ran outside to look, as running out we found that it had fallen outside the village on the southern aspect, and that in falling it had been shattered to pieces, some of which had been scattered far. We put our hands upon that which lay together; it felt cool; shortly after it became rather warm. When first we saw it, the pieces were black; after a day's interval the colour changed to blue, and now the fragments are white.

"*Question.* When the ball fell, was any flash perceptible, or was the heaven darkened? Who saw it fall? How large was it? And who heard the noise at the distance of twenty miles?

"*Answer.* We *saw* nothing. When the ball fell, we heard the noise and ran to see what had caused it. The spot on which it fell was hollowed by the shock a span and a half in diameter, and three fingers' breadth in depth. The ball was about the size of a kedgeree pot (ghurrah, *i. e.* about ten inches in diameter); the people of Edulabad and of other parts heard the noise in the clouds, at least so they say. The ball being shattered, people came and carried away the pieces. The remainder was sent to the Sowdah Komardar, and by him to Dhooliah. What remains I give you*.

"True and literal translation. "J. ABBOTT, Capt.,

"Mundlaisir, August 1843." *Pol. Asst., in Nimaur.*"

"*Note.*—A few grains of this aërolite were first sent me by letter from Asseer. I despatched a karkoon immediately to the spot, to make inquiries and collect as much of the fragments as possible, supposing that he would have cause to believe the report well-founded. The greater part of what he collected accompanies this report. It agrees exactly with the grains first sent me.—J. ABBOTT."

At Capt. Abbott's suggestion, the collector of Khandeish, J. Bell, Esq., Bomb. C. S. was written to, and he has kindly forwarded us a few small fragments more, with the following letter and deposition.

"*To* W. W. BELL, *Esq.*, *Collector of Khandeish.*

"Sir,—With reference to your Mahratta Yad of the 5th ultimo, with enclosure from the Secretary to the Asiatic Society of Bengal, requesting me to transmit any information along with specimens procurable of an aërolite that fell in the month of July 1843, in the vicinity of the village of Manegaum of this talooka, I have the honour to transmit translation of a deposition given before me, by a couple of individuals who were spectators of the fall of the aërolite in question, along with five small specimens of the same, all that I have been able to procure after much search; these however I trust will be sufficient to indicate the nature of the meteorolite.

"I beg to return your enclosure, and to remain, Sir, your most obedient Servant," "C. INVERARITY, *Acting* 1*st Assist. Col.*"

"Camp, Circuit at Rawere, Talooka Joada, Jan. 1st, 1845."

Translation of a deposition given in Mahratta, by Goba Wullud Nagojee Chowdrie, and Hunmunta ud Dama Naik Solie, inhabitants of the village of Manegaum, pergunnah Edulabad, turaf Jaoda, of the Khandeish Collectorate, who were spectators of the fall of an aërolite in the vicinity of their village, in the month of July 1843.

"On the day the aërolite fell we were both seated, about three o'clock of

* The supposed and the actual circumstances are in this expression oddly involved; we consider that the natives employed this language, and that the author of the letter gives their literal words.—ED.

the afternoon, on the outskirts of the village, in a shed belonging to Ranoo Patel. There was at the time no rain, but heavy clouds towards the northward; there had been several claps of thunder for about two hours previously, and some lightning. Suddenly, while we were seated in the shed, several heavy claps of thunder occurred in quick succession, accompanied with lightning, on which we both went out to look around us, when in the middle of a heavy clap, we saw a stone fall to the ground in a slanting direction from north to south, preceded by a flash of lightning. It fell about fifty paces distant from us; on going up to it we found that it had indented itself some four or five inches in the ground; it was broken in pieces, and as far as we could judge, appeared to be about fifteen inches long and five in diameter, of an oblong shape, somewhat similar to the *chouthe* grain measure; it was of a black vitreous colour outside, and of a grayish yellow inside; it was then of a mouldy * texture, and hardened to the consistence of the present specimens afterwards. Only one stone fell. No rain had fallen for eight days previously, nor did it until four days after the fall of the stone. It had been warm all day before, but not much more so than usual. From midday until the time the stone fell (3 P.M.) it was very cloudy towards the northward; after its fall, the thunder ceased and the clouds cleared away. No stone of a similar description had ever fallen near our village before. The pieces of the stone were immediately after carried off by the country people. Our village is situated on the banks of the small river the Poorna; there are no hills in its vicinity, the nearest being three coss (or six miles) off. The above is a true statement, dated at Rawere, talooka Jaoda, on the 17th December, 1844. (Signed) "GOBA UD NAGOJEE CHOWORIE.
"HUNMUNTA UD DAMA NAIK."

"True translation of the deposition given before me on the above date.
"C. J. INVERARITY, *Acting 1st Assist. Col.*"

Chemical Examination.—The specimens were referred to me for examination, of which this is my report.

The specimens are mainly composed of an earthy grayish white pulverulent mass, slightly tinged with a bluish gray in some parts. It is excessively friable, and both crumbles and soils the fingers even when most delicately handled. In the earthy mass are thickly imbedded light greenish glassy particles of olivine, single and in nests, resembling green mica or felspar; the appearance in some parts being almost that of an earthy variety of lepidolite. On the side of one piece of Capt. Abbott's specimens is a bright black crust, thickly but minutely mammillated. When this is touched with the file, it leaves a rusty mark, but gives no metallic trace. This crust is exceedingly thin and splinters off, and in one place a mass of the olivine in it is melted to a green bead. It is too fragile, and our specimens too small to attempt obtaining sparks from it. Two of Mr. Bell's fragments also have small portions of crust yet adhering to them.

Internally, and by the magnifier, a few bright white metallic points are discoverable, and in one or two places small nests of it: there are also a few of a brown kind. We have one fragment of an aërolite which fell in 1808, at Moradabad, which is pulverulent, but not so much so as the present specimen by a great deal. The present specimen is in this respect almost unique; as the only one I now recollect to have read of as very pulverulent, is the one from Benares, mentioned in the Philosophical Transactions.

The aërolite of Moradabad is studded over with rusty specks from the

* So in MSS. Perhaps muddy, *i.e.* soft, earthy texture, was meant?—H. P.

oxidation of the iron. All our other aërolites are of a compact texture. I may note here, that we now possess in our collection ten specimens, comprising six varieties of aërolites, and four of meteoric iron from Siberia, Brazil and India. One of the Society's aërolites is also well entitled to be called meteoric iron, as it consists mainly of that metal (and no doubt nickel) rather than an aërolite, by which we usually designate the more earthy-looking stones.

The magnetism of the Kandes aërolite is nowhere apparent except at the patch of pyrites (magnetic pyrites?) on the piece which has the crust, but here it is strong and distinct.

From its extreme friability I have not ventured to take its specific gravity, which is about 4 or 4·5, I judge, for it might crumble to pieces in the water, and is too rough and tender to admit of varnishing. Specific gravity however is an indication of no value in these heterogeneous compounds.

The green crystals, when examined separately, effect a somewhat rhomboidal or cubical form, but none are clearly defined. Their colour is a bright, clear, and very light grass-green.

List of Meteorolites in the Collection of the Asiatic Society, Jan. 1, 1845.

1. Fell at Moradabad, 1808, Capt. Herring. One piece of this is rather friable, three pieces.
2. Dr. Tytler's aërolite at Allahabad, three large pieces.
3. Aërolite fell about 40 miles to the west of Umbala, between the Jumna and Punja, 1822–23. Obtained by Capt. Murray; given by Mr. J. Bird to Mr. Cracroft.
4. Fell at Bitour and Shapoor, 75 miles N.W. of Allahabad, 30th November 1822.
5. Fell at Mhow Ghazeepore, February 1827, R. Barlow.
6. Fell at Manegaon in Khandeish, July 1843, Capt. J. Abbott, B.A., and J. Bell, Esq., Bombay, C. S., Collector of Khandeish.

Meteoric Iron, or Stones having a large proportion of it.

1. Meteoric stone, containing iron and nickel, fell at Panganoor in 1811. Mr. Ross of Cuddahpah.
2. Meteoric iron; Siberia, Pallas.
3. Meteoric iron; Sergipe, Brazil, Mornay and Wollaston.
4. Lightning stone of Nepal; not examined, but may be meteoric.

Blowpipe Examination.—The grass-green crystals above described. Per se infusible, but take a rusty brown appearance, as of semi-fusion or oxidation on the exterior, remaining still translucent. *On platina wire*, with borax and phosphate of soda, fuses at first in part only (a lump remaining), giving a light clear olive glass; adding more of the flux, it finally dissolves with various shades of olive and grass-green according to the proportions of assay and flux. A minute crystal in muriatic acid does not soften, gelatinise, or colour it by several days' digestion. These are doubtless meteoric olivine.

The white friable part, taken as free as possible from the gray specks and entirely so from the green crystals. *In the forceps* slightly oxidates to a rusty appearance at the outer part, but does not fuse.

On platina wire and with soda. Fuses to a dirty olive-coloured bead, which in the reducing flame gives metallic iron with some earthy residuum. With nitrate of cobalt only a dull rusty colour. Hence the absence of alumina, except perhaps in very minute proportion.

The metallic-looking vein was assayed in various manners for nickel, but no trace of it could be elicited, the vein being apparently pure pyrites.

Nickel may nevertheless exist, though in small proportions, and we cannot venture on consuming more of these precious fragments, since the fused crust, the olivine, and the white matrix are chemical evidence enough of the meteoric origin of the stone.

The whole of the dust which had collected in the paper being carefully collected, was assayed both by the blowpipe and *via humida* for chromium, but no traces were detected. As said of nickel however above, so also of this substance, it may exist in minute proportion, though not detectable in such extremely small assays.

No. 33.—On the 7th of September, about half-past six P.M., a large fireball was seen at Poona to shoot from nearly north to south; it then made a sudden sweep, and proceeded nearly at right angles to its previous path. After being visible for five or six seconds, it split into a number of large fragments which rapidly descended towards the earth; and these again broke up into lesser fragments, till they appeared to descend in a shower of sparks. Before the first bursting, the meteor was of exceeding brightness, of an intense blue colour, and at the instant of explosion it changed into red; it seemed to light up the whole heavens, though the moon was shining, so as to render the lesser stars visible. The last meteor of the sort we remember at Bombay was seen in the sky in the middle of October 1844. Now is the season when a display of luminous meteors in all parts of the heavens may be looked for, the earth appearing in August and November to track a part of its orbit through which a current of these things rushes along.—*Bombay Times*, November 1, 1848.

No. 34.—*Meteor of 29th October* 1848, *observed at Poona and Bombay*.—On Sunday evening, about seven o'clock, a magnificent fireball was seen to shoot across the air from nearly west to east, when its horizontal motion suddenly ceased, and it seemed to drop perpendicularly into the sea betwixt Mazagon and Sewree. At the time of its explosion—for such we may take that of its change of direction to have been,—its illuminating power was equivalent to that of an ordinary-sized blue light; it dazzled the eyes of those near it and who looked at it directly; and though the evening was at the time perfectly dark, the most minute objects in the landscape were for ten or fifteen minutes made visible by it. It appeared to become extinguished some three or four hundred feet before touching the water. It left a long trail of light behind it, which was visible for the space of nearly half a minute.

No. 35.—*Meteor of 27th July* 1849, *observed at Porebunder*.—Porebunder, 2nd August 1849. On the night of the 27th of July, about half-past eight o'clock, a very bright meteor shot out from the northern sky. When first seen, its elevation was about 70°, and it fell nearly perpendicularly. Its fall was not very rapid, it being distinctly visible for about five seconds when it burst, leaving a large train of bright red spots to mark its track. The light was so bright as to attract the attention of persons whose faces were towards the south. At the time of its appearance the weather was calm and cloudy, a slight air now and then from the west, and scud flying rapidly from the same point. An hour afterwards heavy rain set in, which has continued almost without intermission ever since. The whole country in the neighbourhood is under water. Several houses have fallen down in the town, but no serious injury has accrued therefrom. Such a quantity of rain has not fallen in the Zillah for the last five years.

No. 36.—*Meteor of 12th December* 1849, *observed near Shorapore*.—Camp

Bohnal, near Shorapore, December 14th. You are desirous of intelligence of meteors, and therefore I mention that the night before last, about half-past eleven (I had no watch with me), I observed a very brilliant meteor pass rapidly from the zenith, and fall in a south-west direction, exploding when within about 20° of the horizon, in a shower of brilliant sparks; I cannot speak accurately as to its size, which appeared to increase as it descended, but it was at least four times as large as Venus at her brightest, and gave out light enough to dim the light of the stars in the direction of which it passed. I have no doubt, if there had not been many torches burning near me at the time, that its light would have been strong on the ground. I could hear no noise on its explosion. The colour of the meteor was a greenish white.

No. 37.—The following additional extracts from correspondence on meteors observed in India, and inserted in the Catalogue of 1849, have been recently forwarded by Dr. Buist.

Meteor of March 19, 1849.

"Poona, 22nd March.

(1.) "Sir,—None of the Bombay accounts sent you of the aërolite which fell on the 19th are sufficiently explicit. Most of your correspondents must have seen it crossing their meridian; can none of them estimate its *angular height* at that moment? I am not very well acquainted with your localities, but the meteor would seem to have been north of you, and at no great elevation. Supposing it to have had a meridian altitude of 20°, and combining this with the data we sent you two or three days ago, you will find that it must have been about thirty miles high (perhaps ten when it burst), and taking its apparent diameter at 4′, must have measured nearly 200 yards across—an enormous mass, sufficient to furnish, on exploding, a very large shower of meteoric stones. It appeared to pass over about 30° of the heavens in something less than two seconds; and this, at the distance at which it must have been, if the data we have here assumed are anything near the truth, will give a real velocity of thirty miles per second.

"The theory of these bodies, which considers them as moving through space, and becoming hot and luminous on entering our atmosphere, from the rapid compression of the air, would seem to be pretty consistent with all this.

"P.S.—I will just add a word or two concerning the probable errors of these estimates. The *height* and *velocity* are certainly if anything understated, while on the contrary, the volume assigned is not unlikely to be considerably in excess, since the apparent magnitude may have been partly an optical deception, or may have been that subtended—not by the meteor itself, but by its luminous envelope."

* * * * * *

(2.) "I saw it on the 19th, at about 6·30 P.M., away in the S.W., high up in the heavens, falling with great velocity towards the earth, but directed to the N.E. It was intensely brilliant, of a bluish white colour, like a Roman candle, bursting into a sparkling shower of a dull red colour. We heard no sound after it burst here, but at Aurungabad, some considerable time afterwards, a sound of distant thunder was distinctly audible. Everybody differs as to the time; some minutes—say three—elapsed; that will take us just about to the region of fireballs, for assuming 1125 as the rate sound travels per second, three times that will reach about to the crepuscular atmosphere, the nursery of these meteoric bodies. At Aurungabad its course appeared northward, passing over the heads of the good folks there, and bursting about twenty miles to the north of the station.—W. H. B."

"Boldanah, 1st April, 1849."

(3.) "Sir,—On the evening of the 19th ult., between six and seven, I observed the meteor alluded to in the *Times* of 23rd and 26th March. I was in latitude 21° 58′ (by observation next day,) and longitude 76° (taken from a map). The meteor was, as well as I can judge, S.W. by S. It was very brilliant. The longitude I could not work out exactly, not having the necessary tables.—L. H. E."

"Mundlaisir, April 5th, 1849."

(4.) "Sir,—Your correspondent of the 21st inst. desires information about 'a supposed meteor.' It may be gratifying to him to know, that we were favoured, back here in the country, with one of whose personal identity we could have no doubt. It appeared six miles east of Ahmednuggur, in the vicinity of a hill known here by the name of 'Shaha Donger.' The fall of a more splendid meteor I never had the pleasure to witness. Myself riding eastward, its line of direction declined towards the same point, the meteor appearing at right angles on my left. It first invited my attention by throwing across my pathway a brilliant light, seeming for the instant to light up the whole horizon. Instantly glancing to the north, the stranger appeared in full view, a beautiful globe of fire, apparently sixty to eighty yards high, and some three inches in diameter, with a long tail of bluish and red light. At the height of twenty to twenty-five yards it burst, and fragments of a brighter red were visible an instant longer."

(5.) "Sir,—In your issue of Wednesday last I observe a correspondent notices a meteor he had seen in Bombay about half-past six P.M., on the preceding Monday. As you appear anxious for further information on the subject, I send you the following, though I know not if it be worth much. On the same evening, and about a quarter before seven (of our time), I saw from hence a meteor, answering in so many respects that described by your correspondent, as to leave no doubt on my mind but that it was the same as attracted his attention. To my eye the meteor appeared in size rather less than a man's fist; its brilliancy was excessive, and it was surrounded by a colour more yellow I think than green. The flakes it threw off were very large, and strewed its path, so as to form a long and most luminous tail. I note the following particulars:—commencement of course at a height of about 50°; end of height 20°; direction of height nearly perpendicular; direction from Asseer about S.S.W. If I mistake not, your correspondent makes its direction from Bombay to have been about easterly: by a glance at a map I should therefore suppose the meteor would be vertical over some spot between Jooneer and Kandahalla.—A. W."

"Asseerghur, March 26, 1839."

(6.) "The proximity of the hill enabled me to determine its distance to be within 300 yards, the meteor being distinctly visible after passing below the summit. The coincidence which will perhaps most interest your correspondent is the fact of its appearance at *thirty-five minutes past six on Monday evening* (19th inst.).—W."

"Ahmednuggur, March 24, 1849."

(7.) A Mahabuleshwar correspondent says, the meteor seen there on the 19th ultimo, presented nearly the same appearance at Malcolm Peth as at Bombay.

(8.) "Sir,—The same appearance as that described by your correspondent E. in your paper of the 21st, was observed by myself and others from this place on the evening of Monday the 19th, about the same hour mentioned by him, and in a south-westerly direction.—W. R. M."

"Fortress of Asseerghur, March 28, 1849."

(9.) "Sir,—I suppose you have had enough of the meteor of the 19th instant, but I cannot forbear writing to let you know that it was seen at Ahmednuggur also at the time mentioned by the other observers. I was driving, at the time, about a quarter of a mile distant on the west side of the fort, when I observed the meteor towards the N.E. It did not occur to me that it was anything more than a rocket thrown up from the native town, and I was sure it had fallen between myself and the fort. I have been much interested in the accounts sent by your correspondents from such distant places as Sholapoor and Surat, most of them supposing, as we did here, that it was not very distant. Were proper measures taken for simultaneous observation of such meteors at different places, it would be easy to ascertain by a little calculation the height at which they begin to appear and at which they burst, and the velocity with which they move. The apparent velocity of this meteor being so great, while at the same time it was so distant, its real velocity must have been great indeed, more nearly approaching that of electricity than that of any solid body whose velocity has hitherto been calculated.—B."

"Ahmednuggur, March 31, 1849."

(10.) "Sir,—The accounts received by you from different stations regarding the appearance and supposed course of the magnificent meteor of Monday evening, the 19th instant, induce me to add my evidence, with the view of assisting in the determination of the true course of the luminous object. About 6½ P.M. I happened to be seated in the open air, facing due south, and the 'shades of evening' were fast closing over head, when I observed a meteor, which, apparently commencing its course at a point bearing about S.S.W. and about 30° above the horizon, darted in a slightly descending line, and with different degrees of brilliancy, towards a point bearing about S.S.E. and about 15° or 20° above the horizon; and there burst without any perceptible noise into spark-like fragments, flame-coloured, which immediately disappeared. The colour of the meteor, when most brilliant, appeared to me not unlike that of the ordinary 'blue light.' The observer at Aurungabad (near which place the meteor appears to have burst) does not mention the apparent *length* of the course of the luminous body. If this was not very great, nor the apparent motion of the meteor very rapid, it seems to me not improbable that the course of the meteor was seen at Aurungabad *foreshortened* as it were; and, taking into consideration the various accounts, I am disposed to think that a line drawn from the Malsej Ghaut (or a point half-way between Nasik and Jooneer) in the direction of Ellora, would pretty well represent the course of the meteor; and it is not unlikely that fragments of the aërolite may be yet found near the caves.—H. W. B. B."

"Malligaum, March 30, 1849."

Meteor of April 4, 1849, *observed at Delhi.*—A very brilliant meteor, of a deep red colour, was observed at Delhi, on Wednesday evening, at a quarter past seven. Its progress was extremely slow, from N.W. to S.E., and the inclination small. It seemed to have become extinct for an instant, and then assumed greater brilliancy before its final disappearance. The elevation at which it was noticed cannot have been more than 28° or 30°.—*Delhi Gazette*, April 7.

Meteor of April 10, 1849, *observed at Ahmednuggur.*—Ahmednuggur, April 11, 1849.—You may be interested to hear that another meteor was seen here last night nearly about the same time, and in a similar direction, as the meteor of the 19th ultimo. It was observed at a quarter before seven o'clock, and was of a dark yellow colour. When first seen it was just below Deneb in the Lion, and of course about due east from us; and having fallen through an arc of the heavens of 20° or 30°, disappeared at an altitude of 10° or 15°. Its apparent diameter was about the same as that of Venus at present. I would also remark that the meteor of the 19th ultimo started from near the same region of the heavens (perhaps more to the north, in the vicinity of Berenice's hair), and having fallen nearly perpendicularly towards the earth, burst at an altitude of 15° or 20°. Its light was a brilliant white silvery light, and its apparent diameter, as observed here, was two or three times that of Venus. I also observed three other meteors in the course of last evening; one about half-past seven o'clock seemed to commence in the vicinity of the constellation Corvus, and after traversing an arc of 20° or more, disappeared in the vicinity of the large star in the southern part of the ship, about 20° west from the Southern Cross. Its motion was very slow, and it left a bright path behind it.

Meteor of April 13, 1849.—" Sir,—On opening your paper of this morning I was astonished at not seeing any mention made of *another* very brilliant meteor that burst last night. At about a quarter past nine o'clock last night, a light all of a sudden, as brilliant as that of the moon, shone for a second or two. Wondering from where this appeared, I looked round, and saw it just as it was dwindling away. The direction that it burst was south-east. This is the *third* meteor seen within three months."

" Bombay, April 14, 1849."

A meteor of surpassing brilliancy was observed here on Friday evening, 13th inst., at about three minutes to nine o'clock. Our informant was walking in a westerly direction, when the atmosphere, which had been somewhat dull and heavy, was suddenly illuminated by an intense light immediately behind him; turning instantly round he perceived it emanated from a brilliant meteor of a bluish colour and about the size of an egg. It first appeared due east, and proceeded towards the horizon in a southern direction. It was in sight about three seconds, and was first seen at near 30° altitude, and became lost to view at about 8°.—*Poona Chronicle*, April 20.

Meteor of May 6, 1849, *observed at Kurrachee.*—Kurrachee, May 7, 1849. —As you ask for notices regarding meteors, here is one for you. Yesterday evening (May 6th), at 6·45, a meteor fell here. When first observed, it was at an elevation of about 25° or 30°, and appeared to be falling from the zenith to a point of the horizon a little to the eastward of north, where it vanished at an elevation of about 5°, without any appearance of explosion, and I should say that it fell below my horizon in a perfect state. I cannot say that I saw it from the commencement of its course, as I was observing something else at the moment intently when it attracted my notice at the elevation above-mentioned. It had the appearance of a clear ball of fire, with a slight green tinge, and was considerably larger than Venus when at her brightest. Had it occurred an hour later, it would have presented a splendid appearance; but as the sun had only just set, it was still broad daylight. The day had been hot and sultry, but at the time alluded to there was a cool breeze from the N.W., with a clear sky.

Meteor of June 25, 1849, *observed at Kurrachee.*—A Correspondent gives a somewhat more minute account of the meteor seen through Lower Scinde on the 25th of June than that extracted from the 'Kurrachee Advertiser' in our last, or given from the same source in our present issue. It was observed by our friend about ten o'clock at night, just before it broke out. It seemed to be proceeding from south to north, and appeared to explode about 60° above the horizon. It broke into a multitude of bright red fragments, which vanished from sight shortly after the explosion. About five minutes after this a report was heard like that of a heavy piece or ordnance fired at a distance, and we have no doubt that this was the sound of the bursting meteor, the fragments of which may yet be found. We hope our friends at Hydrabad and Sukkur will inform us whether it was seen by any of them. There were no stars visible in the direction of its path at the time when it was first seen, and no immediate means therefore of comparing it with any celestial object; so brilliant was it that it filled the room with light. The following is a list of the meteors for 1849, with the particulars of whose appearance we have been favoured:—24th February, Madras; 19th March, the great meteor seen off the sea-coast of Goozerat, at Bombay, Khandalla, Poona, Ahmednuggur, Mundlaisir, Malligaum, Asserghur, Jaulnah, &c.; 23rd March, Bombay and Khandalla; 4th April, Delhi; 10th April, Ahmednuggur, one large and two small meteors; 13th April, Bombay, Poona, and Hingolee; 30th April, Poona; 2nd May, Bombay; 6th May, Kurrachee; 25th June, Kurrachee. The meteors of the 19th March and 25th June are the only two that were heard to explode; there is every reason to believe that the former of these was burnt to ashes and fell to the ground in the shape of dust. The atmosphere all over the Saugor and Nerbudda territories was throughout the last week of March so filled with fine dust that the sun could be looked at, especially at near noon, with the naked eye.

A most brilliant meteor appeared about half-past nine o'clock on the night of the 25th instant. We did not ourselves see it, having been within doors, but the light thrown out was plainly perceptible for some five or six seconds. About fifty or sixty seconds after its disappearance, a report like that of a distant heavy gun was distinctly heard.—*Kurrachee Advertiser*, June 27.

No. 38.—The following interesting remarks on periodic meteors are extracted from Prof. Silliman's Journal, vol. xxxi. p. 386:—

For six years in succession there has been observed, on or about the 13th of November of each year, a remarkable exhibition of *shooting stars*, which has received the name of the "Meteoric Shower."

In 1831 the phænomenon was observed in the State of Ohio*, and in the Mediterranean, off the coast of Spain†. In 1832 the shower appeared in a more imposing form, and was seen at Mocha, in Arabia‡, in the middle of the Atlantic Ocean§, near Orenburg, in Russia‖, and at Pernambuco, in South America¶. The magnificent meteoric shower of 1833 is too well known to require the recital of any particulars. Of the recurrence of the phænomenon at the corresponding period in 1834 and in 1835, evidence has been presented to the public in previous numbers of this journal. (See vols. xxvii. pp. 339 and 417; xxix. 168.) I now feel authorized to assert, that *meteoric showers reappeared on the morning of the 13th November* 1836.

It has been supposed by some, that the appearance of an extraordinary number of shooting-stars, at several anniversaries since the great phænomenon of November 1833, can be accounted for by the fact, that a general expectation of such an event has been excited, and that many persons have been on the watch for it. Having, however, been much in the habit of observing phænomena of this kind, I can truly say, that those exhibitions of shooting-stars which have for several years occurred on the 13th or 14th of

* Amer. Journal of Science, vol. xxviii. p. 419.
† Bibliothèque Universelle, Sept. 1835.
‡ Amer. Journ. xxvi. p. 136.
§ Edin. New Phil. Journ. July 1836.
‖ Amer. Journ. xxvi. p. 349.
¶ New York, America, Nov. 15, 1836.

November, are characterized by several peculiarities, which clearly distinguish them from ordinary shooting-stars. Such peculiarities are the following:—

1. The *number of meteors*, though exceedingly variable, is much greater than usual, especially of the larger and brighter kinds.

2. An uncommonly large proportion leave *luminous* trains.

3. The meteors, with few exceptions, all appear to *proceed from a common centre*, the position of which has been uniformly in nearly the same point in the heavens, viz. in some part of the constellation Leo.

4. The principal exhibition has at all times, and at all places, occurred between midnight and sunrise, and the *maximum from three to four* o'clock.

In all these particulars, the meteoric showers of 1834, 1835 and 1836, have resembled that of 1833; while no person, so far as I have heard, has observed the same combination of circumstances on any other occasion within the same period. I have not supposed it necessary, in order to establish the identity of these later meteoric showers with that of 1833, that they should be of the same magnitude with that. A small eclipse I have considered a phænomenon of the same kind with a large one; and, conformably to this analogy, I have regarded an eclipse of the sun, first exhibiting itself as a slight indentation of the solar limb, but increasing in magnitude at every recurrence, until it becomes total, and afterwards, at each return, but partially covering the solar disc, until the moon passes quite clear of the sun, as affording no bad illustration of what probably takes place in regard to these meteoric showers. The fact that the Aurora Borealis appears unusually frequent and magnificent for a few successive years, and then for a long time is scarcely seen at all, was proved by Mairan a hundred years ago*. There is much reason to suspect a like periodical character in the phænomenon in question, which first arrested attention in 1831, became more remarkable in 1832, arrived at its maximum in 1833, and has since grown less and less at each annual return. Some seem to suppose that we are now warranted in expecting a similar exhibition of meteors on the morning of every future anniversary; but this, I think, is not to be expected. It is perhaps more probable, that its recurrence, unless in a very diminished degree, will scarcely be witnessed again by the present generation. The shower, however, at its late return, was more striking than I had anticipated; and it must be acknowledged to be adventurous to enter the region of predication respecting the future exhibitions of a phænomenon, whose origin and whose laws we so imperfectly understand.

Accounts of observations before us show, that the meteoric shower was seen in most of the Atlantic States, from Maine to South Carolina.

From these accounts compared, we are led to conclude that the meteoric showers increased in intensity from north to south, that of South Carolina having been the most considerable of all, so far as accounts have reached us.

Does not the recurrence of this phænomenon for six successive years, at the *same period of the year*, plainly show its connexion with the progress of the earth in its orbit? and does not the fact that the greatest display occurs everywhere in places differing widely in longitude at the *same hour of the day*, as plainly indicate its connexion with the motion of the earth on its axis? The supposition of a body in space, consisting of an immense collection of meteors stretching across the earth's orbit obliquely, so that the earth passes under it in its annual progress, while places on its surface lying westward of each other are successively brought, by the diurnal revolution, to the point of nearest approach, will satisfy both these conditions.

* Traité Phys. et Hist. de l'Aurore Boreale. Par M. de Mairan. Memoirs of the Royal Academy of Sciences for 1731.

On the Structure and History of the British Annelida. *By* THOMAS WILLIAMS, *M.D., Swansea.*

AT the meeting of the British Association, held at Swansea, I was appointed, in conjunction with Prof. E. Forbes and Thomas Bell, to collect into a report the undigested materials relating to the organization and habits of the British Annelida, which may be distributed throughout the scientific periodicals of this country. To this most interesting department of natural history, a cursory inquiry soon satisfied me, that the older English writers had contributed little or nothing, and that, with the honourable exception of the papers published from time to time by Dr. Johnston of Berwick, in the 'Annals of Natural History,' the subject on which a systematic and digested report was required by the British Association constituted the least cultivated branch of the zoology of this country. It became evident, therefore, that a report, composed only of such scanty and insufficient materials, would be little worthy of the Transactions of the Association: I accordingly turned the whole of my attention to the collection of new species, and to the elucidation of the anatomy and physiology of the subject. It is already in my power to state to the Association, that I have made numerous additions to the list of British species, and that on the subject of the organization of the known species, I have succeeded in elucidating the anatomy of the branchial, circulating and alimentary systems. To render the description of these parts intelligible, it would be necessary, in this *preliminary* report, to introduce numerous diagrams, which would materially add to the expenses already incurred. I have, however, prepared *a few* of those original illustrations which will accompany the finished report, and which are now presented to the Section through the kindness of Prof. Edward Forbes.

Swansea, July 23, 1850.

Results of Meteorological Observations taken at St. Michael's from the 1st of January 1840 *to the* 31*st of December*, 1849.

British Consulate, St. Michael's, May 1, 1850.

SIR,—I beg leave to inform you that the three barometers and thermometers sent out to me by Lieutenant-Colonel Reid, in application of the grant referred to in your letter of October the 3rd, 1849, have arrived here, and that I have forwarded two of them to the Vice-Consuls at Flores and Fayal, reserving the third for presentation to the Vice-Consul at Terceira, if he can make it convenient to keep a record of his meteorological observations.

I have the honour to be, Sir,

Your most obedient humble Servant,

THOMAS CAREW HUNT.

John Phillips, Esq., Assistant General Secretary of the British Association for the Advancement of Science.

The Tables of Results follow on pp. 134 to 136.

Tables of Results.

		Jan.	Feb. reduced to 28 days.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Summer half year.	Winter half year.	Whole year.
Winds, days of N.	max.	2·3	2·0	3·2	2·0	2·5	2·3	4·0	2·0	2·0	4·3	7·0	4·0			
	min.	0	0	0·5	0	0	0	0	0	0	0	0	0			
	mean	1·32	1·12	1·18	1·27	1·52	0·85	2·11	0·14	1·40	2·15	2·78	2·52	7·29	11·07	18·36
„ „ N.E.	max.	21·7	12·3	15·6	14·2	16·5	17·0	16·0	17·4	18·7	17·0	10·2	15·7			
	min.	1·18	0·7	4·4	0·7	4·7	5·0	8·7	10	6·0	4·5	4·5	2·7			
	mean	7·64	6·13	6·73	8·89	10·11	10·12	13·17	15·13	11·62	10·95	6·84	7·71	69·04	46·00	115·04
„ „ E.	max.	0·8	1·0	1·0	3·0	2	2·2	2·0	2	2·0	1·0	1·0	4·5			
	min.	0	0	0	0	0	0	0	0	0	0	0	0			
	mean	1·07	0·53	0·66	1·80	1·28	0·76	1·17	0·30	1·20	0·62	0·59	1·72	6·51	5·19	11·70
„ „ S.E.	max.	5·0	9·0	8·1	4·7	6·5	11·7	4·7	8·1	13·1	9·5	11·7	14·5			
	min.	1·0	2·0	0	0·7	0·5	1·0	0	1·2	1·3	1·7	0·3	0·2			
	mean	4·45	3·90	3·03	2·44	2·44	3·13	2·73	4·71	4·94	4·45	3·74	3·60	20·98	23·17	44·15
„ „ S.	max.	4·8	4·7	7·3	1·7	2	1·0	0·7	0·8	1·0	2·5	4·5	2·6			
	min.	0	0	0	0	0	0·3	0	0	0	0	0	0·3			
	mean	2·88	0·95	2·25	0·79	0·95	0·67	0·11	0·08	0·12	1·51	1·54	2·00	2·72	11·13	13·85
„ „ S.W.	max.	11·5	13·8	13	10·7	7·6	14·7	13·2	6·0	6·7	6·3	10·8	9·9			
	min.	2·8	1·2	1·0	2·0	0·7	1·7	1·7	0·3	0·7	3·0	4·0	1·7			
	mean	6·46	6·60	9·01	4·08	3·73	4·43	4·63	2·89	3·44	4·13	6·94	5·32	23·20	38·46	61·66
„ „ W............	max.	3·5	3·0	3	2·6	5·0	3·2	4·2	3·7	2·5	4·5	2·0	5·16			
	min.	0·3	0	0·5	0·5	0	0	1·3	0·3	0·3	0	0	0·2			
	mean	1·16	1·17	1·58	1·51	2·38	1·51	2·09	1·73	1·01	1·35	1·39	1·52	10·23	8·17	18·40
„ „ N.W..........	max.	16·5	10	12·2	16·3	15·3	10·6	11·0	7·0	8·2	9·8	11·2	12·8			
	min.	3·0	0·2	2·8	4·5	6·3	4·3	0·8	0·8	0·8	3·0	4·0	0·6			
	mean	5·86	7·04	6·44	8·06	8·09	8·29	4·82	4·73	5·53	5·19	6·08	6·53	39·52	37·11	76·63
„ „ calm	max.	1	1	1·2	1	1	1	1·0	3·2	2·2	1·5	1·0	0·8			
	min.	0	0	0	0	0	0	0	0	0	0	0	0			
	mean	0·19	0·56	0·12	0·57	0·50	0·24	0·17	1·29	0·74	0·65	0·10	0·08	3·51	1·70	5·21
„ „ surf on shore	max.	17	15	13·6	8	2·5	4	0·3	1·0	3·2	11·0	12·1	13·9			
	min.	0·3	1	0	0	0	0	0	0	0	0·6	2·9	0			
	mean	7·13	7·0	6·49	2·70	1·15	0·50	0·03	0·20	2·07	4·42	6·42	7·38	6·65	38·85	45·50

TABLE (*continued*).

		Jan.	Feb. reduced to 28 days.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Summer half year.	Winter half year.	Whole year.
Aspect days sunny	max.	8.3	8.0	10.3	14.2	12.1	15.3	20.4	22.7	15.0	21	14.5	10.3			
	min.	5.0	2.2	4.9	6.0	8.6	11.0	10.2	8.5	8.5	7.2	5.9	4.0			
	mean	6.34	7.80	7.34	8.82	9.49	13.51	14.45	13.55	11.32	12.06	10.0	7.98	71.14	51.52	122.66
„ „ varying	max.	7.9	10.4	6.8	9.0	9.0	10.9	13.8	16.0	10.1	7.8	7.8	10.1			
	min.	3.7	0.7	0	4.3	3.0	2.5	1.2	1.8	1.3	4.0	3.0	4.7			
	mean	6.21	6.0	4.11	6.20	6.65	5.97	6.29	8.16	6.96	6.30	5.36	7.12	40.23	35.10	75.33
„ „ cloudy......... ..	max.	15.3	12.3	16.6	13.0	10.8	11.3	9.0	12.3	16.7	12.2	11.0	15			
	min.	8.0	3.3	9.1	8.7	5.3	5.3	3.8	2.5	4.0	4.6	4.8	7.2			
	mean	11.74	8.43	13.90	11.46	8.87	7.77	5.71	6.95	8.34	8.08	8.80	10.52	49.10	60.57	109.67
„ „ foggy	max.	6.3	5.5	2.6	2.8	5.7	3.2	8.3	1.7	2.2	2.3	3.2	4.5			
	min.	0	0.5	0	0.7	2.1	0.3	0.7	0.3	0.5	0.4	0.7	0.5			
	mean	2.28	2.16	1.24	1.31	3.18	0.76	3.36	0.62	1.39	1.17	1.66	1.77	10.62	10.28	20.90
„ „ rainy	max.	10.2	4.7	8.2	3.7	4.5	3.7	2.6	2.3	6.0	6.0	6.9	10.1			
	min.	1.0	1.7	2.7	1.0	1.0	0.7	0.3	0.8	0.6	1.0	1.3	0.5			
	mean	4.43	3.61	5.31	2.21	2.81	1.99	1.19	1.72	1.99	3.39	4.18	3.61	11.91	24.53	36.44
		in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
Barometer	max.	30.83	30.81	30.71	30.60	30.62	30.57	30.53	30.51	30.53	30.58	30.54	30.66	30.62	30.83	30.83
	min.	29.24	29.49	29.13	29.40	29.62	29.82	29.97	29.67	29.35	29.46	29.55	29.46	29.35	29.13	29.13
	mean	30.214	30.166	30.255	30.247	30.237	30.253	30.311	30.238	30.210	30.142	30.115	30.201	30.250	30.182	30.216
Ditto, monthly range.........	max.	1.59	1.18	1.51	1.14	0.87	0.71	0.50	0.68	1.12	0.86	0.93	0.83	1.14	1.59	1.59
	min.	0.68	0.53	0.63	0.29	0.37	0.45	0.34	0.33	0.37	0.52	0.51	0.46	0.29	0.46	0.29
	mean	1.02	0.82	0.97	0.67	0.77	0.54	0.45	0.53	0.60	0.78	0.77	0.72	0.59	0.85	0.72
Thermometer, Fahr.; open north aspect; shade, external	max.	69½°	70°	72°	77°	79½°	86½°	88½°	90°	85°	81°	74°	69°	90°	81°	90°
	min.	42	44	45	45	51	56	58	62	58	52	45	44	45	42	42
	mean	56.4	57.6	57.8	60.8	63.3	69.5	73.1	74.9	69.8	65.2	60.6	57.8	68.6	59.2	63.9

TABLE (*continued*).

		Jan.	Feb reduced to 28 days.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Summer half year.	Winter half year.	Whole year.
Thermometer, Fahr., daily range	max.	14°	16°	18½°	22°	20°	22½°	21°	22°	18°	19°	17°	16½°	22½°	19°	22½°
	min.	1	1	0	2½	2	4½	3	5	3½	2	1	1	2	0	0
	mean	7·1	7·4	8·9	10·1	10·5	12·5	11·4	12·1	10·6	10·1	8·9	7·6	11·2	8·3	9·8
Ditto, internal; north room; windows closed; door open; no fire	max.	63	64	63	67	70½	74	76½	78	77	74	68	66	78	74	78
	min.	49	52	49	50	56	60	64	66	62	57	50	53	50	49	49
	mean	56·7	57·9	57·9	60·3	62·8	67	70·1	72·2	69·3	64·9	61·4	57·9	67·0	59·4	63·2
Ditto, daily range	max.	7·0	8	7·5	8	9	9	9½	9	8½	7½	7½	7	4½	8	9½
	min.	0·5	1	1	1	1	0·5	1	2	1½	1	1	0·5	0·5	0·5	0·5
	mean	2·9	3·0	3·0	3·6	3·8	3·6	4·1	5·0	3·9	3·5	3·1	3·0	4·0	3·1	3·6
Hygrometer, dew point	max.	64	65½	66	71	72½	77	78	78	76	71	68	66	78	71	78
	min.	39½	39½	40	40	45	51	54	58	53	48	42½	41·8	40	39·5	39·5
	mean	52·6	53·6	53·8	55·9	56·2	62·6	66·3	69·3	63·3	58·6	54·9	53·7	62·3	54·5	58·4
Vapour grains in a cubic foot	max.	6·62	6·91	7·00	8·15	8·50	9·71	9·85	9·95	9·43	8·55	7·94	6·93	9·95	8·55	9·95
	min.	3·06	3·02	3·14	3·14	3·45	4·11	4·92	5·38	4·92	3·98	3·39	3·27	3·14	3·06	2·83
	mean	4·77	4·50	4·75	5·11	5·15	6·27	7·04	7·49	6·41	5·55	4·95	4·78	6·25	4·82	5·54
Air's gravity, weight of a cubic foot	max.	554	552	550	550	5·50	538	536	531	536	543	551	552	550	554	554
	min.	518	518	520	514	5·10	500	499	501	505	510	514	516	500	510	501
	mean	538	537	536	532	5·30	523	519	517	522	528	533	536	524	535	530
Rain, inches	max.	5·91	5·57	7·0	3·89	2·18	2·09	1·28	3·04	5·77	5·84	7·06	7·29			
	min.	0·76	1·04	2·03	0·70	0·82	0·34	0·60	0·43	0·41	0·90	3·08	0·29			
	mean	3·74	3·82	3·54	1·63	1·41	1·17	0·75	1·69	2·18	3·04	4·24	4·19	8·83	22·57	31·40
Evaporation, inches	max.	1·73	1·76	2·23	4·47	6·36	6·26	7·03	7·96	4·73	3·99	2·27	1·80			
	min.	0·93	0·88	1·62	3·48	4·10	4·48	5·21	5·39	3·12	2·39	1·21	0·93			
	mean	1·47	1·37	2·05	3·69	4·65	5·24	5·80	6·15	4·42	3·26	1·92	1·51	29·95	11·58	41·53

On the present State of our Knowledge of the Chemical Action of the Solar Radiations. By Robert Hunt.

The present state of our knowledge of the phænomena of chemical changes produced by the influence of the solar radiations, is very imperfect. But though we have scarcely advanced beyond the threshold of this new line of research, we are enabled to contemplate a large number of striking facts surrounding the very entrance of this fresh field for experimental investigation.

It was thought advisable to gather these facts, which have been hitherto scattered through numerous Transactions of the learned societies and scientific periodicals of these islands, of Europe and of America, into a Report, but which should show all that has hitherto been accomplished in this branch of inquiry. This task having been committed to my hands by the British Association at the recommendation of the Committee of the Chemical Section, I have now much pleasure in submitting the result of my labours to the consideration of this Meeting.

I find it necessary to state the progress of the investigation on those remarkable phænomena, of chemical changes produced by the sun's rays, for the purpose of reviving a consideration of many very curious facts, which have been recorded, but which, from the circumstance that the attention of men of science was directed more earnestly into other channels, at the time of their publication, appear to have escaped attention. In stating, however, the earlier researches, I shall be as brief as possible, since many of them stand merely isolated facts which require new investigations to connect them with the subject in the improved form which it now wears, under the more advantageous lights which have been thrown upon it by the refinements of modern science.

We find, from time to time, in the writings of the elder chemists, faint indications that the changes produced by sunshine in many substances had not entirely escaped their attention; but it is not until the commencement of the eighteenth century that we have an exact record of any observations of these phænomena.

Petit in 1722 noticed that solutions of nitrate of potash and muriate of ammonia crystallized more readily in the light than they did in darkness*.

Scheele about 1777 appears to have been led to an examination of the conditions under which nitrate of silver was blackened by solar influence; and with that refined system of research which distinguishes every inquiry of this Swedish chemist, he employed the prismatic spectrum, and observed for the first time, that the nitrate and chloride of silver were blackened by the rays at the *blue*, or most refrangible end, while no change was detected by him under the influence of the rays at the *red* or least refrangible end of the spectrum†.

Senebier repeated these experiments, and he states that he found chloride of silver darkened in the violet ray in fifteen seconds to a shade which required the action of the red ray for twenty minutes‡. He also experimented on the influence of light in bleaching wax.

In the Philosophical Transactions for 1798 will be found a memoir by Count Rumford, entitled, 'An Inquiry concerning the Chemical Properties that have

* Sur la Végétation des Sels. Mém. de Paris, 1722. In 1788, Chaptal published, 'Observations sur l'influence de l'air et de la lumière dans la végétation des sels.' Mémoires de l'Acad. Roy. des Sc. de Toulouse, vol. iii.; and in the Journal de Phys., vol. xxxiv. Dizé in 1789. Dizé deals with the same subject in a paper entitled, 'Sur la cristallisation des sels par l'action de la lumière.'

† Scheele, Traité de l'Air et du Feu.

‡ Senebier sur la Lumière, vol. iii. p. 199

been attributed to Light.' In this paper a number of experiments are brought forward to prove that all the effects produced upon metallic solutions by bright sunshine can be obtained by a prolonged exposure to a temperature of 210° Fahrenheit. We are now, however, in a position to show that the chemical effects produced by rays of dark heat are of a very different character from those usually attributed to light. Mr. Robert Harrup. in a communication to Nicholson's Journal in 1802, refuted the experiment of Count Rumford, showing that several salts of mercury were reduced by light alone, and not heat.

In 1801 Ritter of Jena* demonstrated the existence of rays beyond the spectrum which have no luminous power, but which exhibited very active chemical agencies. Ritter stated that the red rays had the power of restoring darkened muriate of silver to its original colour, and he infers therefore the existence of two sets of invisible rays, the least refrangible favouring oxygenation, while the most refrangible on the contrary deoxidize. Similar results to these have since been obtained by Sir John Herschel, and more recently still by M. Claudet. Böckman about the same time observed that the two ends of the spectrum acted differently on phosphorus†.

Desmortiers in 1801 published a paper in Gilbert's Annals, entitled 'Recherches sur la Décoloration spontanée du Bleu de Prusse', subsequently translated into Nicholson's Journal, in which he has mentioned the influences of the solar rays in producing the change.

About the same time Dr. Wollaston‡ examined the chemical action of the rays of the spectrum, and arrived at nearly the same results as Ritter. He states, "This and other effects usually attributed to light are not in fact owing to any of the rays usually perceived."

Attention having been directed by Dr. Priestley in 1779 to the influence of light on plants, numerous inquirers were started on this track, and the valuable researches of Senebier, Ingenhousz, DeCandolle, Saussure and Ritter§ were the result. These are already too well known to require anything beyond this incidental notice; but in 1801 Labillardière communicated to the Philomathic Society his discovery that light was necessary to the development of pores in plants, and subsequently we find Victor Michellotti of Turin, in a paper, 'Experiments and Observations on the Vitality and Life of Germs‖,' stating "that light has a decided action on those germs which are exposed to it, that this action is prejudicial to them, and it manifests its action by retarding their expansion if the light be weak, or a reflected light; or by the total extinction of their life, if it be very intense, as that which comes directly from the sun."

M. Macaire Prinsep again states, "that sheltering leaves from the action of light prevents their change of colour in the autumn; that if the entire leaf was placed in the dark, it fell off green; if only a part, the rest of the parenchyma changed colour, and the covered portion retained its original colour¶."

Those appear to be the more important researches in connexion with this particular section of the inquiry, until the correction of the statements of Saussure were published by Dr. Daubeny, who satisfactorily proved that

* Nicholsou's Journal, August 1804. † Voigt's Maazgine, vol. iv.

‡ Philosophical Transactions, 1802, p. 379.

§ SENEBIER. Expériences sur l'Action de la Lumière Solaire dans la Végétation. Paris, 1788.

INGENHOUSZ. Expériences sur les Végétaux. Phil. Trans. 1782.

DECANDOLLE. Mémoires des Savans Étrangers, vol. i.

SAUSSURE. Recherches Chimiques sur la Végétation. Annales de Chimie, vol. l.

RITTER. Gehlen, Journ. der Chem., vol. vi.

‖ Journal de Physique, Ventose, an 9.

¶ Mémoires de la Société de Physique et d'Histoire Naturelle de Genève, tom. iv. p. 1.

Light, the *luminous* power as distinguished from the *chemical* power, was the most active in producing the decomposition of carbonic acid by the leaves of plants*; and these results were confirmed by my own researches published in the Reports of the British Association†. Although these influences upon living organisms are directly connected with the chemical influences of the solar rays, the phænomena being of a very complicated character, and requiring a very enlarged series of researches, it is thought advisable to confine attention mainly, in this Report, to the chemical changes produced upon disorganized matter.

In 1803 Wedgwood, who was assisted by Sir Humphry Davy in some part of his experiments, published in the 'Journal of the Royal Institution,' vol. i. 'An account of a method of copying paintings upon glass, and of making profiles by the agency of light upon the nitrate of silver.' In this communication we have the earliest indications of the photographic processes which have within a few years been brought to a great degree of perfection. "Nothing," says Davy, "but a method of preventing the unshaded parts of the delineation from being coloured by exposure to the day, is wanting to render the process as useful as it is elegant."

An experiment on the dark rays of Ritter, by Dr. Young, included in his Bakerian Lecture‡ is a very important one. Dr. Young, after referring to the experiments of Ritter and Wollaston, goes on to say, "In order to complete the comparison of their properties (the chemical rays) with those of visible light, I was desirous of examining the effect of their reflection from a thin plate of air, capable of producing the well-known rings of colours. For this purpose I formed an image of the rings, by means of the solar microscope, with the apparatus which I have described in the Journals of the Royal Institution; and I threw this image on paper dipped in a solution of nitrate of silver, placed at the distance of about nine inches from the microscope. In the course of an hour, portions of three *dark rings* were very distinctly visible, much smaller than the brightest rings of the coloured image, and coinciding very nearly, in their dimensions, with the rings of violet light, that appeared upon the interposition of violet glass. I thought the dark rings were a little smaller than the violet rings, but the difference was not sufficiently great to be accurately ascertained: it might be as much as $\frac{1}{30}$ or $\frac{1}{40}$ of the diameters, but not greater. It is the less surprising that the difference should be so small, as the dimensions of the coloured rings do not by any means vary at the violet end of the spectrum so rapidly as at the red end. The experiment in its present state is sufficient to complete the analogy of the invisible with the visible rays, and to show that they are equally liable to the general law, which is the principal subject of this paper," that is, the interference of light.

M. B. G. Sage, in the 'Journal de Physique, 1802,' mentions a fact observed by him, that "the realgar which is sublimated at the Solfaterra under the form of octahedral crystals, known under the name of *ruby of arsenic*, effloresces by the light;" and that ordinary native realgar from Japan changes to orpiment by exposure to sunshine§.

In 1806 Vogel exposed fat carefully protected from the influence of the air to light, and found that it became in a short time of a yellow colour, and acquired a high degree of rancidity. Vogel subsequently discovered that phosphorus and ammonia exposed to the sun's rays were rapidly converted into phosphureted hydrogen, and a black powder, phosphuret of ammonia. He

* Philosophical Transactions, 1836. † Report of Seventeenth Meeting, 1847, p. 17.

‡ Experiments and Calculations relative to Physical Optics, Phil. Trans., 1804.

§ Philosophical Magazine, vol. xiii.

also noticed that the red rays produced no change on a solution of corrosive sublimate (bichloride of mercury) in ether, but that the blue rays rapidly decomposed it*. Dr. Davy much more recently repeated a similar set of experiments to those of Vogel. He found that corrosive sublimate was not changed by exposure; but that the Liquor Hydrarg. Oxymur. of the London Pharmacopœia quickly underwent decomposition in the sunshine, depositing calomel.

Seebeck in, and subsequently to 1810, made some important additions to our knowledge of the influences of the solar radiations, the most striking of his statements being *the production of colour on chloride of silver*; the violet rays rendering it brown, the blue producing a shade of blue, the yellow preserving it white, and the red constantly giving a red colour to that salt. Sir Henry Englefield about the same time was enabled to show that the phosphorescence of Canton's phosphorus was greatly exalted by the blue rays.

Dr. Wollaston's experiments on the tincture of gum guaiacum also tended to prove the peculiar differences in the most and the least refrangible rays. Cards moistened with this tincture acquired a green colour in the violet and blue rays, and the original yellow colour was rapidly restored in the red rays.

Gay Lussac and Thenard, being engaged in some investigations on chlorine, on which elementary body Davy was at the same time experimenting, observed that hydrogen and chlorine did not combine in the dark, but that they combined with great rapidity, and often with explosion, in the sunshine, and slowly in diffused light. Seebeck collected chlorine over hot water, and combining it with hydrogen, placed different portions of it in a yellowish red bell glass and in a blue one. In the blue glass combination took place immediately the mixture was exposed to daylight, but without explosion. The mixture in the red glass was exposed for twenty minutes without any change; but it was found that the chlorine had undergone some alteration, probably a similar one to that noticed by Dr. Draper, which I shall have shortly to describe. If the gases were placed in a white glass and exposed to sunshine, they exploded; but if the gas had been previously exposed to the action of the solar radiations in the yellow red glass, it combined with hydrogen in the white glass in the brightest sunshine without any explosion.

Berzelius noticed some peculiar conditions in the action of the solar rays upon the salts of gold; and Fischer pursued some researches on the influence of the prismatic rays on horn silver†.

The most important series of researches however were those of Berard in 1812, which were examined and reported on by Berthollet, Chaptal and Biot. These philosophers write, "He (M. Berard) found that the chemical intensity was greatest at the violet end of the spectrum, and that it extended, as Ritter and Wollaston had observed, a little beyond that extremity. When he left substances exposed for a certain time to the action of each ray, he observed sensible effects, though with an intensity continually decreasing in the indigo and blue rays. Hence we must consider it as extremely probable, that if he had been able to employ reactions still more sensible he would have observed analogous effects, but still more feeble, even in the other rays. To show clearly the great disproportion which exists in this respect between the energies of different rays, M. Berard concentrated, by means of a lens, all that part of the spectrum which extends from *the green to the extreme violet*; and he concentrated, by means of another lens, all that portion which extends from *the green to the extremity of the red*. This last pencil formed *a white*

* Ann. de Chimie, vol. lxxv. p. 225.

† Philosophical Magazine, vol. vii. Second Series, p. 462.

point so brilliant that the eyes were scarcely able to endure it; yet the muriate of silver remained exposed more than two hours to this brilliant point of light without undergoing any sensible alteration. On the other hand, when exposed to the other pencil, which was much less bright and less hot, it was blackened in less than six minutes*." This is the earliest intimation we have of any indication that the luminous and chemical powers may be due to dissimilar agencies. On this, the Commissioners remark :—" If we wish to consider solar light as composed of *three distinct substances*, one of which occasions *light*, another *heat*, and the third *chemical combinations*; it will follow that each of these substances is separable by the prism into an infinity of different modifications, like light itself; since we find by experiment, that each of the three properties, *chemical*, *colorific* and *calorific*, is spread, though unequally, over a certain extent of the spectrum. Hence we must suppose, on that hypothesis, that there exists *three spectrums* one above another; namely a calorific, a colorific and a chemical spectrum. We must likewise admit that each of the substances which compose the three spectrums, and even each molecule of unequal refrangibility which constitutes these substances, is endowed, like the molecules of visible light, with the property of being polarized by reflection, and of escaping from reflection in the same positions as the luminous molecules, &c." Some other objections to M. Berard's views are then urged. The experiment, already named, by Dr. Young on the chemical action of the dark rings, and analogous ones, to be yet noticed, by M. Edmund Becquerel and Professor Miller, go to show, that whether the chemical agency is due to the same principle which produces light or not, it certainly obeys nearly all the same general laws.

It was stated by Arago and others, that M. Charles, an experimentalist of some celebrity, had a process by which he was enabled to produce portraits by the aid of light. He died however without disclosing his secret; and even the Abbé Moigno, always anxious to claim for France the honour of any discovery, admits that Charles left "*no authentic document to attest his discovery*;" and he consequently gives to Wedgwood the merit of being the originator of photography. M. Niepce, of Châlons on the Saône, communicated to our Royal Society, in 1827, an account of his experiments, upon which it would appear he had been engaged since 1814. This memoir was not printed by the Royal Society, owing to the circumstance that M. Niepce refused to publish the secret of the process by which he produced the pictures he then exhibited, some of which are now in the possession of Mr. Robert Brown of the British Museum.

The discovery of Niepce appears to have been, that the luminous rays have the property of solidifying several resinous substances, thus rendering the parts which had been exposed less soluble than those which have been preserved in shadow. He appears to have also observed, that resins thus changed by the influence of sunshine returned to their original state when kept for a short time in the dark. We have not however any exact statement of the researches of Niepce, which appear to have been extensive, but devoted principally to the production of what he called heliographic pictures. In 1829 Niepce associated himself with Daguerre, to whom we owe the iodized silver plate and the discovery of that peculiar condition induced by the solar rays, which regulates the deposit of mercurial vapour; the distinguishing feature of the well-known Daguerreotype process. In addition to this, Niepce discovered that silver plates could be rendered sensitive to solar agency by being washed " with a decoction of the herb Shepherd's purse (*Thlaspi Bursa-pastoris*), fumes of phosphorus, and

* Annales de Chimie, vol. lxxxv. p. 309.

particularly of sulphur, as acting on silver in the same way as iodine; and that caloric produced the same effect by oxidizing the metal, *for from this cause proceeded in all these instances this extreme sensibility to light.*"

Mr. Henry Fox Talbot commenced his experiments in photography in 1834; and in 1839, about six months prior to the publication of Daguerre's process, he published 'Some Account of the Art of Photogenic Drawing, or the process by which natural objects may be made to delineate themselves without the aid of the artist's pencil.' Mr. Talbot, pursuing his inquiries, discovered his extremely sensitive process, the "calotype," which consists in exalting the sensibility of iodide of silver by the action of gallic acid.

From the period of the announcement of the discovery of Daguerre in 1839, the inquiry into the phænomena connected with the chemical action of the solar radiations assumed a more inductive character; and having no longer to record isolated discoveries made at far distant intervals, the historical arrangement will now be abandoned for a more philosophical examination of the subject.

All the observations which had been made on the influence of the prismatic rays upon the salts of silver and other bodies, point to a very remarkable difference in the action of the several rays; and this class of observations being more completely carried out by living philosophers, among whom Sir John Herschel demands the most distinguished notice, a still larger number of curious facts were elicited.

It is the peculiar habit of our minds to endeavour to explain new phænomena by received theories, and thus, I fear too often, to create imaginary resemblances where no real analogies exist. In this way it has, I think, been too hastily decided that the varieties of action observed in the colorific rays of the spectrum in relation to chemical change are due to varying undulations and to the phænomena of wave interferences. The amount of mathematical skill which has been brought to bear on the wave theory of light, has placed it in a most popular position; but, without for one moment attempting an objection to any part of this theory as it explains luminous phænomena, it cannot be too strongly insisted on, for it is too often forgotten, that excepting Dr. Young's experiment already quoted, no attempt has ever been made by any mathematician to associate the chemical agency of the solar rays with the theory of luminous undulations. Speculations there have been, but all these have been ventured on without any attempt at analysis. This is particularly mentioned to show that the entire subject remains open for examination, and that this examination should be prosecuted without reference to any preconceived hypotheses.

Sir John Herschel* remarks on "the high probability at least that the chemical energy is distributed throughout the spectrum in such a way as to be by no means a mere function of the refrangibility, but to stand in relation to other physical qualities, both of the ray, and of the analysing medium, and that relation by no means the same as that which determines the absorptive action of the latter on the colorific rays."

Without stopping to consider the question of the colours of the bands constituting the spectrum, it being perfectly indifferent to this subject whether we adopt the seven rays of unequal refrangibility of Sir Isaac Newton or the views arrived at by the refined researches of Sir David Brewster, which reduce the chromatic phænomena to three,—I shall at once pass to the chemical agency exercised along different lines of the spectrum. It is however necessary that

* On the Chemical Action of the Rays of the Solar Spectrum, &c. Philosophical Transactions, 1840, pt. 1.

we should regard the spectrum, from the extreme red ray at one end of the spectrum to the lavender or gray ray at the other*, as representing the extent of luminous power, which has its maximum in the yellow ray and its minima at the outer limits of the extreme red and the lavender rays, since we have not been enabled to trace any luminous effects beyond these points. It is convenient to employ these coloured rays to mark points of action and of inaction; but it appears important that we should dispossess our minds of the idea that chemical change, or the contrary, takes place by virtue of any function of a particular coloured ray.

It had been already noticed by Berard, that the mean luminous rays, even when condensed by a lens, produced no chemical change on chloride of silver. Sir John Herschel was the first to observe that the rays at the red end of the spectrum protected chloride of silver from that change which is induced even beyond the spectrum by the diffused light which always accompanies the prismatic image; that whereas papers prepared for photographic purposes were darkened more or less over every other part; over the space "on which the full red of the spectrum had fallen, there was an appearance of whiteness, a sort of white prolongation of, or appendage to, the dark photographic impression." It is thus proved that the red end of the spectrum is not inactive; it is not, that any sort of polarity exists in the spectrum: we have a positive evidence, an action as energetic as that of the blue end of the spectrum, but exerted in an opposite direction. If paper is blackened by exposure to the violet end of the spectrum, or by the influence of diffused light, and subsequently exposed to the action of the red rays, it becomes of "a full and fiery red" over the entire space upon which those rays fall. A similar result, but not so decided, is produced by the radiations which permeate a ruby glass coloured with oxide of gold.

It has lately been shown by M. Claudet that on the Daguerreotype plate these red rays restored the sensibility of the iodized silver after it had been acted upon by the more refrangible chemical rays†. The powerful action of the red end of the spectrum was further proved by Sir John Herschel, who employed two prisms and threw the red rays of one spectrum upon the violet rays of another. "The *blackening* power of the more refrangible rays

* It is important that the condition of the prismatic spectrum should be distinctly comprehended: for a complete examination of the subject I must refer to the Transactions of the Royal Society of Edinburgh for 1822; and to Sir John Herschel's Treatise on Light, Encyclopædia Metropolitana; Sir David Brewster's Optics, Lardner's Cyclopædia; and numerous memoirs in the Transactions of the Royal Society of Edinburgh. To state in brief the facts as presented to us, upon examining the Newtonian spectrum of seven colours—red, orange, yellow, green, blue, indigo and violet,—we must at once perceive that those seven are compounds of but three colours—red, blue and yellow. By the combination of these all the others can be produced, but not by any combination of the other rays. By examining the spectrum with coloured media we can detect extensions of these primary colours, and fair evidence is afforded that these colorific bands overlap each other. Now, if we look at the spectrum through a cobalt blue glass, a colour unseen by the naked eye becomes visible, *the extreme red ray*. This is evidently the result of a mixture of blue and red. By throwing the spectrum upon turmeric paper a prolongation of the luminous portion beyond the violet is seen, to which Sir John Herschel gave the name of *the lavender ray*. Thus *nine* instead of *seven* bands present themselves. Now, if we examine all the conditions of these colours, we shall find that the yellow ray blends with the blue, and produces green; then, that the blue becomes more and more decided, passing on to blackness in the indigo; but that red reappearing at that, the most refrangible end, produces by mixing with blue *the violet*, and yellow blending with the violet produces the neutral *lavender* or *gray* ray. On the other side, *yellow* mixing with *red* produces *orange*, and then the red growing in intensity and purity, again blends with blue at the least refrangible end of the spectrum to produce the *crimson* ray or extreme red.

† Philosophical Magazine, 1850.

seemed to be suspended over all that portion on which the less refrangible fell, and the shades of green and sombre blue which the latter would have impressed on *white* paper, were produced on that portion, which, but for their action, would have been merely blackened."

It was, however, subsequently proved by the same excellent experimentalist, that if a paper, blackening under the influence of the red rays of the spectrum, was repeatedly drenched with the solution of the iodine salts, the blackening eventually gave way, and was succeeded by a very feeble degree of bleaching. This bleaching appears to be distinctly due to thermic action, as it can be produced to an equal degree by the influence of heat alone. The action of the spectrum on this variety of paper may be divided into four parts :—

1st, bleaching by the most refrangible rays; 2ndly, blackening by the least refrangible rays; then, 3rdly, bleaching by the same rays of low refrangibility; and, 4thly, an actual darkening to a pale brown, by the more active chemical rays.

If paper blackened by exposure is washed with a solution of iodide of potassium and exposed to sunshine, it is rapidly bleached. This forms the basis of a process for obtaining positive pictures which appears to have been noticed nearly about the same time by Dr. Fyfe, Lassaigne and myself, Dr. Fyfe, I believe, being the first to publish his process. If, however, this paper is exposed to the prismatic spectrum, it will, at the same time as it is bleaching under the influence of the most refrangible rays, blacken under that of the least refrangible; the iodine under the action of the chemical (actinic) rays combining and forming an iodide of silver, while under the operation of the calorific rays and others associated with them, an actual exaltation of the oxidation of the silver salt results.

Here we have evidence of two sets of rays of widely different refrangibility, and consequently of dissimilar lengths of undulation, producing equally energetic chemical changes, but of an opposite character. This might have been predicated by what we already knew of the action of the red and blue ends of the spectrum; but the experiment mentioned by Sir John Herschel, in which, under the combined influence of these two sets of rays acting upon one spot, an effect was produced which did not belong to either of them when separated, could not have been expected, and has not been explained upon any of the theories of light.

A very interesting modification of the above phænomena may be produced by the use of coloured media. If an engraving is placed upon a piece of darkened photographic paper washed over with a solution of iodide of potassium, and it is then exposed to sunshine, a positive copy of the engraving, as has been already explained, resnlts. Now, if we place a piece of blue glass over one portion, and a ruby glass over another, the bleaching process goes on with great energy under the blue, and the blackening with equal intensity under the red; and we obtain a positive and negative copy of the engraving at the same time on the same piece of paper.

It has been proved by the experiments of Sir J. Herschel that this blackening power is exerted by rays beyond the extreme red ray, where no luminous influence can be detected. This result is particularly shown upon papers prepared with acetate of lead, chloride of platinum, and washed when under the influence of the light with hydriodate of potash.

When experimenting with photographic papers prepared with the tartrate of potash and soda (Rochelle salts), Sir John Herschel observed that a protected line presented itself on every side of the spectrum. "If the light was allowed to continue its action, there was observed to come on suddenly a new and much more intense impression of darkness confined in length to the blue and violet rays, and, what is most remarkable, confined in breadth to the middle of the sun's image, so far at least as to leave a border of a lead-coloured spectrum, traceable not only round the clear and well-defined convexity of the dark interior spectrum, at the least refrangible end, but also laterally along both its edges."

At the same time, ignorant of these refined researches of Sir John Herschel, I observed similar results upon a Daguerreotype plate: the record of these observations will be found in the Philosophical Magazine (vol. xvi. 3rd Series, p. 267), the same number containing the abstract of the Memoir of Sir John Herschel, read before the Royal Society, which first made me acquainted with his observations. It was most distinctly stated that there was "a real difference between the chemical agencies of those rays which issue from the central portion of the sun's disc, and those which emanating from its borders have undergone the absorptive action of a much greater depth of its atmosphere." Therefore the first observation of this is not due to M. Arago, who has only very recently noticed the fact in his 'Memoirs on Photometry.' It must not, however, from any evidence yet afforded us, be supposed that the peculiar protecting influence of the extreme red ray, and the similar influences of the lateral edges of the spectrum, are of precisely the same order. It would rather appear that the least refrangible rays have a function arising from a combination of chemical and calorific power which is distinct from anything exhibited by the other radiations.

We have now to consider the remarkable fact, that nearly all bodies susceptible of receiving any impression from the ordinary *red* rays assume more or less a red colour. This was noticed very early by Daguerre and Talbot, and it has been confirmed by every subsequent experimentalist. The cause of this production of colour is not very evident; but we must regard it as due to the new molecular arrangement produced by the chemical changes effected by these radiations. From time to time we hear of the productions of coloured images of prismatic spectra, and lately M. Edmund Becquerel has created some sensation by exhibiting such images, and also copies of highly coloured drawings.

This is not a novelty in photographic phænomena. Herschel, in 1839, obtained a coloured spectrum upon a paper prepared with two washes of a solution of nitrate of silver and a wash of muriate of soda applied between each. This was described as "coloured with sombre, but unequivocal tints imitating those of the spectrum itself." In the same year I found that papers prepared with muriate of barytes and nitrate of silver, would, after having been allowed to darken, if placed under different coloured media, assume, to a certain extent, the colours of the rays permeating them. "After a week's exposure to diffused light, it became *bright red* under the red glass, a *dirty yellow* under the yellow, a dark *green* under the green, and a light olive under the blue*." Again, in 1844, I was fortunate enough to obtain very decided evidences of colour upon papers prepared with the fluoride of potassium and nitrate of silver†.

M. Edmund Becquerel, investigating the conditions of the spectrum with particular reference to its influences on the Daguerreotype plate, was led to regard the spectrum as consisting of two remarkable divisions, which he calls *rayons excitateurs* and *rayons continuateurs*; the least refrangible rays being supposed to continue the action set up by the chemical or most refrangible

* Philosophical Transactions for 1840, pt. 1, p. 43.

† Researches on Light, p. 106.

rays. For example, a Daguerreotype plate being impressed in the camera with its dormant, invisible image, is placed under the influence of radiations which are deprived of their *actinism*, and yet the image is slowly and steadily developed. On this curious question the papers of M. Claudet should also be consulted. M. E. Becquerel's classification of the effects observed, which is as follows, is good:—

1st series. Bodies exhibiting a physical modification without any change in composition.

2nd series. Elements combined under solar influence.

3rd series. Combination destroyed in part or entirely by the influence of solar rays.

If a careful examination is made of spectra chemically formed, it will be found that scarcely one of those impressed upon papers prepared with inorganic matter exhibit any influence over the space covered by the yellow ray; that is, the most luminous portion of the prismatic spectrum produces no chemical change upon them. This is only a confirmation of the observation of Berard previously mentioned. As the sensibility of the photographic preparation is increased, we find the resulting chemical impression considerably lengthened: it is not only extended to a greater distance beyond the utmost extent of the luminous image, but chemical change becomes evident more nearly up to the centre of the yellow ray,—the point of maximum illuminating power. In no case however has any decided effect been observed up to this point. I have been disposed to refer this to a power of light antagonistic to that of chemical action. But it must not be disguised, that the phænomenon appears to be explicable also upon some view of interference, although this is by no means reducible to any satisfactory condition in the present state of our knowledge. It has been proved by experiments with coloured media, which have been employed to analyse the prismatic spectrum, that every luminous ray may be made to protect chloride of silver from chemical change. Thus lines of blue, yellow and red rays, with their interblending tints (after having been filtered by a glass stained with oxide of silver), have been thrown upon highly sensitive photographic papers, which have been at the same time under the influence of diffused light; and it has been found, that although every part of the paper, *except that portion covered by the spectrum*, has been deeply darkened, the whole of this line has been protected and preserved perfectly white*. We have usually been accustomed to speak of the chemical agency of the solar radiations, as belonging in their varieties to some particular coloured ray. Thus the yellow ray has been regarded as the least chemical, and the blue as the most energetically so. Evidence however has been afforded to show that the blue ray may be deprived of its chemical power, and we shall presently see that some forms of chemical change are in a peculiar manner determined by the rays emanating from the yellow band. Therefore, without in any way interfering with any theory of luminous action, we can no longer regard the colour of a particular ray as an indication of its power to produce chemical change. Colour is a peculiar function of light, not directly connected with any chemical phænomena.

It becomes important to ascertain the effects of transparent media on these chemical radiations. It was shown by Malagutti that certain colourless transparent media possessed a power, in virtue of which the chemical action of the rays permeating them was very frequently exalted†. This subject has also been investigated by M. Biot and M. Edmund Becquerel, who have

* British Association Reports, 1848, Swansea. Lecture by R. Hunt, Royal Institution. Athenæum, 1849, No. 1122, p. 438.

† Annal. de Chimie, vol. lxxii. 5.

equally remarked the differences produced on actinic power by colourless screens.

The exalting or depressing power of certain media was also particularly examined by Sir John Herschel, who observed very early in the progress of his inquiries, that if a piece of thin post-paper, merely washed with nitrate of silver, was exposed to clear sunshine, partly covered by and strongly pressed into contact with glass, and partly projecting beyond it, the portion under the glass was very much more affected than the part exposed, it being often blackened, in the same time, to a tone which would require at least three times the exposure uncovered. In practice photographers have availed themselves of this, and it is usual to place the prepared paper in the camera behind a plate of glass.

The philosophy of this is ill understood: it has been thought to be due to the circumstance, that the most transparent glass abstracts a portion of LIGHT, and thus leaves the *actinic* power more free to act on the sensitive material. The entire question demands a more attentive examination than it has hitherto received. The peculiar action of coloured media is more accurately defined; and as a knowledge of the influences exerted will have its value in guiding new observers, the more decided and peculiar cases of obstruction to the actinic radiations must be given. It cannot however be too strongly impressed, that every variety of glass or fluid media employed should be submitted to prismatic examination, since the colour alone is not a guide to the quality of the radiations permeating a particular medium.

Supposing the effect of exposure of a standard photographic preparation to the direct solar radiations in a given time to be represented by 100, the action produced by the interposition of coloured media is relatively shown in the other numbers. Although many specimens of blue glass show an exalting effect, and consequently should be represented by a number in excess, it is thought advisable to regard them as equal to unshaded exposure.

Glasses.

Exposure to unshaded sunshine	+100
Ruby glass coloured with oxide of gold which insulates perfectly the red rays	— 25
Brown red coloured with copper, which admits the permeation of all the rays below the orange, and a faint line of blue	— + 30
Orange glass coloured with iron, cutting off the violet, indigo, and nearly all the blue rays	— 10
Lemon-yellow glass, probably coloured with iron, reducing the spectrum to three patches of blue, red and yellow	— 8
Yellow glass stained with oxide of silver	— 3
Green glass,—a deep pure green produced by oxide of copper	+ 74
Blue glass, cobalt, obliterating all the mean luminous rays, and exhibiting the extreme red in great purity	+100

Fluids.

Red.—Carmine dissolved in ammonia; —cutting off all the rays above the red, except when in very thin layers it admits a small line of the violet	— 20
Orange yellow.—Solution of bichromate of potash with a little sulphuric acid; giving but a trace of the blue rays, all the least refrangible being well-defined	— 7
Lemon yellow.—Quadro-sulphuret of lime of Dalton;—cutting off all the prismatic rays above the inner limits of the blue	5

Green.—Muriate of copper and iron;—blue, green, yellow and orange rays permeate freely . . . . + 64
Blue.—Ammonia, sulphate of copper;—obliterating all the rays below the green . . . . +100

When the mark + is affixed to a number it indicates that the kind of action detected is positive, or belongs to the so-called chemical rays (actinism); on the contrary, when — is employed, the action detected belongs to that class which is associated with the least refrangible rays, or is of a negative order. Thus, when the ruby-glass is employed, the chloridated photographic paper is very slowly changed to a red, as under the red rays; but in the case of the brown-red glass, an action, both positive and negative, is detected: the resulting colour is a gray; but if the spectrum is passed through such a medium, the impression is made at the two extremities of the spectrum + by the small portion of the blue ray which passes and — by the ordinary red ray. From these notices it will be seen to how large an extent we can succeed in separating the phænomena of the solar radiations from each other. Under one set of conditions, we can command a large amount of light, which possesses no positive chemical power; while under another set, we can cut off nearly all the light, and admit freely the full amount of the chemical rays (actinism).

Again, it must be remembered that we can, as Melloni pointed out*, separate the luminous and calorific radiations very readily from each other. By the use of a green glass stained with oxide of copper, for example, a very large amount of the calorific rays are obstructed; and I have found that a very slight tint of green is quite sufficient to stop those radiations which have been distinguished by Sir John Herschel as parathermic rays, and to which in all probability the browning of the autumnal leaves is due. From a series of experiments undertaken at the request of the Commissioners of Woods and Forests, I was induced to advise that a glass, stained slightly green with the oxide of copper, should be employed for glazing the Palm House in the Royal Botanical Gardens at Kew. This advice was acted upon; and as far as the opportunities of observing enable us to form an opinion, nothing can be more satisfactory†.

A peculiar difference is found in the action of the solar spectrum on vegetable colours. This branch of the inquiry has particularly engaged the attention of Sir John Herschel, and, notwithstanding the interesting nature of the inquiry, it appears to have been pursued by but one other experimentalist, Mrs. Somerville.

It is proved that the chemical action of the solar rays upon all vegetable juices is confined within the limits of the *luminous radiations*, no change having been detected over those dark spaces which are purely chemical and calorific.

In the instance of gum guaiacum, it was observed by Dr. Wollaston, that paper washed with its tincture was changed to a blue or green by the most refrangible rays, and restored again to its original yellow colour by the least refrangible, which he regarded as due to the heat of those rays. M. Biot has shown that that portion of the resin soluble in water was not affected by the sun's rays. These experiments have been confirmed by Herschel, who has however proved, contrary to the opinion of Wollaston, that the return of the colour was not due to heat alone; since *beyond the luminous rays*, where the calorific effect is at a maximum, no such change is produced. "Obscure

* Bibliothèque Universelle de Genève, No. 70, for October 1841.

† On the Coloured Glass employed in glazing the New Palm House in the Royal Botanic Garden at Kew (Report of the British Association for 1847).

terrestrial heat is shown to be capable of *assisting* and *being assisted* in operating this peculiar change, by those rays of the spectrum, whether luminous or thermic, which occupy its red, yellow and green regions; while on the other hand it receives no such assistance from the purely thermic rays beyond the spectrum, acting under precisely similar circumstances, and in an equal state of condensation." The action of the solar rays is *positive*, that is to say, vegetable colour is destroyed; but in most cases it is susceptible of restoration by chemical agents. When vegetable colours have been removed—bleached—by the action of bleaching agents, they may be restored by the action of the sun's rays. If exposed to the action of the prismatic spectrum, it will be found that the *restoration of colour is operated by rays complementary to those which destroy it in the natural state of the paper*; "the violet rays being the most active, the blue almost equally so; the green little, and the yellow, orange and most refrangible red not at all*."

Although the restoration of vegetable colours is occasioned by rays within the limits of the luminous spectrum, it must be remembered that the green, yellow and orange rays—those having the most illuminating power,—are, in nearly all cases, inactive. The effects would appear to be due to the combined influences of the light and of the chemical agency, whatever it may be. But even under this view a peculiar difficulty presents itself; we find for example the blue rays, or the actinic power associated with that colour, destroying a vegetable colour; and then, having used a chemical agent,—as sulphurous acid—to destroy that colour, it can be restored by the action of the orange or red rays. The peculiar variations in the scale of action which we find in almost every different substance exposed to solar influence, presents the greatest difficulty to any theoretical view of the physical constitution of the sunbeam.

Mrs. Somerville has pointed out some very remarkable actions of the spectrum on vegetable juices†. The colouring matters examined by this lady were derived from the

Pomegranate.	Scarlet Geranium.
Globe amaranthus.	Scarlet Balsam.
Plumbago auriculata.	Dahlia.
Beet root.	Scarlet Zinnia.
Rose Verbena.	Walnut.
Nasturtium.	Fig.

These were sometimes employed pure, in other cases they were united with common salt, some acid, or carbonate of soda. The differences produced were singular, presenting, as in the case of the silver salts, a variation in the scale of action in every case. The maximum amount of action was observed, however, to lie between the yellow and the green rays, and seldom extending beyond the blue; showing that those radiations which exert the most energetic action on metallic compounds have little or no influence on the products of the vegetable world. In nearly all cases a peculiar effect was observed at the least refrangible end of the spectrum. Coloured spots were produced, which appear to correspond to the rays named by Sir John Herschel, the Parathermic rays; and at the same time, as the evidences of heat were clear from the drying of the paper, it became apparent that some peculiar chemical change was being induced. At present, however, there is nothing determined as to the real agency producing this set of phænomena. Allusion having been made more

* Herschel, Philosophical Transactions, Part 2 for 1842, p. 192.

† On the Action of the Rays of the Spectrum on Vegetable Juices (Philosophical Transactions, 1846, p. 111).

than once to a set of rays acting in some respects like heat, and at the same time exhibiting chemical power, it appears necessary that the mode of ascertaining the positions of the points of maximum calorific power should be described.

Paper being blackened or strongly coloured, is stretched on a frame, so placed that a well-defined luminous spectrum is thrown upon its uncoloured side. This is then washed over with alcohol or ether, and the points of greatest heat are shown by the rapid evaporation which takes place. After a few minutes a whitish spot begins to appear considerably below the red ray, which increases in breadth until it equals that of the luminous spectrum, and in length till it forms a long appendage exterior to the spectrum, and extends moreover within it and beyond the mean yellow ray. By applying a second wash of alcohol or æther, thermographic spots are produced still lower than the first heat spot, which show a very remarkable and unexpected extension of calorific radiations. The want of continuity in the calorific spectrum is its most striking phænomenon; it consists of four distinct patches, extending to a distance below the luminous rays equal to the whole length of the spectrum, and a prolongation through the luminous rays up to the end of the violet rays. The parathermic rays can scarcely be said to have a defined place amid the calorific radiations, but they are usually most strongly manifested in the red rays. In this part of the Report it appears likely to prove useful, if we give a list which shall as correctly as possible exhibit most of those bodies which have been shown to be susceptible of chemical change under the influence of the solar radiations, distinguishing the date of observation as far as it can be ascertained, and the name of the earliest observer. Although every care has been taken in examining authorities, it is not improbable that some errors of dates will occur,—but it is hoped they may be few and trivial,—the date of publication always being given as correctly as it can be ascertained.

Silver.

Nitrate of	Ritter	1801
—— (photographically employed)	Wedgwood and Davy	1802
—— with organic matter	J. F. Herschel	1839
—— with salts of lead	J. F. Herschel	1839
Chloride of	C. W. Scheele	1777
—— (photographically employed)	Wedgwood	1802
	Talbot	1839
—— darkened, and hydriodic salts	Fyfe, Lassaigne	1839
Iodide of (photographically used)	Herschel	1840
	Ryan	1840
—— with ferrocyanate of potash	Hunt	1841
—— with gallic acid (Calotype)	Talbot	1841
—— with protosulphate of iron (Ferrotype)	Hunt	1844
—— with iodide of iron (Catalysotype)	Woods	1844
Bromide of	Bayard	1840
Fluoride of	Channing	1842
Fluorotype	Hunt	1844
Oxide of	Davy	1803
—— with ammonia	Uncertain.	
Phosphate of	Fyfe	1839
Tartrate—Urate—Oxalate—Borate, &c.	Herschel	1840
Benzoates of	Hunt	1844
Formiates of	Do.	1844
Fulminates of	Do.	1842

Silver Plate.		
With vapour of iodine (Daguerreotype)	Daguerre	1839
With vapour of bromine	Goddard	1840
With chlorine and iodine	Claudet	1840
With vapour of sulphur	Niepce	1820
With vapour of phosphorus	Niepce	1820
Gold.		
Chloride of	Rumford	1798
	Herschel	1840
Etherial solution of	Rumford	1798
Etherial solution of, with percyanide of potassium	Hunt	1844
Etherial solution of, with protocyanide of potassium	Do.	1844
Chromate of	Do.	1844
Plate of gold and iodine vapour	Goddard	1842
Platinum.		
Chloride of	Herschel	1840
Chloride of, in ether	Herschel	1840
Chloride of, with lime	Herschel	1832
Iodide of	Herschel	1840
Bromide of	Hunt	1844
Percyanate of	Do.	1844
Mercury.		
Protoxide of	Uncertain.	
Peroxide of	Guibourt.	
Carbonate of	Hunt	1844
Chromate of	Do.	1843
Deutiodide of	Do.	1843
Nitrate of	Herschel	1840
Protonitrate of	Herschel	1840
Chloride of	Boullay	1803
Bichloride of	Vogel	1806
Iron.		
Protosulphate of.		
Persulphate of.		
Ammonia citrate of.		
Tartrate of.		
Attention was first called to the very peculiar changes produced in the iron salts, by	Sir John Herschel	1845
Cyanic compounds of (Prussian blue)	Scheele	1786
	Desmortiers	1801
Ferrocyanates of	Fischer	1795
Iodide of	Hunt	1844
Oxalate of	Do.	1844
Chromate of	Do.	1844
Several of the above combined with mercury	Herschel	1843
Copper.		
Chromate of (Chromatype)	Hunt	1843
—— dissolved in ammonia	Do.	1844

COPPER.		
Sulphate of	Hunt	1844
Carbonate of	Do.	1844
Iodide of	Do.	1844
Copper-plate iodized	Talbot	1841
MANGANESE.		
Permanganate of potash	Frommherz	1824
Deutoxide and cyanate of potassium	Hunt	1844
Muriate of	Do.	1844
LEAD.		
Oxide of (the puce-coloured)	Davy	1802
Red lead and cyanide of potassium	Hunt	1844
Acetate of lead	Do.	1844
NICKEL.		
Nitrate of	Do.	1844
—— with ferroprussiates	Do.	1844
Iodide of	Do.	1844
TIN.		
Purple of cassius	Uncertain.	
COBALT	Hunt	1844
Arsenic sulphuret of	Sage	1803
Arsenical salts of	Hunt	1844
ANTIMONY	Hunt	1844
BISMUTH	Hunt	1844
CADMIUM	Hunt	1844
RHODIUM	Hunt	1844
CHROMIUM.		
Bichromate of potash	Mungo Ponton	1838
—— with iodide of starch	E. Becquerel	1840
Metallic chromates (Chromatype)	Hunt	1843
CHLORINE AND HYDROGEN	Gay-Lussac & Thenard	1809
Chlorine (tithonized)	Draper	1842
—— and ether	Cahours	1810
GLASS, manganese, reddened	Faraday	1823
CYANOGEN, solution of	Pelouse and Richardson	1838
METHYLE	Cahours	1846
Crystallization of salts influenced by light	Petit	1722
	Chaptal	1788
	Dizé	1789
Phosphorus	Schulze	1727
	Ritter	1801
—— in nitrogen	Beckman	1800
Phosphorus and ammonia	Vogel	1806
Nitric acid decomposed by light	Scheele	1786
Fat matter	Vogel	1806
Development of pores in plants	Labillardière	1801
Vitality of germs	Michellotti	1803
Resinous bodies (*Heliography*)	Niepce	1814
Asphaltum	Niepce	1814
Resin of oil of lavender	Niepce and Daguerre	1830
Guaiacum	Wollaston	1803

Resinous bodies (*Heliography*).

Bitumens all decomposed	Daguerre	1839
All residua of essential oils	Daguerre	1839
Flowers, colours of, expressed, and spread upon paper	Herschel	1842
Yellow wax bleached	Senebier	1791
Phosphorescent influences of solar rays	Licetas	1646
	Kircher	1646
	Canton	1768
	Biot	1840
	E. Becquerel	1839
Vegetation in stagnant water	Morren	1841
Influence of light on electrical phænomena	E. Becquerel	1839

Magnetism induced by Solar Rays.

Affirmative.		Negative.	
Morichini	1812–13	Configliachi	1813
Moscati	1812–13	Firmas	1819
Grotthuss	1812–13	Berard	1819
Carpa	1816	Seebeck	1829
Ridolfi	1816	Riess and Moser	1829
Playfair	1817	Berzelius	1829
Christie	1826	Matteucci	1829
Baumgartner	1826	Kastner	1832
Somerville	1826	Haser	
Mark Watt	1827		
Barlocci	1829		
Zantedeschi	1829		
Moleyns	1842		
Knox, G. J. & T.	1840		

This array of names will show the exceeding degree of uncertainty which hangs about the supposed magnetic results; and, notwithstanding the elaborate experiments of Riess and Moser*, it does not appear safe, as they require of us "to reject totally a discovery which for seventeen years has at different times disturbed science."

Memoirs, &c. embracing Influences of Light on Organic Bodies.

Experiments upon the influence of light on plants	B. C. Méese	1775
Experiments on ditto	Priestley	1779
Experiments on vegetation	Ingenhousz	1782, 1784, 1786
Physico-chemical memoirs	Senebier	1782, 1788
Observations on Ingenhousz's experiments	De la Ville	1783
The effects of light on certain plants	Tessier	1783
On the influence of light	Berthollet	1786
On vegetable nutrition	Hassenfratz	1792, 1795
On the green colour of vegetables exposed to light	Humboldt	1792
Experiments on germination	Leféboure	1799

* Edinburgh Journal of Science, N. S. No. 4, p. 225.

Experiments relative to the influence of light on some vegetables	Decandolle	1801
On the vegetation of plants	Woodhouse	1801
Chemical researches on vegetation	Saussure	1803
Foxglove leaves in dry powder. Hemlock ditto. Henbane ditto. Aconite ditto. Jalap root ditto. Ipecacuanha ditto. Cascarilla bark ditto. Valerian root ditto. Rhubarb root ditto. Ginger root ditto.	Ordinary observation has shown that all these preparations lose colour, and are much deteriorated in their medicinal values by exposure to light. First particularly noticed in the Journal of the Pharmaceutical Society, 1846.	
Uber Pflanzenerregbarkeit im Allgemeinen und Besonderen	Ritter	1808
Recherches sur la respiration des plantes exposées à la lumière du soleil	Ruhland	1816
On the action of light on plants, and of plants upon the atmosphere	Daubeny	1836
On the action of light upon the colour of the river sponge	J. Hogg	1838
Experiments and observations on light which has permeated coloured media, and on the chemical action of the solar spectrum	Hunt	1840
Influence de la lumière sur les racines	Payer	1843
On the action of yellow light in producing the green colour, and indigo light the movements of plants	P. Gardner	1844
On the influence of light on plants	Hunt	1844
Note on the decomposition of carbonic acid by the leaves of plants under the influence of yellow light	Draper	1844
Influence des rayons solaires sur la végétation	Zantedeschi	1844
Ueber die Respiration der Pflanzenblätter	Grischow	1845
Ueber die Nahrungsstoffe, aus denen die Pflanzen in Lichte das Sauerstoffgas ausscheiden	C. H. Schultz	1845
Tendance de certaines racines à fuir ou rechercher là lumière	Durand	1845
Quelques expériences sur la respiration des plantes	Matteucci	1846
Reports of British Association	Hunt	1846
Directions of plants as influenced by light	Maccaire	1847
Report. Influences of the solar rays on the growth of plants. British Association	Hunt	1847

As the last Report comprehends the principal points of interest in connexion with the influences of the solar radiations on vitality, and we have now afforded the means of referring to the inquiries of those numerous authors who have examined this part of the subject, it is thought unnecessary to dwell on this important subject in the present Report.

From the extensive list which has been given, it will be seen that the action of the solar radiations,—so far from being confined, as it was formerly thought to be, to a few peculiar chemical compounds, which, existing in a state of exceedingly nice equilibrium, were liable to have their affinity disturbed by the operation of any external force,—is so extensive, that scarcely any body in nature, organic or inorganic, is independent of the solar influences, although their scales of sensibility to them are widely different.

There are a few remarkable chemical facts recorded, which prove yet further how very extensive is the operation of the actinic force, and point at the same time to a line of inquiry, which is only now beginning to engage attention.

Dumas was the first to point out, that when crystallizable acetic acid $C^4 H^3 O^3 + HO$ is exposed to sunshine in an atmosphere of dry chlorine, it is gradually decomposed, and that an equal volume of chlorine completely takes the place of the hydrogen, a new acid composed of $C4\ Cl3\ O3 + HO$ (chloracetic acid) resulting*.

Auguste Cahours has shown that some very striking effects are produced by sunshine on the combination of chlorine and some ethers of the methylic series†. "La préparation de l'oxalate et du formate de méthylène perchlorés est des plus simples : il suffit, en effet, de placer ces produits bien purs et bien secs dans des flaçons remplis de chlore desséché, puis d'exposer ces derniers à la radiation solaire directe. Dans les premiers moments, l'attaque est excessivement vive, mais elle se ralentit à mesure que la chloruration fait des progrès ; on reconnait que l'opération est terminée, lorsque, après une exposition de plusieurs jours à un soleil assez vif, la teinte de l'atmosphère du flaçon ne s'affaiblit plus."

At the meeting of the British Association at Cork, Dr. Draper of New York communicated the very remarkable fact, that chlorine which has been exposed to daylight or sunshine possesses qualities which are not possessed by chlorine made and kept in the dark. It acquires from that exposure the property of speedily uniting with hydrogen, under circumstances in which the combination with ordinary chlorine is effected with very great slowness. Dr. Draper found that if a flask of chlorine and hydrogen was placed in an atmosphere of chlorine, and then exposed to sunshine, no formation of hydrochloric acid took place. The agent producing the combination had been stopped by the yellow atmosphere of the chlorine surrounding the flash. It was now found that if this chlorine which had stopped the chemical agent, was itself mixed with hydrogen, it combined, under the influence of the weakest light, with an energy which unsolarized chlorine did not exhibit. Hence Dr. Draper inferred, "that those rays are absorbed by ponderable bodies, and that they become latent after the manner of heat ‡." He also concludes, that the indigo rays are the most active in effecting the formation of hydrochloric acid, and that the indigo rays are absorbed by the solarized chlorine. That remarkable changes do take place under the influence of sunshine in elementary bodies is further shown by the experiments of Berzelius on phosphorus §. This chemist has proved that when phosphorus, dissolved in ether, oil, or hydrogen gas, is exposed to sunshine, it undergoes a peculiar modification, and separates under the form of red phosphorus; and that in the Torricellian vacuum it sublimes in red scales.

I have also shown ‖ that a solution of protosulphate of iron in distilled water, (freed of, and carefully kept from the air,) exposed to sunshine, acquires a property of precipitating gold and silver from its solutions with much greater rapidity than a similar solution kept in the dark. In the same paper I have given some experiments, proving that with certain compounds precipitation

* Sur les Types Chimiques, Ann. de Ch. et Ph. lxxiii. 77.

† Recherches relatives à l'action finale du chlore sur quelques éthers composés de la série méthylique sous l'influence de la radiation solaire. Comptes Rendus, xxiii. 1070.

‡ On Tithonized Chlorine. Philosophical Magazine, July 1844.

§ Traité, tom. i. 258.

‖ Contributions to Actino-Chemistry. Phil. Mag. 1845.

goes on much more rapidly in light than in darkness, and that peculiar chemical changes take place in virtue of some solar force.

These phænomena stand at present as isolated facts, and serve only to show how extensive a field of inquiry is indicated, into which the experimentalist has scarcely ventured. I am not prepared at present to support the view which I once entertained, in common with Dr. Draper and others, that the results obtained afford evidence of the absorption of any solar radiation. We know so little of the constitution of molecules, and of the peculiar powers grouped under the name of molecular forces, and variously referred to as capillarity, endosmose, catalysis, allotropic and epipolic forces, that it is necessary to pause in our consideration of this intricate question.

The subject of this Report has been investigated with considerable caution by M. Edmund Becquerel*. His conclusions in general do not widely differ from those of the other investigators already named; but from these and a subsequent series of investigations on the dark lines of the chemical spectrum, M. Becquerel expresses his conviction that all chemical change is the result of *light*—luminous power.—"Je crois qu'on peut conclure de l'ensemble des faits que j'ai réunis dans ce travail, que les phénomènes lumineux chimiques et phosphorogéniques proviennent d'un seul et même agent, dont l'action est modifiée suivant la nature de la matière sensible exposée à son influence et la genre de modification dont cette substance est susceptible." The fact noticed by E. Becquerel, and also by Professor Miller and Dr. Draper, that the chemical spectrum has the same inactive or dark lines as the luminous spectrum, has been thought by some to be conclusive as to the identity of the chemical and luminous rays; but although it certainly proves that the agency in both cases obeys a similar law of motion, or is subject to the same wave interference, it does not appear necessarily to follow that the two phænomena, so broadly distinguished in their effects, are the result of a precisely similar cause.

It has been already stated that M. Edmund Becquerel distinguishes the most chemically active rays as *exciting rays*, and the least refrangible rays of the spectrum as *continuing rays*, since he finds that the chemical change commenced by one set of rays is capable of being continued by the other set. Shortly after this announcement, M. Gaudin found that the red, orange and yellow rays not only continue the action on iodized plates, but that they develope without mercury an image having the same appearance as that produced by mercurial vapour.

This class of phænomena has been also investigated by M. Claudet, so well known for the success with which he has prosecuted Daguerreotype portraiture†. This experimentalist states, as the result of his inquiries, that upon silver plates, prepared simply with iodine, all the rays " have the property of decomposing the iodide of silver in a longer or shorter time, as they have that of producing the affinity for mercury on the bromo-iodide of silver; with the difference, that on the former compound the separate actions of the several rays continue each other, and that on the second compound these separate actions destroy each other. We can understand, that in the first case, all the rays are capable of operating the same decomposition; and that in the second, the affinity for mercury, when imparted by one ray, is destroyed by another."

The phænomena of phosphorescence have attracted much attention, and

* Des Effets produit sur les Corps par les Rayons Solaires. Ann. Ch. et Ph. vol. ix. N. S. p. 257.

† Researches on the Theory of the principal Phænomena of Photography in the Daguerreotype Process. Phil. Mag. November 1849.

in many of the instances, that electricity is an active exciting agent appears proved; but in the phosphorescence, produced by the solar rays, we have effects which can scarcely be referred so easily to electrical effect.

If sulphuret of calcium (Canton's phosphorus) or the sulphuret of barium (the Bolognian stone) are exposed to sunshine they become luminous in the dark. If a paper covered with either of these substances is rendered luminous by exposure to sunshine, and is put under the influence of the solar spectrum, two very dissimilar actions occur; over that portion of the spectrum where the chemical rays exert their maximum power the phosphorescence is greatly increased, but that portion on which the least refrangible rays fall, is completely darkened. If the phosphorescent body is rendered luminous by the action of the actinic radiations, this phosphorescence is immediately destroyed by the momentary action of the calorific rays of the red spaces of the spectrum. This latter effect is not a mere formation of heat, since by the agency of artificial heat we can increase the amount of phosphorescence which is excited by the rays at the chemical end of the spectrum. Seebeck appears to have been the first to notice this peculiar property of the red rays.

In 1839 Edmund Becquerel first directed attention to the electricity developed during the chemical action excited by solar agency. Plates of platina, being placed in acidulated water, were connected with a delicate galvanometer; and the needle, after the first disturbance having come to rest at zero, the spectral radiations, commencing with the red, were thrown upon one of the plates. Neither the red, orange, yellow or green rays produced any action; the blue and indigo induced a slight disturbance; but the violet rays and the dark rays beyond the violet gave very decided indications of action by the deflections of the galvanometer. These experiments were repeated by me with many modifications*. I never obtained any deflections of the galvanometric needles by any rays below the green; we must therefore conclude that electro-chemical action is due to the most refrangible rays. At the York meeting of the British Association I produced some experiments, showing that certain electro-chemical decompositions which took place in the dark, giving rise to delicate metallic precipitates, were entirely prevented by exposure to sunshine. It is my intention to prosecute this line of inquiry with all care at the earliest opportunity.

In Poggendorff's 'Annalen' for 1842, M. Ludwig Moser announced the discovery of some very remarkable phænomena which he attributed to light. These are, "If a surface has been touched in any particular parts by any body, it acquires the property of precipitating all vapours which adhere to it, or which combine chemically with it, on these spots, differently to what it does on the other untouched parts." Dr. Draper described some similar phænomena in 1840. In three papers, which have been translated and published in the 'Scientific Memoirs,' Moser has stated all the results which he obtained: the deductions from these were, that light was susceptible of becoming latent, and that it was continually being radiated as "invisible light" from all bodies, different bodies giving off rays of different refrangibility. After a very searching examination of all the phænomena, I arrived at conclusions widely differing from those of Moser, and I was induced to refer them all to the influence of calorific radiations†. M. Fizeau‡ states his belief that the effects observed are the result of organic matter being transferred from one surface to another, and Professor Grove has expressed himself favourable to the same view. I believe, however, that invisible heat

* Researches on Light, by Robert Hunt, p. 213.

† On Thermography. Phil. Mag. Dec. 1842.

‡ Comptes Rendus, Nov. 1842.

radiation is capable of producing a sensible action on surfaces rendered perfectly free from organic matter. Those interested in this branch of inquiry are referred to the 'Scientific Memoirs,' since the subject can scarcely be said to belong to this Report.

I have purposely avoided any special notice of the photographic processes which have been discovered during the progress of the investigations we have been considering. Herschel, Talbot, Woods, Fyfe, Ponton, the writer of this Report, and others, in our own country, have introduced new processes; and Daguerre, Becquerel, Lassaigne, Fizeau, Everard, Niepce, &c. on the continent have enriched our store. Improvements in the Daguerreotype have been effected by Goddard, Claudet and others, until they have brought the silver plates to a state of sensibility which is almost marvelous. We have recently been surprised with an announcement, that by the agency of fluorine the processes on paper are rendered instantaneous, particularly on the calotype variety. In justice to myself, I must however claim to have published, in 1844*, a process called by me "the Fluorotype," which corresponds with the process now introduced in France, and which enabled me, with a non-achromatic meniscus lens, to procure "good images in the camera in half a minute." If the differences between the lenses employed be taken into account, it will be found that the result I then obtained was equal to that of which the discoverer of the new process (?) now boasts.

It will be evident that the question which assumes the most prominence in our consideration of these remarkable phænomena is that of the identity or otherwise of light and actinism.

Fresnel has stated that the chemical effects produced by the influence of light are owing to a mechanical action exerted by the molecules of æther on the atoms of bodies, so as to cause them to assume new states of equilibrium dependent on the nature and on the velocity of the vibrations to which they are subjected.

Arago says†, it is by no means proved that the photogenic modifications of sensitive surfaces result from the action of solar light itself. These modifications are perhaps engendered by invisible radiations mixed with light properly so called, proceeding with it, and being similarly refracted.

These views fairly represent the condition in which the argument stands, and a yet more extensive set of experiments appears to be necessary before we can decide the question. It appears however important that we should dismiss, as completely as possible, from our minds, all preconceived hypotheses. The phænomena were all unknown when the theories of emission and of undulation were framed and accepted in explanation of luminous effects; and it will only retard the discovery of the truth, if we prosecute our researches over this new ground, with a determination to bend all our new facts to a theory which was framed to explain totally dissimilar phænomena.

We may sum up the amount of our knowledge of the chemical influences of the solar radiations as follows:—

1. The rays, having different illuminating or colorific powers, exhibit different degrees and kinds of chemical action.

2. The most luminous rays exhibit the least chemical action upon all inorganic matter. The least luminous and the non-luminous manifest very powerful chemical action on the same substances.

3. The most luminous rays influence all substances having an organic origin, particularly exciting vital power.

4. Thus, under modifications, chemical power is traced to every part of the

* Researches on Light, p. 106. † Comptes Rendus, 1843.

prismatic spectrum; but in some cases this action is positive, *exciting*; in others negative, *depressing*.

5. The most luminous rays are proved to prevent all chemical change upon inorganic bodies exposed, at the same time, to the influence of the chemical rays.

6. Hence actinism, regarded at present merely as a phænomenon different from light, stands in direct antagonism to light.

7. Heat radiations produce chemical change in virtue of some combined action not yet understood.

8. Actinism is necessary for the healthful germination of seed; light is required to excite the plant to decompose carbonic acid; caloric is required in developing and carrying out the reproductive functions of the plant.

9. Phosphorescence is due to actinism, and not to light.

10. Electrical phænomena are quickened by actinism, and retarded by light.

Numerous other points of minor importance will present themselves on studying the facts described. Without venturing to obtrude my own views, I now leave the subject for that full investigation which it will, I trust, receive, as promising beyond all others to enlighten us on those curious phænomena which appear to link together the organic and the inorganic worlds.

Dr. Daubeny reported that some little progress had been made by him during the present season in the inquiry which was commenced last year, as stated in the Reports of the British Association, vol. xviii. p. 56. The object he last had in view was to ascertain whether such an addition to the amount of carbonic acid in common air, as that which had been shown by the experiments of the preceding year to be compatible with the health of ferns, would tend to promote their growth and luxuriance in a greater degree, than the proportion of the gas normally contained in the atmosphere did under similar circumstances.

He therefore had placed three species of ferns, viz. *Pteris longifolia*, *Pteris serrulata* and *Nephrodium molle*, under a jar, the air of which was impregnated with about five per cent. of carbonic acid gas, which amount was kept up by occasional additions throughout the whole period during which the experiments were continued; whilst three other ferns of the same kinds were kept under a similar jar containing common air without any such addition.

After the expiration of eleven weeks the two sets of ferns presented in their general aspect no material difference, although whatever superiority there might be, appeared to be on the side of the plants which had grown in air containing only the normal amount of carbonic acid.

In another set of experiments, however, in which two similar sets of ferns were watered, the one with rain water, the other with water impregnated with carbonic acid gas, those under the latter treatment appeared, after a time, decidedly more vigorous than the former.

Tenth Report of a Committee, consisting of H. E. Strickland, *Esq.*, Prof. Daubeny, Prof. Henslow, *and* Prof. Lindley, *appointed to continue their Experiments on the Growth and Vitality of Seeds.*

The seeds which were collected in 1842 have been sown for the third time this season, and the results are registered in the accompanying Table, and also in the General Summary of the results of these experiments since 1841, which is annexed.

Besides those named in the General Summary, there have been small quantities of many kinds submitted to a single sowing; but as in most cases the probable age at which they ceased to germinate could not be traced, they have been omitted. This observation applies more especially to those registered in vol. xiii. pp. 96–99, vol. xv. pp. 22–24, and vol. xvi. p. 147, of these Reports, where, by glancing at the numbers of each kind sown, it will be seen, that a just result could not be arrived at from so slight a test. Those kinds however which germinated at any known period have been inserted, merely to show that vitality had not altogether ceased at such ages.

We are again indebted to Miss Molesworth of Cobham, Surrey, for many packets of seeds from which we selected six kinds, being all that were available for our purpose; the remaining kinds having been either already tested, or, if new seeds, were in such small quantities, as would not admit of their being distributed in conformity with the specified instructions.

The seeds sent to Cambridge last year were not sown till the present season, the results of which have been received and registered in the General Summary.

Name and Date when gathered.	No. sown.	No. of Seeds of each Species which vegetated at			Time of vegetating in days at			Remarks.
		Oxford.	Cambridge.	Chiswick.	Oxford.	Cambridge.	Chiswick.	
1842.								
1. Aconitum Napellus	100							
2. Adonis autumnalis	50	......	....	7	......	....	24	
3. Amaranthus caudatus	100	1	....	......	8			
4. Anagallis arvensis	100	69	....	89	14	....	12	
5. Buffonia annua	100							
6. Buphthalmum cordifolium	100							
7. Bupleurum rotundifolium	100							
8. Conium maculatum	100							
9. Cytisus Laburnum	50	2	....	......	10			
10. Dipsacus laciniatus	50							
11. Elsholtzia cristata	100							
12. Erysimum Peroffskianum	100							
13. Helianthus indicus	25							
14. Heracleum elegans	50							
15. Hyoscyamus niger	100	......	....	4	......	....	72	
16. Iberis umbellata	100							
17. Iris sibirica	50							
18. Lathyrus heterophyllus	50	21	....	42	20	....	12	
19. Leonurus Cardiaca	100	5						
20. Malcolmia maritima	100							
21. Malope grandiflora	100	2	....	4	8	....	24	
22. Momordica Elaterium	25							
23. Nepeta Cataria	100	......	....	2	......	....	24	
24. Nicandra physaloides	100	74	....	68	5	....	12	
25. Nigella nana	50							

Name and Date when gathered.	No. sown.	No. of Seeds of each Species which vegetated at			Time of vegetating in days at			Remarks.
		Oxford.	Cambridge.	Chiswick.	Oxford.	Cambridge.	Chiswick.	
1842.								
26. Orobus niger	50	12						
27. Stenactis speciosa	100							
28. Tetragouolobus purpureus	25							
29. Trigonella fœnum-græcum	50							
30. Tropæolum majus	25							
31. Cucurbita Pepo, var.	15	8	....	11	7	....	12	
32. Gilia achilleæfolia	100							
33. Capsicum	25							
34. Medicago maculata	100	54	....	59	7	....	12	
35. Calandrinia speciosa	100	6	....	12	......	....	12	
36. Callichroa platyglossa	100							
37. Collomia coccinea	100							
38. Coreopsis atrosanguinea	100							
39. Cotoneaster rotundifolia	20							
40. Cratægus macracantha	50							
41. ,, punctata	50							
42. Cynoglossum glochidatum	100							
43. Digitalis lutea	100							
44. Eutoca viscida	100							
45. Glaucium rubrum	100							
46. Godetia Lindleyana	100							
47. Gladiolus psittacinus	100							
48. Impatiens glanduligera	50	11						
49. Lupinus succulentus	100							
50. Nolana atriplicifolia	100							
51. Oxyura chrysanthemoides	100							
52. Papaver amœnum	100							
53. Phacelia tanacetifolia	100							
54. Potentilla nepalensis	100							
55. Sphenogyne speciosa	100							
56. Acacia pseud-acacia	100							
57. Alstrœmeria pelegrina	20							
58. Betula alba	200							
59. Carpinus Betula	100							
60. Catalpa cordifolia	50							
61. Cercis canadensis	50							
62. Cerinthe major	50							
63. Cichorium Endivia	150	48	....	91	5	....	12	
64. Cobæa scandens	6							
65. Cuphea procumbens	50							
66. Dolichos lignosus	25	7	....	18	10	....	12	
67. Galinsogea trilobata	100							
68. Ilex Aquifolia	100							
69. Juniperus communis	100							
70. Liriodendron Tulipiferum	50							
71. Loasa nitida	100							
72. Magnolia, sp.	15							
73. Martynia proboscidea	20							
74. Mesembryanthemum crystallinum	100	40	....	72	10	....	12	
75. Mirabilis Jalapa	25							
76. Morus nigra	100							
77. Ricinus communis	15							
78. Rudbeckia amplexicaulis	150							
79. Scorpiurus sulcatus	25							
80. Tetragonia expansa	15							
81. Ulex europæa	100	17	....	......	17			
82. Quercus Robur	10							
83. Phœnix Dactylifera	3							

Name and Date when gathered.	No. sown.	No. of Seeds of each Species which vegetated at			Time of vegetating in days at			Remarks.
		Oxford.	Cambridge.	Chiswick.	Oxford.	Cambridge.	Chiswick.	
1844.								
84. Ornithogalum pyrenaicum	35							
85. Aquilegia sibirica	50							
86. Datura Stramonium	50	20						
1845.			......	......	......	......	......	Sown only at Oxford.
87. Senecio Doronicum	50							
88. Fedia dentata	50	3						
89. Œnothera tetraptera	50							
Upwards of 50 *years old.*								
90. Barley	50							

General Summary of the Experiments from 1841 to 1850 inclusive.

Name.	Sown in	Age.	No. germinated.	No. sown.
1. Graminaceæ.				
1. Zea, *Cobbett's wheat*	1846	2	12	27
Zea Mays	1848	3	127	300
2. Phalaris canariensis	1844	3	147	300
" "	1849	8	19	200
" "	1850	9	nil.	
3. Panicum Miliaceum	1849	2	178	400
" "	1850	3	100	200
4. Avena sativa	1844	3	237	300
" "	1849	8	37	200
" "	1850	9	nil.	
" "	1844	3	210	300*
5. Triticum æstivum	1844	3	163	300
" "	1849	8	nil.	
" "	1850	9	nil.	
" "	1844	3	139	300*
" "	1844	3	140	300†
" *Mummy wheat*	1850	?	nil.	
6. Secale Cereale	1848	3	4	600
7. Hordeum vulgare	1844	3	167	300
" "	1849	8	nil.	
" "	1850	9	nil.	
" "	1844	3	236	300‡
" "	1844	48	nil.	
" "	1850	50	nil.	
2. Palmaceæ.				
8. Phœnix Dactylifera	1845	3	5	
" "	1850	8	nil.	
3. Amaryllidaceæ.				
9. Alstrœmeria pelegrina	1845	3	5	60
" "	1850	8	nil.	
" aurantia	1847	3	nil.	
4. Iridaceæ.				
10. Sisyrinchium bermudianum	1848	2	1	100
11. Iris sibirica	1845	3	14	150
" "	1850	8		
" sp.	1848	3	4	75

Name.	Sown in	Age.	No. germinated.	No. sown.
4. Iridaceæ, *continued.*				
12. Tigridia Pavonia	1846	3	36	300
13. Gladiolus psittacinus	1845	3	17	300
" "	1850	8		
5. Liliaceæ.				
14. Allium fragrans	1846	3	98	300
" "	1842	5	nil.	
" "	1847	10	2	450
" senescens	1848	4	3	60
15. Camassia esculenta	1842	5	nil.	
" "	1847	10	1	300
16. Ornithogalum pyrenaicum	1850	6		
17. Asphodelus luteus	1846	3	32	150
18. Asparagus officinalis	1847	3	97	450
6. Pinaceæ.				
19. Pinus Pinea	1846	12	3	19
20. Juniperus communis	1845	3	nil.	
" "	1850	8		
7. Betulaceæ.				
21. Betula alba	1845	3	uil.	
22. Alnus glutinosa	1848	3	nil.	
8. Cannabinaceæ.				
23. Cannabis sativa	1844	3	nil.	
" "	1849	8	13	100
" "	1850	9	nil.	
9. Moraceæ.				
24. Morus nigra	1845	3	59	300
" "	1850	8		
10. Euphorbiaceæ.				
25. Euphorbia Lathyris	1846	3	46	150
" "	1842	7	nil.	
26. Croton, sp.	1844	21	30	50
27. Ricinus communis	1845	3	15	45
" "	1850	8		
11. Corylaceæ.				
28. Fagus sylvatica	1848	3	nil.	
29. Carpinus Betula	1845	3	nil.	

* Preserved (in waxed cloth). † Preserved (in open jar). ‡ Preserved (in waxed cloth).

Name.	Sown in	Age.	No. germinated.	No. sown.
11. Corylaceæ, *continued*				
30. Quercus Robur	1845	3	3	30
" "	1850	8		
12. Cucurbitaceæ.				
31. Momordica Elaterium	1845	3	13	75
" "	1850	8		
32. Cucurbita Cucuzza	1846	14	29	40
" *di Spagna*	1846	13	11	20
Green Egyptian Melon	1846	14	3	40
Marari	1846	14	8	29
Mellone di Acqua	1846	13	8	90
" *di Pane Bianca*	1846	13	2	50
Valencian Melon	1846	12	20	50
Early Cantalupe Melon	1846	10	50	72
Melon from Lisbon	1846	10	11	20
Melon	1846	9	50	150
Melon from Cassabah	1846	8	11	15
Memoja	1846	10	4	5
Cucurbita, sp.	1845	3	37	45
" "	1850	8	19	45
33. Bryonia dioica	1847	3	5	300
13. Passifloraceæ.				
34. Passiflora Herbertiana	1842	8	nil.	
35. Tacsonia pinnatistipula	1842	6	nil.	
14. Violaceæ.				
36. Viola lutea	1846	3	99	450
15. Cruciferæ.				
37. Matthiola annua	1846	3	236	600
38. Cheiranthus, sp.	1846	3	38	80
39. Turritis retrofracta	1842	6	nil.	
40. Arabis hirsuta	1848	3	36	200
" lucida	1842	8	nil.	
41. Koniga maritima	1846	3	170	600
42. Lunaria biennis	1846	3	114	300
43. Vesicaria grandiflora	1847	3	nil.	
44. Iberis umbellata	1848	3	11	100
" "	1845	3	150	200
" "	1850	8		
45. Biscutella erigerifolia	1846	3	71	300
46. Malcomia maritima	1845	3	178	300
" "	1850	8	nil.	
47. Hesperis matronalis	1846	3	66	300
48. Erysimum Peroffskianum	1845	3	82	300
" "	1850	8		
49. Lepidium sativum	1844	3	195	300
" "	1849	8	19	200
" "	1850	9	1	100
50. Ethionema saxatile	1848	3	15	100
51. Isatis tinctoria	1848	4	15	100
52. Brassica Napus	1844	3	323	450
" "	1849	8	4	300
" "	1850	9	nil.	
" Rapa	1844	3	335	900
" "	1849	8	15	600
" "	1850	9	5	300
" Rapa oleifera	1846	4	85	100
" oleracea	1844	3	11	150

Name.	Sown in	Age.	No. germinated.	No. sown.
15. Cruciferæ, *continued*				
52. Brassica oleracea	1844	3	40	150*
" "	1849	8	nil.	
" "	1850	9	nil.	
53. Diplotaxis tenuifolia	1846	3	4	300
54. Crambe maritima	1847	3	6	300
55. Bunias orientalis	1849	3	57	100
" "	1850	4	2	50
56. Heliophila araboides	1846	3	165	600
57. Schizopetalon Walkeri	1848	3	30	150
16. Capparidaceæ.				
58. Cleome spinosa	1846	3	61	300
17. Byttneriaceæ.				
59. Hermannia, sp.	1844	4	1	150
18. Tropæolaceæ.				
60. Tropæolum majus	1845	3	52	75
" "	1850	8	nil.	
" peregrinum	1848	2	15	30
61. Limnanthes Douglasii	1848	3	nil.	
19. Malvaceæ.				
62. Malope grandiflora	1845	3	127	300
" "	1850	8	10	300
63. Kitaibelia vitifolia	1848	4	23	200
64. Lavatera trimestris	1848	2	50	100
65. Malva mauritiana	1847	3	281	600
" moschata	1846	4	18	100
" sp.	1846	10	6	80
" sp.	1844	25	17	100
66. Hibiscus, sp.	1844	27	3	100
67. Gossypium, sp.	1846	4	2	8
68. Sida, sp.	1844	25	75	150
20. Tiliaceæ.				
69. Corchorus, sp.	1844	27	2	50
70. Triumfetta, sp.	1844	25	30	75
21. Hypericaceæ.				
71. Hypericum hirsutum	1846	3	94	450
" Kalmianum	1842	8	nil.	
22. Magnoliaceæ.				
72. Magnolia, sp.	1845	3	4	45
" "	1850	8	nil.	
73. Liriodendron Tulipiferum	1845	3	nil.	
" "	1850	8	nil.	
23. Ranunculaceæ.				
74. Clematis erecta	1842	6	nil.	
75. Thalictrum minus	1849	3	nil.	
" "	1850	4	nil.	
76. Anemone coronaria	1849	3	nil.	
" "	1850	4	nil.	
77. Adonis autumnalis	1845	3	79	150
" "	1850	8	7	150
78. Ranunculus caucasicus	1849	3	nil.	
" "	1850	4	nil.	
79. Nigella nana	1845	3	40	150
" "	1850	8	nil.	
80. Aquilegia sibirica	1850	6	nil.	
81. Helleborus fœtidus	1847	3	nil.	
82. Delphinium intermedium	1848	4	nil.	

* (In waxed cloth.)

Name.	Sown in	Age.	No. germinated.	No. sown.
23. Ranunculaceæ, *continued*				
82. Delphinium flexuosum	1842	5	nil.	
„ „	1847	10	nil.	
„ sp.	1848	6	1	200
83. Aconitum Napellus	1845	3	13	300
„ „	1850	8	nil.	
84. Pæonia, mixed vars.	1844	3		
„ „ „	1849	8	nil.	
„ „ „	1850	9	nil.	
24. Papaveraceæ.				
85. Argemone alba	1847	3	159	300
„ grandiflora	1848	3	nil.	
86. Papaver somniferum.........	1846	5	73	150
„ orientale	1842	5	nil.	
„ amœnum	1845	3	47	300
„ „	1850	8	nil.	
87. Glaucium rubrum	1845	3	47	300
„ „	1850	8	nil.	
88. Eschscholtzia californica ...	1847	3	124	600
89. Chryseis crocea...............	1842	5	4	100
„ „	1847	10	nil.	
25. Fumariaceæ.				
90. Hypecoum procumbens ...	1842	6	nil.	
„ „ ...	1842	7	nil.	
91. Fumaria spicata.....	1848	3	5	300
26. Berberidaceæ.				
92. Mahonia Aquifolia.	1842	7	nil.	
27. Anacardiaceæ.				
93. Rhus, sp.	1844	4	7	50
28. Xanthoxylaceæ.				
94. Ailantus glandulosa	1848	3	3	150
29. Linaceæ.				
95. Linum perenne	1848	2	16	100
„ usitatissimum	1846	3	56	200
„ „	1844	3	202	450
„ „	1849	8	18	300
„ „	1850	9	nil.	
30. Balsaminaceæ.				
96. Balsamina hortensis	1846	6	81	150
97. Impatiens glanduligera......	1845	3	34	150
„ „	1850	8	11	150
31. Geraniaceæ.				
98. Pelargonium, sp.	1844	4	15	62
32. Caryophyllaceæ.				
99. Buffonia annua	1845	3	16	300
„ „	1850	8	nil.	
100. Dianthus barbatus	1846	3	181	300
„ chinensis	1846	3	62	150
101. Saponaria annua.............	1847	3	38	450
102. Gypsophila elegans.........	1846	3	143	600
„ „	1842	7	1	500
103. Silene quadridentata	1848	2	31	100
„ pendula...............	1848	2	41	200
„ inflata	1846	3	88	150
„ Armeria alba	1848	3	31	100
104. Viscaria oculata	1848	3	22	450
105. Pharnaceum, sp.	1844	4	3	100
33. Portulacaceæ.				
106. Talinum ciliatum	1846	3	188	600

Name.	Sown in	Age.	No. germinated.	No. sown.
33. Portulacaceæ, *continued*				
107. Calandrinia grandiflora ...	1848	4	nil.	
„ „ ...	1842	5	39	200
„ „ ...	1847	10	nil.	
„ speciosa	1845	3	171	300
„ „	1850	8	18	100
34. Polygonaceæ.				
108. Polygonum fagopyrum ...	1844	3	25	150
„ „ ...	1849	8	7	100
„ „ ...	1850	9	nil.	
109. Rumex obtusifolium	1846	3	162	450
„ sp.	1846	5	13	30
35. Nyctaginaceæ.				
110. Mirabilis Jalapa	1845	3	30	300
„ „	1850	8	nil.	
36. Phytolaccaceæ.				
111. Phytolacca decandra	1846	3	21	75
37. Amarantaceæ.				
112. Amaranthus caudatus	1845	3	178	300
„ „	1850	8	1	300
38. Chenopodiaceæ.				
113. Chenopodium Botrys	1848	2	nil.	
„ „	1847	3	nil.	
„ Quinoa......	1849	2	171	400
„ „	1850	3	14	200
114. Beta vulgaris	1848	3	155	225
39. Saururaceæ.				
115. Saururus, sp.	1844	4	2	50
40. Mesembryaceæ.				
116. Mesembryanthemum crystallinum	1845	3	94	300
„ „	1850	8	112	300
41. Tetragoniaceæ.				
117. Tetragonia expansa.........	1845	3	22	45
„ „	1850	8	nil.	
42. Proteaceæ.				
118. Leucadendron, sp.	1844	4	19	75
43. Leguminosæ.				
119. Podalyria, sp.	1844	4	113	150
120. Pultenæa, sp.	1844	21	2	100
121. Lupinus succulentus	1845	3	85	300
„ „	1850	8	nil.	
„ rivularis............	1842	5	1	25
„ „	1847	10	nil.	
„ grandifolius	1842	5	nil.	
„ „	1847	10	1	300
„ polyphyllus	1842	6	1	100
„ lucidus	1847	10	nil.	
122. Crotalaria, sp.	1844	27	4	50
123. Aspalathus, sp.	1844	4	1	25
124. Ulex europæa	1845	3	113	300
„ „	1850	8	27	300
125. Spartium Scoparium	1848	3	38	600
126. Cytisus albus	1848	3	24	300
„ Laburnum	1845	3	21	150
„ „	1850	8	2	150
127. Tetragonolobus purpureus.	1845	3	40	75
„ „	1850	8	nil.	
128. Trifolium repens	1844	3	22	450

Name.	Sown in	Age.	No. germinated.	No. sown.
43. Leguminosæ, *continued.*				
128. Trifolium giganticum	1846	3	38	100
„ sp.	1849	8	nil.	
„	1850	9	5	150
129. Melilotus cærulea	1846	3	149	300
„ leucantha	1846	3	60	100
„ macrorhiza	1846	4	36	100
„ „	1849	7	180	500
„ „	1850	8	69	250
130. Trigonella fœnum-græcum	1845	3	89	150
„ „	1850	8	nil.	
131. Medicago maculata	1845	3	71	300
„ „	1850	8	113	300
132. Ononis angustifolia	1842	6	1	100
133. Indigofera, sp.	1844	4	28	175
134. Psoralea bituminosa	1849	3	46	100
„ „	1850	4	7	50
„ sp.	1844	4	107	200
135. Galega sibirica	1846	10	9	110
„ sp.	1844	26	16	100
136. Sutherlandia, sp.	1844	4	5	100
137. Colutea, sp.	1844	43	1	75
138. Pisum sativum	1844	3	94	150
„ „	1849	8	15	100
„ „	1850	9	nil.	
„ *Fullard's German Marrow Fat*	1846	5	4	4
„ „ „	1846	3	100	150
„ sp.	1846	7	36	50
139. Ervum, sp.	1846	4	90	100
140. Vicia sativa	1844	3	87	150
„ „	1846	4	82	100
„ „	1849	8	8	100
„ „	1850	9	nil.	
„ „	1844	3	115	150*
„ lutea	1846	3	27	100
„ „	1848	4	91	100
„ grandiflora	1848	3	18	25
„ „	1846	5	70	150
141. Faba vulgaris	1844	3	71	75
„ „	1849	8	40	50
„ „	1850	9	14	25
„ *Augusta Beans*	1846	7	24	50
„ „ „	1846	3	30	30
„ „ „	1846	2	5	5
„ *Canada Beans*	1846	6	42	50
„ „ „	1846	5	16	16
142. Lathyrus annuus	1848	2	21	25
„ sativus	1848	3	6	6
„ heterophyllus	1845	3	105	150
„ „	1850	8	63	150
143. Orobus niger	1845	3	18	150
„ „	1850	8	12	150
144. Scorpiurus sulcatus	1845	3	22	75
„ „	1850	8		
145. Coronilla, sp.	1844	42	17	25
146. Æschynomene, sp.	1844	26	28	100

Name.	Sown in	Age.	No. germinated.	No. sown.
43. Leguminosæ, *continued.*				
146. Æschynomene, sp.	1844	27	1	100
147. Hallia, sp.	1844	4	14	25
148. Hedysarum, sp.	1844	26	3	100
„ sp.	1844	27	9	200
149. Clitoria, sp.	1844	26	2	20
150. Erythrina, sp.	1844	4	1	3
151. Phaseolus multiflorus	1844	3	47	75
„ „	1849	8	1	50
„ „	1850	9	nil.	
„ sp.	1844	25	25	25
152. Dolichos lignosus	1845	3	61	75
„ „	1850	8	25	75
„ sp.	1844	27	2	5
? „ sp.	1846	8	36	50
153. Cæsalpinia, sp.	1844	27	2	6
154. Cassia Canarina	1846	10	1	10
„ sp.	1844	26	86	120
? „ sp.	1846	8	4	20
155. Tamarindus, sp.	1844	25	1	3
156. Cercis canadensis	1845	3	4	150
„ „	1850	8	nil.	
157. Gleditschia triacanthos	1848	3	nil.	
158. Mimosa, sp.	1844	4	5	42
159. Adenanthera, sp.	1844	25	4	6
160. Acacia pseud-acacia	1845	3	30	300
„ „	1850	8	nil.	
44. Pomaceæ.				
161. Cotoneaster rotundifolia	1845	3	16	60
„ „	1850	8	nil.	
162. Cratægus macracantha	1845	3	4	150
„ „	1850	8	nil.	
„ punctata	1845	3	3	150
„ „	1850	8	nil.	
45. Rosaceæ.				
163. Potentilla nepalensis	1845	3	52	300
„ „	1842	7	nil.	
„ „	1850	8	nil.	
„ sp.	1842	6	nil.	
164. Geum, sp.	1842	5	nil.	
„ „	1847	10	3	1500
46. Lythraceæ.				
165. Cuphea procumbens	1845	3	45	150
„ „	1850	8	nil.	
47. Rhamnaceæ.				
166. Trichocephalum, sp.	1844	4	2	25
167. Phylica, sp.	1844	4	1	42
168. Cryptandra, sp.	1844	21	9.	50
48. Aquifoliaceæ.				
169. Ilex Aquifolium	1845	3	nil.	
„ „	1850	8	nil.	
49. Solanaceæ.				
170. Petunia odorata	1848	3	nil.	
171. Datura Stramonium	1844		109	300
„ „	1850	6	20	50
„ „	1849	8	30	200
„ „	1850	9	nil.	

* (In waxed cloth.)

Name.	Sown in	Age.	No. germinated.	No. sown.
49. SOLANACEÆ, *continued.*				
172. Hyoscyamus niger	1845	3	7	300
" "	1850	8	4	300
173. Nicandra physaloides	1845	3	143	300
" "	1850	8	142	300
174. Capsicum, sp.	1845	3	33	75
" "	1850	8	nil.	
175. Solanum ovigerum	1847	3	nil.	
176. Lycopersicum esculentum	1846	9	76	100
50. ASCLEPIADACEÆ.				
177. Asclepias verticillata	1847	2	31	73
51. CONVOLVULACEÆ.				
178. Convolvulus major	1846	3	41	150
52. POLEMONIACEÆ.				
179. Collomia coccinea	1845	3	64	300
" "	1850	8	nil.	
180. Gilia achilleæfolia	1845	3	69	300
" "	1844	3	214	600
" "	1849	8	1	400
" "	1850	8	nil.	
" "	1850	9	nil.	
" capitata	1842	7	nil.	
181. Leptosiphon androsacea	1846	3	121	600
182. Polemonium cæruleum	1846	3	78	300
" gracile	1842	7	nil.	
183. Cobæa scandens	1845	3	3	18
" "	1850	8	nil.	
53. HYDROPHYLLACEÆ.				
184. Nemophila atomaria	1842	2	62	200
185. Eutoca viscida	1845	3	84	300
" "	1850	8	nil.	
186. Phacelia tanacetifolia	1845	3	122	300
" "	1846	4	50	150
" "	1850	8	nil.	
54. PLANTAGINACEÆ.				
187. Plantago media	1846	3	130	450
" Cynops	1848	3	nil.	
55. PRIMULACEÆ.		7		
188. Androsace macrocarpa	1848	3	nil.	
189. Anagallis arvensis	1845	3	89	300
" "	1850	8	158	300
56. NOLANACEÆ.				
190. Nolana atriplicifolia	1845	3	150	300
" "	1850	8	nil.	
57. BORAGINACEÆ.				
191. Cerinthe major	1845	3	79	150
" "	1850	8	nil.	
192. Echium grandiflorum	1846	3	135	300
193. Amsinckia augustifolia	1848	2	3	100
194. Cynoglossum glochidatum	1845	3	45	300
" "	1850	8	nil.	
58. LABIATÆ.				
195. Elsholtzia cristata	1845	3	44	300
" "	1850	8	nil.	
196. Horminum pyrenaicum	1842	7	nil.	
197. Nepeta citriodora	1848	2	3	100
" Cataria	1845	3	43	300
" "	1850	8	2	300

Name.	Sown in	Age.	No. germinated.	No. sown.
58. LABIATÆ, *continued.*				
198. Dracocephalum denticulatum	1847	3	24	260
199. Leonurus Cardiaca	1845	3	78	300
" "	1850	8	5	300
200. Betonica hirsuta	1849	3	nil.	
" "	1850	4	nil.	
59. VERBENACEÆ.				
201. Verbena Aubletia	1848	3	nil.	
60. SELAGINACEÆ.				
202. Hebenstreitia tenuifolia	1846	3	102	300
61. PEDALIACEÆ.				
203. Martynia proboscidea	1845	3	10	60
" "	1850	8	nil.	
62. BIGNONIACEÆ.				
204. Eccremocarpus scaber	1848	3	3	300
205. Catalpa cordifolia	1845	3	nil.	
63. SCROPHULARIACEÆ.				
206. Browallia elata	1848	3	6	150
207. Schizanthus pinnatus	1846	3	240	600
208. Verbascum Thapsus	1844	3	126	1500
" "	1849	8	nil.	
" "	1850	9	nil.	
209. Alonsoa incisa	1848	3	5	300
210. Linaria bipartita	1848	3	6	100
" Spartea	1848	3	3	100
" Prezii	1847	3	1	600
211. Antirrhinum majus	1844	3	475	900
" "	1849	8	nil.	
" "	1850	9	nil.	
" calycinum	1848	3	9	25
212. Scrophularia vernalis	1848	2	nil.	
213. Collinsia heterophylla	1844	3	578	900
" "	1849	8	1	600
" "	1850	9	nil.	
214. Pentstemon, 8 sps.	1842	6	nil.	
215. Mimulus moschatus	1842	6	3	1000
216. Digitalis lutea	1845	3	46	300
" "	1850	8	nil.	
217. Verouica peregrina	1849	3	nil.	
" "	1850	4	nil.	
64. CAMPANULACEÆ.				
218. Campanula Medium	1846	3	110	300
65. VALERIANACEÆ.				
219. Valeriana officinalis	1846	3	17	300
220. Fedia dentata	1850	5	3	50
66. DIPSACACEÆ.				
221. Dipsacus laciniatus	1845	3	60	150
" "	1850	8	nil.	
222. Knautia orientalis	1848	3	nil.	
67. COMPOSITÆ.				
223. Ageratum mexicanum	1846	3	135	600
224. Aster tenella	1846	3	120	600
225. Callistemma hortensis	1846	3	161	600
226. Stenactis speciosa	1845	3	18	300
" "	1850	8	nil.	
227. Kaulfussia amelloides	1846	3	114	300
228. Buphthalmum cordifolium	1845	3	26	300

Name.	Sown in	Age.	No. germinated.	No. sown.
67. Compositæ, *continued*				
228. Buphthalmum cordifolium	1850	8	nil.	
229. Zinnia elegans	1848	2	nil.	
,, multiflora	1846	3	37	450
,, grandiflora	1848	3	2	300
230. Rudbeckia amplexicaulis	1845	3	55	450
,, ,,	1850	8	nil.	
231. Calliopsis tinctoria	1846	6	3	150
232. Coreopsis atrosanguinea	1845	3	138	300
,, ,,	1850	8	nil.	
,, Drummondii	1848	2	nil.	
233. Helianthus indicus	1845	3	68	75
,, ,,	1850	8	nil.	
234. Bidens diversifolia	1846	3	124	450
235. Tagetes patula	1848	3	20	200
,, ,,	1848	4	nil.	
,, lucida	1848	3	5	450
236. Gaillardia aristata	1848	3	nil.	
237. Helenium Douglasii	1846	3	186	600
238. Callichroa platyglossa	1845	3	92	300
,, ,,	1850	8	nil.	
239. Galinsogea trilobata	1845	3	100	300
,, ,,	1850	8	nil.	
240. Sphenogyne speciosa	1845	3	75	300
,, ,,	1850	8	nil.	
241. Oxyura chrysanthemoides	1845	3	67	300
,, ,,	1850	8	nil.	
,, ,,	1842	5	nil.	
,, ,,	1847	10	1	225
242. Madia splendens	1847	3	nil.	
243. Cladanthus arabicus	1846	3	175	600
244. Lasthenia glabrata	1844	3	363	600
,, ,,	1848	3	53	100
,, ,,	1844	3	270	600*
,, californica	1849	8	4	400
,, ,,	1850	9	nil.	
245. Chrysanthemum coronarium	1848	3	122	450
246. Athanasia, sp.	1844	4	16	25
247. Ammobium alatum	1847	3	1	600
248. Senecio Doronicum	1850	5	nil.	
249. Xeranthemum annuum	1846	3	64	600
,, ,,	1848	3	nil.	
250. Calendula maritima	1848	2	26	100
,, officinalis	1848	2	53	200
,, pluvialis	1844	3	401	600
,, ,,	1849	8	nil.	
,, ,,	1850	9	nil.	
251. Arctotis, sp.	1844	4	48	100
252. Centaurea depressa	1846	3	49	300
253. Kentrophyllum tauricum	1848	3	11	25
254. Carthamus tinctorius	1847	3	44	300
255. Onopordon tauricum	1846	3	22	150
,, acanthium	1846	3	40	100
256. Arctium Lappa	1846	3	64	300
257. Rhagadiolus stellatus	1849	3	34	100
,, ,,	1850	4	31	50
258. Catauanche cœrulea	1847	3	94	600

Name.	Sown in	Age.	No. germinated.	No. sown.
67. Compositæ, *continued*				
259. Cichorium Endivia	1845	3	260	450
,, ,,	1850	8	139	450
260. Tragopogon porrifolium	1848	3	32	100
,, ,,	1847	3	138	600
261. Arnopogon Dalechampii	1848	2	10	30
,, ,,	1849	3	10	100
,, ,,	1850	4	nil.	
262. Scorzonera hispanica	1847	3	32	600
263. Picris echioides	1848	2	73	100
264. Lactuca sativa	1844	3	1	150
,, ,,	1849	8	nil.	
,, ,,	1850	9	nil.	
265. Borkhausia fœtida	1848	3	35	100
,, rubra	1846	3	196	300
68. Onagraceæ.				
266. Œnothera tenella	1848	2	1	100
,, tetraptera	1850	5	nil.	
,, sp.	1848	3	nil.	
,, ,,	1842	5	nil.	
,, ,,	1847	10	1	1800
267. Godetia Lindleyana	1845	3	90	300
,, ,,	1850	8	nil.	
lepida	1842	5	15	250
,, ,,	1847	10	nil.	
268. Clarkia elegans	1842	5	1	500
,, ,,	1847	10	1	1500
269. Eucharidinum concinnum	1848	2	nil.	
,, ,,	1846	3	256	600
270. Lopezia racemosa	1848	3	268	450
69. Myrtaceæ.				
271. Eucalyptus, sp.	1844	21	1	207
70. Loasaceæ.				
272. Loasa lateritia	1846	3	112	450
,, nitida	1845	3	52	300
,, ,,	1850	8	nil.	
273. Bartonia aurea	1846	3	160	600
71. Umbelliferæ.				
274. Petroselinum sativum	1844	3	42	150
,, ,,	1849	8	1	100
,, ,,	1850	9	nil.	
275. Carum Carui	1844	3	nil.	
,, ,,	1847	3	2	600
,, ,,	1849	8	2	400
,, ,,	1850	9	nil.	
276. Sium Sisarum	1847	3	nil.	
277. Bupleurum rotundifolium	1845	3	67	300
,, ,,	1850	8	nil.	
278. Œnanthe Crocata	1846	3	65	300
279. Æthusa cynapiodes	1844	3	3	300
,, ,,	1849	8	1	200
,, ,,	1850	9	nil.	
280. Fœniculum dulce	1849	3	84	200
,, ,,	1850	4	4	100
281. Ligusticum Levisticum	1844	3	35	300
,, ,,	1849	8	2	200
,, ,,	1850	9	nil.	
282. Angelica Archangelica	1846	3	47	300

* (In open jar.)

Name.	Sown in	Age.	No. germinated.	No. sown.	Name.	Sown in	Age.	No. germinated.	No. sown.
71. UMBELLIFERÆ, *continued.*					71. UMBELLIFERÆ, *continued.*				
283. Pastinaca sativa	1844	3	20	300	285. Daucus carota...............	1845	8	37	900
„ „	1849	8	nil.		„ „	1847	10	nil.	
„ „	1850	9	nil.		286. Scandix brachycarpa	1848	3	95	180
284. Heracleum elegans.........	1845	3	17	150	287. Conium maculatum	1845	3	144	300
„ „	1850	8	nil.		„ „	1850	8	nil.	
285. Daucus carota...............	1844	3	79	300	„ „	1842	5	2	150
„ „	1849	8	1	200	„ „	1847	10	nil.	
„ „	1850	9	nil.		288. Smyrnium Olusatrum......	1846	3	66	300

From the above Table we extract the following examples of Plants whose seeds have germinated at considerable ages.

I. At from 10 to 19 years inclusive.

Allium fragrans.
Camassia esculenta.
Pinus pinea.
Cucurbita cucuzza.
Lupinus grandifolius.
Galega sibirica.
Cassia canarina.
Geum, sp.
Oxyura chrysanthemoides.
Œnothera, sp.
Clarkia elegans.

II. At from 20 to 29 years inclusive.

Croton, sp.
Malva, sp.
Hibiscus, sp.
Sida, sp.
Corchorus, sp.
Triumfetta, sp.
Pultenæa, sp.
Crotalaria, sp.
Galega, sp.
Æschynomene, sp.
Hedysarum, sp.
Clitoria, sp.
Phaseolus, sp.
Dolichos, sp.
Cæsalpinia, sp.
Cassia, sp.
Tamarindus, sp.
Adenanthera, sp.
Cryptandra, sp.
Eucalyptus, sp.

III. At from 30 to 39 years inclusive.

(nil.)

IV. At from 40 to 49 years inclusive.

Colutea, sp.
Coronilla, sp.

It will be seen by the above summary, that seeds of no less than 288 genera, which illustrate 71 natural families, including too nearly all the kinds cultivated for culinary and other domestic purposes, have been collected, and to a certain extent tested.

Many of the kinds show a considerable decrease in the comparative numbers which vegetate after their periodical sowings, and a few kinds have apparently already ceased to germinate; but some years must yet elapse before the subject can be sufficiently investigated to enable us to submit what we should consider a decided and satisfactory statement, respecting the limits assigned to the vegetative powers of the seeds in different genera.

Examples of seeds belonging to any of the natural families not enumerated in the above Table, will be very acceptable, and may be addressed to Mr. W. H. Baxter, Botanic Garden, Oxford.

On the Aboriginal Tribes of India. By Major-General John Briggs, *F.R.S., Vice-President of the Ethnological Society of London.*

On the occasion of the meeting of this Association at Oxford, I was pressed to read a paper on the Aboriginal tribes of India. At that period my inquiries were incomplete, and I was unable to trace them to any separate stock, though it appeared clear they were in almost every respect distinct from the mass of the population consisting of Hindûs of the Bramanical persuasion. Since that period I have extended my researches, and have given two or three lectures on the same subject at the meetings of the Ethnological Society in London.

The Hindûs are universally acknowledged to be of that branch of the human family denominated by Blumenbach Caucasian, and they believe they invaded India from the north-west. They were at one time further advanced in literature, in philosophy, in the science of mathematics, in anatomy, in surgery, in medicine in all its branches, in legislation, and even in purity of religious doctrines than their contemporaries in other regions of the globe.

This description will be readily admitted if it can be shown that the Vedas, or holy scriptures of this people, date, as is asserted, fourteen centuries before our own æra; and that the commentaries on a code of civil and criminal law (of a more ancient date) were written about twenty-seven centuries ago. At that period, it appears, from the latter work, that the Hindûs had not yet penetrated further south than the twenty-second parallel of north latitude, beyond which (the work states) there then existed "extensive forests, inhabited by a wild and impure race speaking barbarous tongues."

Here we find an aboriginal race clearly alluded to, and subsequent inquiries and monumental remains prove that they were a numerous people, having established forms of government though living in a very simple and rude state of society.

My investigations lead me to believe that these abnormal tribes, probably of one common stock, had previously occupied the whole of the extensive region of India, in successive incursions made from some other remote country. Though the religious tenets and civil institutions of these aborigines were alike, yet two separate hordes subsisted by different means. The one obtained their food by the chase, dwelling in or near the forests abounding with game; the other occupying the open plains, subsisted on the milk of their cattle (cows and buffaloes), and fed on the flesh of their flocks of sheep.

These two classes were eternally at war, and the same aversion and innate hostility against each other exist at the present day. At the time the Hindûs entered India both classes of this race appear to have been spread over the whole surface of the country, under the several denominations of Minâs, Mérs, Bhils, Dhiro Kolies, Mhars, Mangs or Mans, Béders, Dhérs, Gowlies, Carumba, Cherumars, Morawa, Collary, Pully, Pariah, Yenedy, Chenchy, Barka, Tallary, Gond, Kond, Sawara, Banderwa, Cheru, Bengy, Kooki, Garro, Kassia, Hajïn, Bhar, Dhanuk, Dhome, with many others of which I have not sufficient details.

Among these tribes the etymologist may without difficulty trace the names of many of the territorial divisions which have been assigned to several portions of India by the Hindûs.

Thus Kolwan, from the Koles; Bhilwan and Bhilwara, from the Bhils; Mhar-rashtra, by contraction Mharatta, from the Mhars; Man Désa, from the Mans or Mangs; the city of Beder, from the Beders; Gondwara, from the Gonds; Oria-Desa or Orissa, from the Orias; Kolwan and Koliwara, from the Koles; Bengala, from the Bengies; Behar, from the Bhars; Merwar or Marwar, from the Mérs; as also the forts of Ajmere, Jessalmere, Combelmere, so called after chieftains of the Mér race, and Ahirwara from the Ahirs.

At what precise period the Hindu invasion from the west first occurred it is impossible to say, but the geography of India indicates at once, that that race necessarily came through Afghanïstan and the Punjab, ere it turned the borders of the Great Desert and penetrated in the direction of Dehli.

One of the ancient Hindu works left to us, indicates that at a very remote period a great war broke out between the Sovereign Princes of the Punjab and those of the Plain, including Hastnapoor, since called Dehli, and the latter people, aided by the Princes of Mathura and others, maintained on the field of Panipeet a long and desperate conflict.

There is every reason to believe that the Hindu race gradually overspread the territory of Upper India east and west, between the Himalaya mountains and the Great Desert, without penetrating to the south for many centuries; that it enslaved the aboriginal races as it subdued them, compelling them to till their own lands as serfs, and took from the latter the whole produce, except what was actually required as food for the tillers of the soil.

The Hindu race introduced into India municipal institutions wherever they formed townships. To each of these were attached a certain number of families of the aboriginal tribes, as villains or prædial servants of the community. The Hindûs brought with them also the Sanscrit language, not in its present highly refined state, but as a colloquial tongue. Hence it comes that the language of the aborigines has in many parts gradually disappeared.

The historical as well as the religious works of the Hindûs, of a comparatively modern date, together with monumental remains existing in sculptured edifices and rock caves, all tend to show that no portion of the Peninsula of India was subdued by them anterior to the fifth century of the Christian æra. About that time it is supposed that the Peninsula became gradually overspread by the Bramanical race. They seem to have entered in two directions; the one from Guzerat, gradually extending over Khandeish and Berar till they reached to the forests which fringe the banks of the river Wurda, where it meets with the Godavery; the other invasion, according to tradition, occurred about the same time. It passed from the valley of the Ganges and penetrated southward along the line of coast of the Bay of Bengal, keeping within the range of mountains on the east and the Ocean, till after reaching the embouchures of the Godavery and the Kistna, the invaders spread out over the plain and proceeded southward. It has been assumed that about the same period, the Bhudists, a peculiar sect of Hindûs, reached the shores of Ceylon and Southern India from the opposite coast, and thence proceeding northward spread their religious doctrines among the aborigines. About the ninth or tenth century the Bhudists and Bramans appear to have met from opposite directions, which led to deadly conflicts, and ended in the Bramans putting down the Bhudist tenets.

We have historical proof that the island of Bombay was not subjugated to the Hindu rule till the fourteenth century; and that in the beginning of the next century the Mahommedans found princes of the aboriginal race occupying in force several strongholds not far from Poona. The town and district of Sorapoor, lying between Hydrabad and the Western Mountains, is still held by an aboriginal chief with a portion of his tribe; and within the memory of man the kingdom of Mysore contained several principalities of the Béder race. Further south, the Morawas and Collars obtained celebrity in modern times by their adhesion to one or other of the European belligerent powers (France and England), and evinced fidelity and even devotion to the cause of the party which each espoused. Further north we find the vast region of Gondwana still peopled almost entirely by the aboriginal race, which extends throughout the hilly districts of Orissa in the direction of the valley of the Ganges. The territory of Gondwana appears never to have been reduced to the condition of a Hindu state, but has preserved through successive ages its institutions, its laws, and its religion intact.

In the more northern part of India there are recorded instances of principalities of the aboriginal tribes which have resisted with great resolution and sometimes with success the efforts of the Hindûs and Mahommedans to subdue them, but at present there is hardly one in existence which retains anything like independence in the plains; indeed there are not many of any importance throughout all India, even in the hills.

I have described the ancient Hindûs as having attained, at a very remote period, a high degree of perfection in literature and in science. They were not less remarkable for their civil institutions. At whatever period they settled in the northern regions of Upper India, there is no doubt that (in common with the greater part of the Caucasian family, of which they must be deemed a branch) they established throughout the territory they occupied, municipal institutions in each village and township, by means of which, the inhabitants managed their own affairs. Besides this peculiarity of government, the Hindûs adopted the practice of dividing their municipalities into castes, which could neither eat together nor intermarry. These consisted of four principal divisions, from each of which are minor ramifications.

The four castes comprise,—

1st. The military, from which are sprung sovereigns and princes, as well as warriors.

2nd. The priesthood, derived entirely from Bramans.

3rd. The mercantile and mechanical tribes or families.

4th. The cultivator or landholder.

As has been stated, these castes never intermarried, and thus kept themselves free from any admixture with any other race.

The Hindûs burn their dead. They abstain from eating the flesh of horned cattle, and from tasting ardent spirits. They believe in the transmigration of souls, give themselves up wholly to the guidance of the Bramanical priesthood, and are taught to worship their ancient heroes as demigods, who are supposed to plead with the supreme God for those who in humility ask in repentance.

The aboriginal races, one and all, differ in every respect from the Hindûs. Their government is strictly patriarchal; all crimes are punished and disputes settled by the award of the elders or heads of tribes assembled. They have no prejudices against animal food of any kind, whether the animal be slaughtered, or die a natural death. They have no municipalities; have no laws of caste: they bury instead of burning their dead. They have no regular priests, but select them for the moment, as necessity requires, out of the lay body. These are chosen usually from those believed to possess the power of magic. They have no other knowledge of a future state than what they occasionally pick up from their intercourse with Hindûs or with other people. Instead of offering up thankgivings with a grateful heart for all the blessings they may enjoy, they confine their prayers to requests from the divinity to gratify their desires, supply their wants, and avert evil. For these purposes they offer up bloody sacrifices. In those parts still unsubdued, such as a great part of Gondwana and the contiguous tracts of Goomser and Bustar, and in some portion of the country lying farther eastward among the Assam

Hills, they continue to make human sacrifices, a practice to which these races have been prone, according to Hindu records, from the earliest ages.

Their offerings are made to the god of the elements, of floods and of the soil; they propitiate the goddesses of contagious and epidemic diseases. They also worship power in every shape to avert danger; hence all beasts of prey, such as tigers, bears and leopards, venomous serpents and other reptiles; as also the elephant and the rhinoceros in a wild state.

Their domestic habits and institutions have a strong affinity to those of the great Tartar family; they may serve as a specimen of the whole race. They employ whipping as a remedy for tertian fever and ague, as practised among the Turkish hordes in Persia; and it is also adopted as a remedy for violent insanity, for they consider persons so afflicted to be possessed of an evil spirit, whom they thus endeavour to expel.

In some parts both men and women bore their ears and wear heavy rings to extend the lower lobe. Unlike the Hindu women, they wear no bodice to support the breasts, instead of which, in many cases they gracefully throw the end of a muslin cloth ten or twelve yards long, as it comes from the loom, round the body, and which is tastefully arranged so as to cover the person. Their weapons are the sword, the bow and arrow, the javelin, and almost universally a bill-hook, which is worn in a belt over the right hip.

The virtues of this race consist in dauntless courage, fidelity and loyalty to their superiors and chiefs, and probity towards those with whom they may have entered into engagements. They have great regard to truth, and exercise hospitality, and are generous in their dealings with each other, as well as with strangers.

In Rajputâna such is the consideration they obtain from the Hindu princes, that the latter submit to the form of being placed on the throne by an aboriginal chieftain, from whom each receives on his succession a recognition of his sovereignty by the impression of a spot of blood fresh drawn from the foot of one of the ancient race.

This act ensures devotion and loyalty; these are never withheld unless in case of some acts of wanton oppression on the part of the sovereign, which calls forth resistance and open war. Such are the virtues of the aboriginal tribes.

Among their vices may be reckoned drunkenness on all occasions of domestic or national festivity. Those who dwell in the forests and mountains chiefly subsist (where they can succeed) by plundering or levying tribute on the inhabitants in the open plains, on the plea of the latter having dispossessed them of their native soil. In their pursuit of this object they seldom commit murder, if it can be avoided; but they sometimes practise cruelty on their prisoners in order to extort confessions of concealed wealth, or to deprive them of the means of escape in the absence of guards, which is effected in the latter case by burning the soles of the feet and the palms of the hands of their captives.

Captain Newbold of the Madras army, who has written on the Chenchies of the Nalla Malla or Black Mountains, represents those he saw as having long bushy hair, thick lips, high cheek bones, and small but piercing eyes. Sir Richard Jenkins and Colonel Agnew confirm this description in speaking of the Gonds; and I believe no instance will be found of those residing entirely on the hills having the aquiline nose or the delicacy of feature of the Caucasian family. In this respect they partake rather of the Tartar or Thibetan physiognomy than of the Hindu.

The remote period of their settlement in India, and the possibility of an occasional intermixture with the Hindûs, may in some cases have somewhat changed their physiognomy from that of their ancestors, so as to render it doubtful whether or not they are derived from that branch of the human family, though in their habits and institutions they certainly bear a strong affinity to the Tartar branch.

It remains now to say something of their language. It is not disputed that when the Hindûs came to India from the westward, they brought with them that language now recognised as Indo-Germanic, and which pervades almost all the spoken languages of Europe, extending from the banks of the Ganges westward to the shores of the Atlantic.

There is the strongest reason to believe that the Hindûs occupied the continent of India, north of 22 degrees of north latitude, for twenty centuries in succession before they invaded the south. Hence our ablest Oriental philologists have divided the various dialects in India into two classes called the Northern and the Southern groups, viz. the Hindi, Bhirji, Guzeratti, Mharatti, Bengali and Oria, constitute the northern group, which consists of six languages; and the Gondi, Telugu or Telingi, Canari and Tamili, constitute the southern group, which consists of four languages.

Each of these may be subdivided into local dialects, differing from each other as much, and even more so than those of portions of the same countries in Europe; but it is not my intention to enter here upon an examination of these dialects.

In the languages of the northern group (especially the Hindi), Sir William Jones and Mr. T. H. Colebrooke after much pains found that nearly nine-tenths of the words have a Sanscrit origin. This great abundance of Sanscrit diminishes as we proceed southwards; and the language at the extreme point of the Peninsula, and that spoken on the Nilgherry hills, scarcely contains any Sanscrit words at all but those of science and abstract metaphysical terms.

The Rev. Dr. Stevenson of Bombay, one of the closest investigators of the Hindu institutions and languages, and who is well-versed both in the Sanscrit and in the vernacular tongues of the South, has discovered in the Mharatti (which is apparently a Sanscrit dialect) numerous words belonging to the southern group. For the purpose of these inquiries he consulted the following dictionaries compiled by Europeans, viz.—

1. Dr. Hunter's Hindu..........	published in	1808
2. Campbell's Telugu or Teliugi..	„	1821
3. Marshman's Bengali	„	1828
4. Cloughs's Cingali (of Ceylon)..	„	1830
5. Molesworth's Mhratti	„	1831
6. Reeves's Canari	„	1832
7. Rolter's Tamili..............	„	1834
8. Guzeratti Vocabulary		

Dr. Stevenson carefully compared all these dictionaries one with another; and he made out tables placing words of similar sound and meaning in juxtaposition, by which he traced several hundred vocables to be identical, though the nations using them are at the present day unknown to each other, and living hundreds of miles apart; but not one of these identical words was of Sanscrit origin.

To Dr. Reinhold Rost of Berlin I am deeply indebted for the aid which he has afforded me in my philological investigations, from his accurate knowledge of the Sanscrit and some of the languages of Southern India. He admits the propriety of classing the languages of India into the northern and southern groups, and allows that the former contain a very large proportion of Sanscrit words with a certain admixture of words of the southern group. He remarks that the palatial sounds of the letters *r*, *d*, *j*, *t* are confined to

India, and cannot, as stated by Dr. Stevenson, be pronounced without difficulty by any but by a native of the province in which the language containing them is spoken. These sounds are unknown in Sanscrit.

He is disposed to think that the Sanscrit of the languages spoken in the northern group owes its present grammatical construction to the gradual adoption of the forms of speech of the abnormal nations, this construction being universal throughout India, even among the Hill tribes, and so different from the rules of Sanscrit construction, that it is impossible to conceive the one to be derived from the other. The similarity of words and formation of sentences in the language of the Todas on the Nilgirry Hills, and that of the Gonds on the Nerbudda, is very remarkable; and it is stated on good authority that some American missionaries who had long resided in Mysore could understand and make themselves understood when they spoke the Canarese language among the Gonds at Amarkantak. The identity of the Gond language with those of the South of India has been proved by myself in comparing 350 words of Gondi, Telingi, Mharatti, Marwari, and Guzeratti together, and of these scarcely one word occurs that is not common to one or more of those languages.

The peculiarity of construction of all these languages differing from the Sanscrit, consists,—1st. In the termination and in the conjugation of the verbs. 2nd. In the preposition of the Sanscrit, and the languages derived from it, becoming in India a postposition. 3rd. In the several meanings of the plural; being inclusive and exclusive, such as, *We*—including the person spoken to and the speaker that is—*You and I*, only; while another plural form signifies *We ourselves*, only and not you. 4th. Different words are used as adjectives, in their application to animate and inanimate objects. 5th. The passive voice of verbs is formed by auxiliaries, such as to suffer, to fall, to get, to take, to eat. 6th. In the languages of India each sentence is divided into two parts, viz. the subject and the verb; the latter is invariably placed at the end of the sentence. In the same way, remarks Dr. Rost, the affirmative branch of a sentence is preceded by the negative; the effect by the cause; the inference by the reason, and the consequence by the condition,—all of which indicates a radical form and construction essentially different from the Sanscrit.

Dr. Stevenson winds up his dissertation on this subject by arriving at the same conclusion, viz. "that Bramanical influence has modified grammatical structure, and introduced into the northern group of Indian languages some affixes for those in former use, especially in the inflexion of nouns, need not be denied, but the general structure of all of them has remained unaffected. There is as little analogy in the construction of a Hindu or Mharatti sentence to the syntax of the Sanscrit, as there is in that of an English or French sentence to that of the Latin."

The next question, then, is to consider to what great class these Indian languages belong. We are naturally disposed to place them in the position indicated by the physiology of the people, and in support of this conclusion we have the following testimony. The peculiarity of the plural which has been pointed out belongs to the Manchou and Mongolian tongues, and also to the Malayan, an offset of the same family. "The peculiarity of structure of the Indian languages belongs equally," says Dr. Rost, "to those of Northern Asia. Of this the position of the pronoun affords proof; also the same use of an affix to supply the place of the inflexions in the Sanscrit and its derivatives the Greek and Latin. The Mongolians and the Indians use special personal pronouns to denote respect; they also use a distinct relative participle in lieu of a relative pronoun.

"In short," observes Dr. Rost, "the same rigorous structure of sentences pervades the whole class of Indian languages and those of Upper Asia, and which cannot be better explained than it has been by Gablenz in his 'Grammaire Mandchou,' p. 276. 'On y place toutes les expressions modificatives avant celles auxquelles elles s'appliquent; ainsi l'adjectif avant le substantif; le régi avant le mot qu'il régit; le régime direct et indirect avant le verbe; l'expression modificative avant l'expression modifiée; la proposition incidente, conditionelle, circonstantiale, hypothetique, et causale avant la proposition principale.'"

Almost all these peculiarities differing from the Sanscrit construction are participated in by the languages of Thibet and Burma, which Dr. Rost considers to be the connecting link between the languages throughout India and the Chinese.

In confirmation of the opinions of Rost and Gablenz, I find Professor Westergard of Copenhagen, in writing to a friend in London so late as September 1846, observes, "I never entertained any doubt of these [the Indian] languages being of Scythian descent, a term which I adopt from Rask for the stock of languages usually called Tartar, and which I prefer as a more general name to be adopted in speaking of the Fins, the Mongols, and the Deckan or southern languages of India." Professor Rask, alluded to by Professor Westergard, who passed some years in the South of India, was an excellent Sanscrit scholar, and was also well acquainted with the Tamili, writes in like manner:—"I am of opinion, that not only are many words of the southern group of languages (in India) common to those of Upper Asia, but that the construction of the whole of them differs essentially from the Sanscrit, and is based on the languages of Northern Asia."

The supposition, that all the aborigines are derived from the stock of Northern Asia, meets with strong additional confirmation when we find a very prevalent opinion to that effect confirmed by tradition, as in the ancient poems of Chand and others of the bards of Rajputana, who describe the Gujers and the Jats as of the Tacshac or Scythian race, in common with the Gackers since converted to Mahommedism, which are spoken of as the bravest of the opponents of Mahmûd of Ghizny, in the tenth and eleventh century, in the Punjab, and on the banks of the Indus. When the remote period of the Hindu invasion is considered, which cannot by any possibility be less than thirty-two centuries ago,—when there are so many proofs from tradition and history that they found India peopled by races of hunters and herdsmen,—when we find these races still existing in every part of India, and living in a state of prædial slavery in towns as a portion of each village community, and in the hills claiming the right of the soil though dispossessed of it, —we cannot fail to recognise the fact of their being a wholly distinct people from the Hindûs. To establish with any degree of certainty, however, their origin, may well be deemed a difficult task. In my endeavour to do so, I have, I think, shown that the whole of those who have been described as aborigines must belong to one great family; that they in many respects resemble the character of the great Scythian horde; that they are also found to partake of the features of the same race, and that all the Indian languages differing in construction from the Sanscrit (the language of the Hindus), assimilate not only in grammatical form, but also in words with the Tartar tongue.

While writing this paper I have met with a singular coincidence of language and physiological character in the remarks of Dr. James Bird, the President of the Bombay branch of the Royal Asiatic Society of Great Britain and Ireland. That gentleman read some time since a paper before the Ethnological Society, on the affinity of the language of the Gonds, the purest of all the aborigines of India, and the mountaineers east of the Himalaya chain, giving rise to the Ganges and to the Bramapûtra river, and which are denominated Bhûtia. Of these Dr. Bird remarks, the connexion of this race with the Nomadic Tartar tribes possessing the central region of Upper Asia may perhaps account for that mixture of Sabeism which prevails in the religious worship of the Gonds, and is characteristic of the superstitious system of belief existing among the Mongolian tribes. Mr. Bradley, who has taken some pains on this subject, traces also a close connexion between the language of the Gonds and that of the Burmas, called by Mr. Marsden *Oraug benouas*, signifying literally the aborigines of the Malayan or Malacca peninsula.

The result of all my inquiries on the several aboriginal tribes of India leads me to the following conclusions:—First, that they are of a stock essentially differing in almost every character of a race from the Caucasian Hindu. That the whole have a common origin; and though they may have come, as they probably did at different times, both from the east and from the north, they are all derived from the same great Tartar horde, and undoubtedly inhabited India anterior to the invasion of that ancient and venerable people the Hindûs. The latter, proceeding eastward from Persia, extended over the barbarous nations of India, and introduced their laws, their civil institutions, and their language, at the same time enslaving the aborigines wherever they settled. The exclusive rules of caste forbade the intermixture of the two races, and this circumstance alone suffices to account for the separation having continued to exist for so lengthened a period.

While the Hindu branch of the Caucasian family proceeded eastward, other portions of the same race spread themselves westward and became the progenitors of the present European race. They subjected those they subdued to the yoke of slavery as serfs of the soil; they brought with them the Sanscrit or Indo-Germanic tongue, and to them Europe owes the introduction of that system of municipal administration which is the only true foundation of free institutions and constitutional government.

Report concerning the Observatory of the British Association at Kew, from September 12, 1849 *to July* 31, 1850. *By* FRANCIS RONALDS, *Esq., F.R.S., Honorary Superintendent.*

AT the conclusion of my last Report (for 1848–49), various proposals were made for the prosecution of new experiments and observations, and for the continuance of others already instituted at Kew: and the General Committee of the British Association, at the Birmingham meeting in September 1849, resolved that "Sir John Herschel having reported that the Meteorological Observations made at Kew are peculiarly valuable, and likely to produce the most important results, the sum of £250 be voted for the continuance of that establishment for the ensuing year," &c.*

Endeavours have accordingly been made, not only to cause this sum, added to about £50, the residue of the former year's grant, to go as far as possible toward the attainment of the principal objects contemplated, but, *at the same time*, to promote the views of Her Majesty's Government in the establishment of a convenient and *exact* system of self-registering magnetical and other meteorological instruments in the colonial observatories under the superintendence of our highly distinguished Honorary Secretary Colonel Sabine.

* *Vide* Report for 1849, p. xx. The *observations* here alluded to were principally those on atmospheric electricity.

It would be seen (on reference to some of the following details) that several of the proposed experiments have resulted in the construction of a new magnetograph; in considerable improvements upon others; in an improvement upon the barometrograph; in a convenient method of producing engraved copies of photographic curves, &c., procured by the self-registering instruments; in a few minor contrivances, &c. of other kinds; and finally, in an *attempt* to institute a series of observations on the frequency of atmospheric electricity, intended as preliminary to the formation of a system, and an apparatus which should permit the self-registration of this species of observations.

In the Kew Report for 1843–44, p. 141, are tabulated a very few of my observations on the subject of frequency made at Kew in that year; and the apparatus then employed, consisting of *two* atmospheric conductors, is shortly described. I believe that they were the first experiments of the kind which have been published since Beccaria's extremely interesting observations at Turin about 1750 (which were effected by means of apparatus having very imperfect insulating power), and I think that the above-named apparatus, of two conductors, &c., is somewhat better suited to the purpose than one rod which I now employ; but the funds and *localities* at Kew do not at present permit the use of the former. These few experiments, however, taken in conjunction with Beccaria's, with my own *old* experiments (at Highbury Terrace, and at Hammersmith, Upper Mall, not published), and with what little has been done at Kew this year, have tended to increase in my estimation the importance of carrying out such researches effectively. Their results may form a link in the chain of phænomena connecting the static with the dynamic electricity of the atmosphere; for it is only when frequency is great that *galvanometers* manifest a current. *If* atmospheric electricity exerts *any* agency on animal life, &c., is it not this condition (of frequency) which has prime influence?

These considerations, joined to the circumstance of frequency having been already in some measure a subject of inquiry at the Royal Greenwich, and even at the Bombay Observatories (with apparatus of the kind which I use), naturally create very great regret that the indisposition of the observer who was engaged at Kew during a part of this year, caused the series of observations on frequency to be so limited as it will be found to have been.

We shall, I trust, fully compensate for the deficiency under Mr. Welsh's able exertions next year.

I now proceed, as usual, to matters regarding—first, the Building, Instruments, &c., of the Observatory; secondly, to some remarks concerning observations; and thirdly, to an account of what has been done in the way of experiment since the last general meeting of the Association.

I. The Building, Instruments, &c.

The exterior of the premises has required very little repair. The addition of a rail, &c. has been made to the former arrangements on the Dome for the greater security and convenience of the observer whilst attaching the lantern to the top of the principal conductor.

In the interior, some painting, plastering, papering, &c. have been executed (in the basement). A few book-shelves have been added to those in the North Hall, for the reception of books presented to the Association, and for the stock of the Association's Reports, &c.

A small upper apartment has been appropriated to the mechanic or photographist as a sleeping-room.

The South Upper Room (or laboratory) has been supplied with a good lathe, turning tools, various chucks and necessary appendages; also with a vice-bench, &c., in order to render it efficient for experimental purposes, and to avoid the great delay and expense occasioned by having to send to London for many articles which can be constructed here.

The *Principal Conductor* on, and in, the Dome is in an efficient state, but should be dismounted and cleansed, &c. The slight inclination spoken of in my last Report has been remedied.

The *Volta-Electrometers* in the Dome have been repaired.

The *Galvanometer* (Goujon's) appears to have lost a little in sensibility, the needles being no longer perfectly astatic.

The *Discharger*, the *Gold-leaf Electroscope*, the *Distinguisher*, and the three *Night-registering Electrometers* are effective.

The pair of *portable Volta Electrometers*, and the *Peltier's* or rather *Erman's Electrometer*, are in working order.

The *Electrograph* (at the central window of the upper south room) has been somewhat damaged by a violent storm. It is intended to repair it, remove it to the dome, and connect it with the principal conductor there after the preliminary observations on frequency have been accomplished.

The *Wind-Vane* has been restored.

The *Rain and Vapour-Gauge*, and the *Balance Anemometer*, have been properly examined and adjusted at the requisite intervals.

The *Standard Thermometer*, and the *Wet-Bulb Hygrometer*, have been removed from their position at the north window of the Quadrant Room, and mounted on a thermometer stand.

The *Ordinary Barometer* has been (again) compared with the Royal Society's Instrument.

The *Kreil's Barometrograph* has been repaired, and a few curves have been drawn by it.

The *Photo-Barometrograph* has been removed from the Transit Room to the Quadrant Room, and has had a little alteration made in it for the purpose of rendering it applicable to either the Daguerreotype or the Talbotype processes. It still requires further alterations and improvements.

The *Declination Magnetograph* (in the Transit Room), described in the Phil. Trans. part 1 for 1847, has had some alterations made in it similar to those made in the Photo-Barometrograph.

A *Horizontal-Force Magnetograph* has been added to our collection, from apparatus sent from Woolwich, with my photographic self-registering arrangements. This instrument is in most respects similar to that described in my last Report, and sent to Toronto; the differences will be alluded to and easily understood when the experiments, &c. for the construction of the vertical-force instrument sent to Toronto are described below.

Also some apparatus of an improved kind, used in the *Daguerreotype process*.

An instrument for dividing right lines (necessary for the scales, &c. of all self-registering instruments), and a new kind of compasses or dividers, will be described under the head of "Experiments," as they are not yet considered to be complete.

The *Storm-clock* is in proper working order, and greatly facilitates observations on frequency. [As it is applicable extensively to meteorological, and even some astronomical observations, it should perhaps have the more general appellation of "*Observer's Clock*."]

The description of this instrument in our Journal for 1844–45 not having been printed, the following short account of it may not perhaps be deemed unnecessary:—

A (in Plate III. fig. 1) is a strong deal table firmly secured upon the stage in the Electrical Observatory. B is an inclined writing-board solidly attached

Frequency paper.—No. 1.

May 12. 17^h 17^m P 65·0

•

• 12·5

• 17·5 P

• 25

• 27·5

• 30

• 35

5 • 37·5

• 42·5

• 45

• 47·5

• 50

• 55

• 57·5

• 62·5

• 65

10

• 67·5 11^m 15^s

• Cirro cumuli in zenith.

• 67·5

• P

to A, and C is the clock-case. d^1 is the long pendulum within C, and d^2 its very heavy bob. d^3 is a lever which enters C through a slit, and whose fulcrum is at d^4: a spring (not shown) forces the nearest end of d^3 upwards when it is not stopped in the horizontal position. d^5 is a little stop fixed upon d^3. d^6 is a rod attached, by a pivot, through a slit to d^3, and passing through a hole in a piece of wood (not shown) attached to A. This part of the instrument is so constructed, that when the clock is not in motion d^5 is in a higher position than that shown, and the extremity of the then inclined pendulum d^1 is placed by the observer against its nearest side, preventing vibration; but when it is to be set in motion, d^5 is brought into the position shown by depressing the handle at the top of d^6. d^7 is a gut-line proceeding from the barrel of the clock contained in C, passing over B, round a pulley at an angle of A, and sustaining a weight, d^8, which gives motion to the clock-work. d^9 is another line sustaining the winding-up weight, d^{10}, which line passes round another pulley (unseen) under B, and entering C is attached to and winds round the barrel of the clock in the contrary direction to d^7.

The continuity of d^7 is interrupted by a small steel wire, upon which turns, or hangs freely, a little pointed brass plate d^{14}, pressing very lightly on B.

When the clock is at rest d^{14} is adjusted to the upper part of a "*Frequency Paper*" fixed (by drawing pins) upon B, and the whole is ready for use. When an observation is to be commenced, the time (by our chronometer) is written exactly opposite to the point of the index d^{14} (which has been placed at the top of the paper by pulling down the weight d^{10}); the conductor is then discharged, and the pendulum started (by pressing down d^6) at the same moment.

As the charge of the conductor advances towards its former intensity (or any other approximative maximum intensity), marks are made opposite to the index from time to time at convenient intervals; and the various tensions are noted down at those intervals near the marks until a maximum has been arrived at by estimation (*i. e.* when no increase of tension *seems* to be going on, or when a decrease has actually begun). The observation now ceases, and the fiducial edge of a scale, accurately divided into spaces corresponding with the rate of our chronometer, is applied to the above-mentioned first and last marks or "*notes of tension*," and occasionally to other of the marks. Or, in order to estimate as accurately as possible by these means the time of a maximum, the observation is carried on even beyond the apparent first maximum.

A copy of one of the "Frequency Papers" is annexed which has been employed for procuring the "Frequency Observation of Atmospheric Electricity," where it may be seen that on May 12th, 17^h $17'$, the charge of the conductor was positive and $=65$ divisions of the Electrometer, and that the Frequency (at about 11 minutes afterwards) was $=11'$ $15''$ (the charge had increased to 67·5 divisions).

The remaining apparatus and instruments of various kinds belonging to the Association, or on loan to it, do not seem to require particular notice here. They are carefully preserved.

II. Observations.

The only observations (or experiments) worth notice here, on the frequency of atmospheric electricity which have been made at Kew this year (by means of apparatus particularly described in the Society's Reports for 1843–44), commenced on the 12th of May and terminated on the 1st of June. The plan of procedure adopted was intended as merely preliminary, and in order to arrive at certain data for choosing the preferable mode of instituting a regular series of such observations (self-registering or ordinary).

The instructions given to the observer were as follow:—

"The pillar lamp, and the lamp of the lantern belonging to the electrical apparatus in the Electrical Observatory having been filled with good olive oil, and provided with wicks of the usual uniform size, which have not been used more than three or four days, to be at sunrise of every day, excepting Sundays and Wednesdays, lighted and placed in their usual positions for observations.

"At one hour after sunrise, or as near to that time as possible, an observation of the barometer, its attached thermometer, the standard thermometer, the wet-bulb hygrometer, the balance anemometer, and the wind-vane, together with remarks on the state of the sky, to be made and entered in the appropriate columns and page of the printed form headed 'Electro-Meteorological Observations,' &c., noting also the time of these observations, &c. having been commenced.

"As soon as possible after these entries have been effected, a note of the *kind and tension* of electricity to be made and recorded, with the time, on a paper, called a '*Frequency Paper*,' and immediately afterwards the principal conductor to be discharged suddenly and allowed to assume a new charge.

"A series of *notes of tension*, with the times, to be then commenced for the purpose of ascertaining (as nearly as the conditions below stated and other circumstances will permit) the length of time which may elapse between the moment of allowing the new charge to commence and the moment of that new charge arriving at a maximum tension. These notes of tension and times to be also set down upon the above-named frequency paper (or papers), together with any variation in the kind (positive or negative) of charge which may have occurred.

"The primary observation of kind and tension to be copied into the columns headed 'kind' and 'periodical observations' respectively; and the length of time which may elapse (as above) for obtaining a maximum tension, in the column headed 'frequency' of the above-mentioned printed form or journal.

"If a maximum tension should occur at any time after the expiration of half an hour, and within one hour, from the moment of allowing the above-mentioned new charge to commence, then fresh observations of the barometer and of the above-named other meteorological instruments, with remarks on the state of the sky, to be made as nearly as possible at the time of the maximum. This second set of observations of the barometer, &c. to be also entered in the printed form as before, with the times of these observations having been commenced.

"If a maximum tension should not occur before the lapse of one hour after the moment of allowing the above-mentioned new charge to commence, the series of notes of tension (which serve for endeavouring to attain the frequency observation correctly) to be discontinued; and the circumstance to be noted in the 'frequency paper' and the printed form as above.

"The lamps of the electrical apparatus to be kept burning and ready for observations from the time of being lighted until one hour after sunset. The charcoal stove (Joyce's) to be lighted and kept burning whenever the hygrometer indicates a damp state of the atmosphere, in order to preserve a sufficient insulating power in the distinguisher, &c.

"At one hour after meridian, or as near to that time as possible, and at sunset, the frequency observation, accompanied by observations of the barometer and other above-mentioned meteorological instruments, and remarks on the state of the sky, to be repeated. An observation of the rain and vapour-gauge to be also made at sunset (only), and the whole to be entered as before. The rain and vapour-gauge to be set at or near to this time.

"The frequency papers, the electro-meteorological journal, and the chronometer, to be kept usually on a table at the south end of the Transit Room.

"The mode of procedure here spoken of is chiefly applicable to serene weather, including fogs, mists, &c. If rain or snow, impending or more distant clouds, or sudden changes from a positive to a negative state of charge should occasion difficulties or impossibilities of observing frequency, these circumstances to be noted in the electro-meteorological journal and frequency paper."

III. Experiments.

The first subject of consideration, as respects instrumental experiments, after the last annual meeting, was a better mode of mounting the standard thermometer and wet-bulb hygrometer.

In October, a revolving stand, on the Greenwich plan, was erected at the north entrance of the building; but objections exist to this, and in fact to all "thermometer-stands" hitherto invented. Either the sun or the wind has injurious influences, which it should seem are hardly to be got rid of. I trust, however, the method will be improved under the suggestions of Col. Sykes.

In November 1849 some work and preparations were executed here for the vertical-force magnetograph (*vide* Plates I. & II.), alluded to in my last Report as being in an advanced state for the Toronto Observatory. In December some principal parts of it arrived from Mr. Ross and Mr. Newman, and its completion was proceeded with.

A successful attempt to improve this sort of apparatus was that of fitting a sliding plate to the frame containing the Daguerreotype plate, in such manner that it completely excluded light from the latter, whilst it was not in its place in the instrument, but allowed the focus to act upon it when properly placed there. This contrivance (a modification of one commonly practised by photographists) precludes entirely the necessity of operating upon the plate or paper in a dark room before the mercurializing part of the operation is performed.

An improvement in the mouth-piece permits a much greater facility and accuracy of adjustment in the breadth of the slit than had been before attained, a matter of some importance, when the delicate and rapid changes of the magnet's position are required to be registered. A chain was substituted for a gut-line for suspending the sliding-frame, which somewhat improves the accuracy of the magnetic curve produced on the contained metallic plate or paper. A little frame, containing ground glass, was added, in order to save time and trouble in examining the image of the slit in the shield. A screen, placed temporarily in the place of the fixed shield, was used with advantage for dividing the aberration of the lenses between the central and the outer parts of the range of the said image. This screen was provided with a series of slits, in lieu of the one slit only of the fixed usual shield. An improvement applicable to this and all photo-registering instruments of similar construction was adopted, consisting in a sliding shutter, which, by a simple, small, rotatory movement, given by the fingers to an arbor passing through the clock-plates, is opened in order to expose the Daguerreotype plate to the focus of light, and at the same moment to set the clock in motion, and *vice versâ*.

In order that the new arrangements may be clearly comprehended, and trouble saved in recurring to former descriptions, it will be convenient to place the whole apparatus before the eye as finally constructed.

Description of the Vertical-Force Magnetograph.

Similar letters refer to similar or analogous parts in the figures of this instrument, as well as of the horizontal-force magnetograph described at page 80 of the British Association's Report for 1849.

The figures 1 and 2 of Plate I. are drawn to one-eighth of the real size; figures 3, 4, 5 and 6, to one-fourth of the size. The figures of Plate II. to one-quarter of the real size.

V, figs. 1 and 2, Plate II., is the magnet box (in section), of mahogany, not coated, as before, with gold paper, provided with a squared tube, T, of cast brass, which opens into A.

A is the camera box (of mahogany).

a^1 is the usual solid brass casting, forming (in part) one of the ends of A.

B is a fifteen-inch magnet belonging to a vertical-force balance magnetometer of Dr. Lloyd's construction.

b^2, a piece screwed upon the upper edge of B.

b^3, a pair of very light, sliding brass tubes attached to b^2, and capable of vertical adjustment (for length).

b^5, a weight adjustable on a screw attached to the lower edge of B, for poising b^3, &c. properly.

b^1, the *moveable shield*, composed of very light sheet-brass, flat, and having its upper edge curved to a radius of 12 inches, and attached to b^3. It has a very narrow slit at the centre of its upper edge.

O is a diaphragm plate, whose aperture is about an inch long (horizontally), and a quarter of an inch wide; it is supported by two angular plates (as o^3) resting upon X, and attached (with means of adjustment) to g^1 by screws passing through slits.

o^1, the fixed shield attached to O by means of a little bolt, washers and nut, o^2. It is capable of adjustments for horizontality, height, &c. At about three-eighths of an inch from its centre is a slit, somewhat larger than the slit in b^1. The lower edge of this shield stands at about a twentieth of an inch lower than the upper edge of b^1, and at about the same quantity from its interior plane.

C is the shutter apparatus.

c^1 is a plate screwed upon A, and having an aperture about equal to and corresponding with an aperture and little plate of glass in A. It is provided with grooved pieces, between which slides freely c^2.

c^2 is a plate having an aperture (c^3) equal to that of c^1 and A, but corresponding with the latter only when it has slid into its lowest position.

c^4 is a small line attached at one end to c^2, passed over a pulley, c^5, under another pulley, c^6, and fixed to a lever, c^7 (fig. 7, Plate I.), within the clock case K, which lever is attached to the apparatus used for stopping and starting the clock (*vide* k^2, Plate II. of the Report of the British Association for 1849).

The object of this arrangement (C, &c.) is to admit light into A at the moment of starting the clock, and to exclude light therefrom at the moment of stopping it.

D (Plate I. fig. 1) is a modification of Count Rumford's polyflame lamp, having three flat wicks and rack-work to raise them.

d^1, its high, squared copper chimney, with a narrow glass plate opposite to the best part of the flame.

E (Plate II. fig. 1) is the mouth-piece, in section, consisting of two angular pieces and of two little plates attached to them, forming the lips and aperture e^1, which aperture can be diminished or increased at pleasure, with great and *requisite* accuracy; for,

e^2 is a plate screwed upon a^1.

e^3 e^3 (fig. 3) are two screws, which, freely sliding through e^2 and screwing into the upper portion of E, are employed to elevate that portion.

e^4 is another screw, screwing through e^2 and pressing occasionally upon the upper portion of E. This is employed to move it downwards (when the mouth is to be more nearly closed e^3 e^3 must, of course, be released before e^4 is screwed downwards, and *vice versâ*).

A narrow vertical slit is cut in the lower lips of E, as shown in fig. 3, and a horizontal aperture of about 3 inches long, and about a quarter of an inch broad, (not shown) is cut through a^1 for the passage of light to c^1.

F is the slider-case for receiving the sliding-frame.

f^2, a perfectly true ruler of brass attached vertically to a^1 by means of three screws passing through it, through three little pillars and through three oblong slits in a^1, &c., which admit of its vertical adjustment.

f^3 is a roller spring attached to a^1, and acting upon H laterally, pressing it gently against f^2.

f^5 is a pair of similar springs acting upon H in front, and pressing a plate belonging to it (to be presently described) against E.

G is the lens tube containing two groups of achromatic lenses (by Ross), and of curvature specially adapted to the purpose. The range of the image of the slit in the moveable shield is four times greater than the range of the slit itself (*vide* fig. 2. Plate I.).

g^1 is apparatus of sliding plates, &c., for support and due centring of G.

g^2 is apparatus of stud, pinion, milled-headed key, &c., for moving the rod g^3 which is attached to the stud at g^4, and serves for adjustment to focus (of G).

H is the sliding-frame suspended in F. h^4 is a door closed by means of three little turn buckles, h^5. Upon its interior side are fixed three springs, h^1, for retaining the Daguerreotype plate y (or a glass plate, if Talbotype paper is used) in its proper place.

h^2 are the three friction rollers.

h^3, a hook with a little peg in it, which attaches it to a clock chain.

h^6 is a brass plate capable of sliding freely in a groove in H.

When both h^6 and H rest on the bottom of E, h^6 covers entirely y (of course not touching it); and the height of h^6 is such that when placed in F properly its upper edge always stands at about one-twentieth of an inch below the opening of the mouth at E, as shown by the dotted line; but when H is drawn upward (carrying Y with it and leaving h^6 still resting on the bottom of E), portions of Y are successively exposed to the action of light passing from the lamp (or daylight) through the slit in b^1, the lenses in G and the aperture e^1.

At the upper end of h^4 a narrow aperture and a piece of finely ground glass is placed opposite to it and above y, for the purpose of receiving the image (before the clock is started), and the microscope, f^6 (fig. 1. Plate I.), is used in examining the image on the ground glass for focus and *colour*.

I is the pulley on the hour-arbor (or barrel arbor) of the time-piece. Its diameter is somewhat less than 4 inches. It moves H upwards at the rate of an inch per hour: but a pulley of half that diameter may be substituted for it, and the *time-scale* thus diminished to half an inch pér hour if required.

i^1 is the clock chain by which H is suspended from I; and

i^5 is a counterpoise to H, &c.

K (fig. 1. Plate I.) is the time-piece.

k^2 (fig. 7.) is the back view of the lever and fork, &c. above mentioned, attached to an arbor passing through the clock plates, and furnished with a milled-headed nut (not shown in front), and by a spring and detent, k, by means of which the fork can be made to stop or to release the pendulum at any given second.

K^1 is the frame supporting K & F (*vide* Plate I. of former Report).

k^3, brass tubular braces.

P^N & P^S (fig. 1. Plate I.), are stone pillars whose common centres are in the mean magnetic meridian (about).

Q Q are two of four brass tubular columns.

q^1 and q^2 are screws and nuts which enter and clamp those four columns to two marble slabs.

R is the lower slab of black marble resting on P^N.

r^2 r^2 are bolts and nuts which firmly secure the magnet support upon R.

S is the support of and apparatus for raising and lowering the magnet of Dr. Lloyd's construction, but without the cross wires, &c.

s^1, the base.

s^2, four leveling screws.

s^5, pieces carrying the agate pallets.

s^6, frame-work moveable by means of a key, &c., for raising the magnet off from its pallets.

T, a squared brass tube passing through V into A.

X is the upper black marble slab carrying A, G, a^1, K^1, &c.*

Some minor improvements have been made in the apparatus used for the preparation, &c. of the Daguerreotype plates, viz. on the polishing board, Plate I. fig. 3; the buffs, fig. 4; the coating boxes, fig. 5; and the burning-off and fixing stand, fig. 6.

The Polishing Board.

A (fig. 3. Plate I.) is the mahogany board.

a^1 a^1 are screws which attached it to a firm table.

B is a piece of mahogany attached to A by means of two screws.

b^1 b^1 are the two screws which pass through it and screw into A.

b^2 b^2 are two pins fixed firmly in B but sliding stiffly in A.

b^3 is a rim (or edging) of thin sheet brass attached to A and projecting upwards a little less than the thickness of a photo-plate.

b^4 is a similar edging of sheet brass attached to B.

The surfaces of b^3 and b^4 are always in exactly the same plane, and the photo-plate may be firmly held between them by using the screws b^1 b^1.

The Buffs.

A (fig. 4.) is a deal board 1 inch thick in the middle and $\frac{3}{4}$ inch at each end. Its lower surface is bellied (in the manner of a large file), and covered first with flannel and then with thick plush cotton velvet. It is rubbed across the plate. Its handle (a^1) is glued and screwed firmly upon it.

The Coating Boxes.

A (fig. 5.) is the deal box.

a^1 a^1 are the usual openings in its sides.

a^2 is the door which carries the usual mirror (on its interior face).

a^3 a^3 are strips of mahogany with screws and washers which fix them upon the edges of A but allow them to be approached towards, or withdrawn from each other a little, in order that any sliding-frame, as H, may fit exactly between them.

a^4 is a little projecting piece to support the glass plate below mentioned.

B is the glass cistern fitted into A, and containing crystals of iodine, distributed on the bottom.

b^1 is the glass plate cover of B resting on its upper edges and projecting beyond A.

H is the sliding-frame containing the photographic plate (or paper) and

* This vertical-force magnetograph was shipped for Toronto on the 23rd of March, and Captain Lefroy, the Director of the Royal Observatory of Toronto, has acknowledged the arrival of it as well as of the horizontal-force magnetograph. I understand that he has mounted and successfully worked this latter instrument.

its sliding plate h^6 (*vide* fig. 1. Plate II.), with a little handle for withdrawing it in order to expose the photo-plate to the action of the iodine, &c.

The Burning-off and Fixing Stand.

A (fig. 6.) is a heavy mahogany board.

a^1, a milled-headed screw passing through A and projecting (about half an inch) below it.

a^2 a^2, two little brass feet projecting (about the same quantity) below.

B is another heavy mahogany board.

b^1, another screw similar to a^1 and pressing on A.

b^2, one of two feet similar to a^2 a^2, also resting on A.

C C, two tubular pillars fixed upon B.

c^1 c^1, two wires attached perpendicularly to caps on C C, which caps can turn on their axes.

V is a photo-plate resting on c^1 c^1.

The axes of a^2 a^2 are in a plane perpendicular to the plane of the axes of b^2 b^2. This stand allows of much more rapid adjustment for horizontality than the usual stand having three adjusting screws.

About the end of the month of February last, I think, Sir John Herschel proposed a very ingenious method of procuring surfaces in relief (as in wood engravings) on gelatine paper, which should exactly coincide with impressions procured on the gelatine by photographic means, in order that they might be employed in printing.

On hearing of this, I suggested to Colonel Sabine the expediency of engraving gelatine paper as if it were actually copper, with the figures of the magnetic and other curves on our Daguerreotype plates, by using the gelatine as tracing-paper commonly is used for the purpose of copying drawings, &c., and also of employing such engraved gelatine as copper plates are employed for printing any required number of copies of such magnetic and other curves.

The experiment succeeded on the first trial.

Specimens are preserved in our Journal of gelatine paper thus engraved, and of declination, horizontal force, and barometric curves as *printed* from the gelatine.

The ordinate board has been slightly modified to render it useful in this process.

The method of Sir John Herschel, however, will certainly be found far preferable to this, when chemical difficulties have been conquered, as I sincerely hope they will be.

In order to correct certain errors of the clock's rate—errors arising from expansion, &c.,—it has been found necessary sometimes to divide the time-scale belonging to the curves produced into equal parts. An instrument, correct in principle at least, and which I hope to render an accurate and generally applicable mathematical instrument, has been experimented upon.

Its principle of action is that of a well-known instrument called the "Lazy-back," and will be instantly understood by reference to Plate III. figs. 2 and 3 (the perpendicular rods are *fixed* to the lower joints, but slide through the upper ones).

It is evident that the points of this instrument cannot be brought very close to each other: if, therefore, minute divisions of a scale are required, the first large division may be subdivided by means of a pair of parallel dividers (figs. 4 and 5), which, it may be readily seen, is an instrument constructed on similar principles to the above, but allowing the points to touch each other. The first large division having been so subdivided, the first instrument (figs. 2 and 3) may be evidently so applied as to divide with accuracy, facility and dispatch, each of the other large divisions into the same subdivisions "without stepping."

In the early part of the year many experiments were made on electrotyped and other kinds of plates. It was found that the former were preferable.

About the end of April Mr. Ross's portion of the horizontal-force magnetograph already alluded to arrived, and claimed our attention and labours. It was placed on the corbels in the Quadrant Room, which had been occupied by its predecessor the vertical-force magnetograph sent to Toronto. No material variation was introduced differing from those already described relative to the vertical-force instrument, excepting such as were required for its special object. It was so arranged, that it might be, with very slight variations, used either for a declination or horizontal-force magnet. The gold-paper covering of the magnet-case is dispensed with, yet this magnet seems to be as quietly disposed as the former horizontal-force instrument. Increased diligence has been used for promoting accuracy, &c.

In concluding this Report, I will only allude slightly to a little correspondence which I have had with gentlemen who seem obligingly disposed to second my views as to the establishment of electrical observatories, both in this country and in distant parts of the globe, and have proposed to them a portable modification of mine at Kew, which would, I believe, be found efficient in promoting a more extensive range of inquiry into the interesting subject of Atmospheric Electricity.

Report on the Investigation of British Marine Zoology by means of the Dredge. Part I. *The Infra-littoral Distribution of Marine Invertebrata on the Southern, Western, and Northern Coasts of Great Britain. By* EDWARD FORBES, *F.R.S., Professor of Botany in King's College, London, and Palæontologist of the Geological Survey of the United Kingdom.*

AT the Meeting of the British Association at Birmingham in 1839, a Committee was appointed for the investigation of the Marine Zoology of the British seas, by means of the dredge; and at the joint recommendation of the Natural History and Geological Sections, a sum of money was granted towards its expenses. Ever since that time the Committee has been annually reappointed, with grants of various amounts placed at its disposal. At each meeting, a provisional report, stating the nature and success of the researches conducted during the interval, has been presented. A considerable mass of valuable materials having been collected, it is now proposed in this Report to present the results in connexion, in such a form as may be useful to science. The extent and value of the data will sufficiently prove the expediency of the researches.

For some years past much attention has been paid to marine zoology by the naturalists of Europe and America. Among the inhabitants of the sea, are many creatures whose organization is as attractive to the physiologist as the singularity of their shapes to the students of external conformation. Many of them were apparent anomalies in their respective classes, and of doubtful position in the animal series. To throw light on the general history of animal tissues, and on the various modifications of vital organs, to fill up gaps in the scale of being as known to zoologists, to ascertain whether in the depths of the ocean there are not still remaining the analogues and homologues of apparently lost species, and the representatives of unknown or conjectural types, it was most desirable that a more searching investigation should be conducted into the number, kinds, and distribution of the inhabitants of the ocean. No single tract had been scientifically explored, and the dredger was in most instances a distinct person from the naturalist by whom he was employed.

The chief purpose for which the dredge had been employed on our coast, was for the procuring of specimens of shells of the Mollusca. Consequently our knowledge of the extent of the marine molluscous fauna of Britain, and of the distribution of the testaceous species in our seas, was much in advance of that of other departments of marine zoology; but even this could be but partially depended on. It was formerly too much the aim of British naturalists and collectors, to endeavour to swell the catalogue of British animals,—the former, from a mistaken patriotism, the latter not always with such disinterested motives; consequently the catalogues of our fauna, especially of the marine mollusca, became enriched by numerous species, very doubtful natives of our coasts. Some of these did not excite surprise, their true distribution being then unknown: others led to hopes of the finding in our seas species of a far more southern type than really inhabit them; and all went to destroy the authority of our lists, and to confound the calculations of the investigators of the laws of geographical distribution, and of the relations of living animals to fossil. The only hope of purging catalogues so vitiated, and at the same time of extending them in those departments to which but little attention had been directed, lay in the establishment of a new series of researches more rigidly precise than had ever before been attempted, and set on foot solely with regard to the determination of the true state of our submarine fauna.

It was for this object mainly the "Dredging" Committee was formed. Their first act was to print blank formulæ, in which the information obtained might be registered at the time and place where procured. Each form consists of a ruled sheet, with a heading for the registration of particulars of *date* of the operation, of the *locality* where conducted, of the *depth* of the sea in the place where the dredge was sunk, of the *distance from the shore* at which the observation was made, of the *ground*, *i.e.* the nature of the sea bottom in the place examined, and of the *region* under which the portion of the sea-bed explored might be classed. Below the heading are ranged the names of the species procured, opposite columns stating the number of living individuals taken, the number of dead specimens, and any observations which might be suggested by the condition of the specimens, or the manner in which they were associated together.

A great mass of these papers has now been accumulated, and are in the possession of the reporter. The time has come when they can be tabulated and reduced to an uniform language with advantage to science. Until very lately this could not have been done. British marine invertebrate zoology has advanced with gigantic strides since the year the Committee was established. Within the last ten years, the nomenclature and characterization of the species of British Mollusca, Crustacea, Echinodermata, Acalephæ, and Zoophyta, have undergone complete and thorough revision. Much has been done too among the Annellidous tribes*. Indeed, at the present moment no

* The following works are used as text-books for these reports:—Yarrell's History of British Fishes; Forbes and Hanley's History of British Mollusca; Bell's History of British Crustacea; Baird's Monograph of British Entomostraca; Forbes's History of British Echinodermata; Forbes's Monograph of British Medusæ; Johnston's History of British Zoophytes, 2nd Edition; Johnston's History of British Sponges. All these works, with the ex-

marine fauna in the world has been investigated with anything like the care devoted to that of the British seas.

Nevertheless much remains to be done. All parts of the British and Irish shores have been more or less explored, but not all in an equally systematic manner. On the eastern coasts, the registration of the depths of marine animals has been carefully attended to by Mr. Alder, Lieut. Thomas, R.N., Mr. Albany Hancock, Mr. Howse, and Mr. King; whilst Dr. Johnston, Sir John Dalyell, Dr. Fleming, Mr. Bean, Mr. Embleton, Professors Goodsir and Macgillivray, the late lamented Dr. J. Reid, and many other able observers, have devoted themselves to the examination of the marine invertebrata. From the north-eastern coast of Scotland, many valuable dredging papers have been filled up by Mr. MacAndrew, and a considerable accumulation of valuable data for tabulating the depths of the Testacea in the southern part of the German ocean, were accumulated by the late Capt. Owen Stanley, R.N., and are in possession of the reporter. Around the shores of Ireland, a valuable mass of data has been collected by Mr. W. Thompson of Belfast, Dr. Robert Ball, Mr. Patterson, Professors Harvey, Allman, and McCoy, Mr. Hyndman, Dr. Farran, Mr. Humphreys, and Mr. Warren, all Irish naturalists, and added to by Mr. Barlee, Mr. Jeffreys, Mr. Hassell, Mr. MacAndrew, and myself. Both from the eastern coasts of Britain, and the whole range of the Irish coast, more well-filled tabulated forms are still wanting; consequently I have thought it advisable in the first instance to report on the results of dredging on the western, southern and northern shores of Great Britain, from which data have been collected very fully and systematically, and more than 140 forms of "Dredging papers" fully filled up. With one exception (by Mr. Hyndman), these have been recorded on the spot at the time of the operation, by Mr. MacAndrew and myself, jointly or separately. Numerous isolated records of depths of particular species within this area are embodied in the following tables from the observations of Mr. Jeffreys, Mr. Smith of Jordan Hill, Mr. Barlee, Mr. Alder, Mr. Hanley, Mr. Clark of Bath, and Captain Otter, R.N.; and for the Orkney Isles, a most valuable record of depths has been drawn up by Lieut. Thomas, R.N., during his survey of those islands. The obligations of science to the officers engaged in the Hydrographical Survey of the British seas cannot be too strongly expressed.

In order to reduce the contents of these papers, and to embody the isolated observations in a useful form, I have tabulated the data in two series of tables. One includes all the depths at which the species of testaceous Mollusca and Radiata were taken during these operations, the species themselves being ranged in systematic order. The nature of the ground upon which they were found is in every registered case recorded, and also whether the individuals were taken alive or dead.

In a second series of tables, all the fully-registered dredging forms are tabulated and analysed, with a record of the year of observation, the distance from shore, the depth, the nature of the sea-bed, the number of species of Univalve testacea taken alive and dead, the same of Bivalve testacea, and the number of Echinodermata, a statement of the species taken most abundantly, of the rare forms found, and of any peculiarities in the assemblage of creatures observed in the particular locality.

ception of the first, have been published since the Meeting of the British Association at Birmingham in 1839, and much of their most valuable materials have been collected in consequence of the researches set on foot at that meeting.

The above sets of tables concern mainly the Testacea and Echinodermata. A statement of the results of the search for plants and for animals of other classes and orders is given in a less formal manner in supplementary paragraphs.

To show the range of the several species of Testacea and Echinodermata as perfectly as possible, the lists of English and Scottish species are drawn up separately. Each are moreover grouped under provinces, these provinces being not merely sections of the coast chosen for convenience, but areas presenting peculiar zoological features of their own, dependent on causes which are briefly discussed in the general observations offered in the latter part of this Report.

The English provinces which have contributed materials to this Report are five:—1st, the coasts of Hants and Dorset; 2nd, the coasts of Cornwall and Devon; 3rd, South Wales and the British Channel; 4th, North Wales and the neighbouring sea; and 5th, the sea around the Isle of Man.

The Scottish provinces (western and northern) are also five:—1st, the Clyde region; 2nd, the Inner Hebrides; 3rd, the Outer Hebrides and the sea off Sutherlandshire; 4th, the Orkney Islands; and 5th, the Zetland Islands.

As all these provinces, English and Scotch, have been personally explored by myself, I am enabled, in tabulating the contents of the dredging papers and the isolated observations on depth embodied in the list of species, to judge with greater accuracy than I otherwise could have done of the value and bearing of the data, and to venture with greater confidence on the general considerations which follow.

The reader must bear in mind constantly that the object of the following papers and tables is not to give a complete enumeration of the animals inhabiting each province, but to present an authentic series of accurate observations on the distribution of such species as can only be procured by the aid of the dredge.

Table I.

Analysis of Dredging Papers drawn up on the Southern and Western Coasts of England.

The depth is given in Fathoms.

Date.	Locality.	Miles from shore.	Depth.	Ground.	Univalves. Alive.	Univalves. Dead.	Bivalves. Alive.	Bivalves. Dead.	Echinodermata.	Remarks, especially noting the animals most abundant.	Observer.
Around the Isle of Man.											
1833.	Off Ballaugh, Isle of Man.	5	20	sh.	14	1	11	11	...	(Ab.) Trochus tumidus, Emarginula Mulleri, Buccinum undatum, Pecten opercularis, Hiatella arctica, Tapes virginea; alive and dead.	E. F.
1836.	Off Ballaugh, Isle of Man.	5	20	sh.	18	2	18	6	14	(Ab.) Pecten opercularis, Venus virginea, Hiatella arctica, Nassa incrassata, Acmæa virginea, Chiton asellus; also in lesser numbers, Pecten tigrinus, maximus and sinuosus, Trochus ziziphinus, Fusus antiquus, gracilis, Buccinum undatum, Fissurella reticulata. Corallines. Nudibranchs.	„
1838.	Off Ballaugh, Isle of Man.	5	20	sh.	21	...	27	2	15	(Ab.) Same as above. Murex erinaceus, Velutina lævigata, Pileopsis hungaricus, and Trophon Bamfius, more plentiful; four species of Nudibranchs.	„
These three Registries are all from the same spot in different years. The difference in the number of species noted, possibly depended on the number of hauls of the dredge. All the Manx observations are of many hauls.											
1840.	North-west coast of the Isle of Man.	1–2	7–12	s. st.	5	...	3	...	...	Laminariæ. Compound Ascidians. (Ab.) Rissoa interrupta and Hiatella arctica. Two specimens of Amphioxus lanceolatus. A few of Chiton ruber on the stones.	„
1840.	Off Douglas Head, Isle of Man.	1	15–18	N.	16	4	13	9	...	(Ab.) Trochus tumidus, Acmæa virginea, Chiton asellus, Pectunculus glycimeris, alive, and dead shells of Trochus montacuti. Corallines. Ascidians.	„
North Wales Province.											
1844.	Off Doolas, Anglesey.	5	12	m. gr.	2	4	8	8	3	(Ab.) Valves of Nucula nucleus. Corallines plentiful. Sabella.	M'A. & E. F.
1844.	East entrance of the Menai.	½	7	sh. s.	1	3	8	12	2	(Ab.) Ostrea edulis, Syndosmya alba. In this dredge were taken dead shells of Patella vulgata and Littorina littorea, also a single Helix aspersa covered by Balani, and inhabited by a living Pagurus. Corallines. Near this point the dredge brought up at the same depth great quantities of Modiola modiolus, mostly dead.	„

NORTH WALES.

1844.	Channel between Puffin Island and Anglesey.	½	12	sh&gr	1	1	6	5	5	(Ab.) Valves of Pecten sinuosus and opercularis, and Ostrea edulis. Many Crustacea.	"
1844.	Off Ormeshead.	2	12	s.	1	1	3	10	2	(Ab.) Donax trunculus, alive and dead; and dead valves of Tellina solidula and fabula, Syndosmya alba and prismatica, and Solen ensis. Two more dredges were taken at four and eight miles off Ormeshead, with the same products in similar proportion.	"
1844.	Off Ormeshead.	½	7	gr.	6	2	8	5	4	(Ab.) Trochus ziziphinus (mostly the smooth variety), Modiola modiolus, Mactra elliptica, and Echinus miliaris. A frond of Laminaria. Crustacea.	"
1844.	Off Moelfre, on the north-east coast of Anglesey.	5	12	s.	3	1	6	6	1	(Ab.) Dead valves of Tellina donacina and Venus ovata; also Ophiura albida.	"
1844.	Caernarvon Bay, middle part.	6	9½	s.&gr. s.	4	...	4	4	1	(Ab.) None. Most specimens (5) of Trochus magus, alive, and valves (10) of Artemis exoleta. Echinus miliaris.	"
1844.	Caernarvon Bay, off west coast of Anglesey.	5	12	...	2	...	1	9	2	(Ab.) Dead valves of Venus striatula, Syndosmya alba, Solen siliqua and Pecten opercularis; Psammobia ferroensis next in number. A single valve of Cytherea chione.	"
1844.	Roscolyn Bay.	¼	10	st. & oyst.	12	2	8	...	3	(Ab.) Ostrea edulis. The univalves were species of Trochus, Cypræa, Buccinum, Nassa, Fusus, Murex and Pleurotoma. Flustra foliacea.	"
1844.	Caernarvon Bay.	6	12	gr.	7	2	5	2	4	(Ab.) Trochus magus and Ophiothrix rosula. Sertulariæ and Crustacea. A Doris.	"
1844.	Off Point Linas, Anglesey.	1½	14	st.	3	1	1	4	...	(Ab.) Dead valves of Nucula nucleus and Anomia, and shells of Natica Alderi; Trochus ziziphinus var. Lyonsii alive in plenty. Serpulæ.	"
1844.	Off Point Linas, Anglesey.	1	16½	st. & sabel.	4	...	3	2	...	(Ab.) Anomia undulata, Hiatella rugosa and Trochus ziziphinus, alive. Nucula nucleus, dead. The stones coarse and incrusted with Pomatoceros tricuspis and Tubularia muscoides.	"
1844.	Off Point Linas, Anglesey.	3	20	gr.	5	3	5	6	2	(Ab.) Trochus ziziphinus, alive. Anomia, Ostrea, Pectens and Modiola, dead. Ophiothrix rosula. Corallines.	"
1844.	North of Point Linas, Anglesey. The mud slimy and gray, and mingled with dead Modiolæ and gravel.	2	20	m.	...	3	1	3	1	(Ab.) Modiola modiolus, dead, a few alive. Dead valves of Nucula nucleus and Syndosmya alba. Ophiothrix and Corallines. Actinea senilis.	"
1848.	South-west part of Caernarvon Bay.	1–2	15–20	gr. st.	12	15	24	5	...	(Ab.) Nucula nucleus, Modiola modiolus, Crenella marmorata, Ostrea edulis, Pecten varius, Trochus ziziphinus and tumidus, alive. One Amphioxus lanceolatus.	"

North Wales (*continued*).

Date.	Locality.	Miles from shore.	Depth.	Ground.	Univalves. Alive.	Univalves. Dead.	Bivalves. Alive.	Bivalves. Dead.	Echinodermata.	Remarks, especially noting the animals most abundant.	Observer.
1844.	Off north coast of Anglesey.	8	25	gr. st. sab.	5	6	14	2	2	(Ab.) Pecten varius, Modiola modiolus. Crenella discrepans and marmorata, Hiatella rugosa, Nucula nucleus, Trochus ziziphinus and tumidus, alive; and dead valves of Pecten sinuosus and opercularis, and Trophon Bamfius. Balanus scoticus. Ascidians.	M'A. & E. F.
1844.	Off north of Anglesey; Point Linas bearing south; Middle Mouse, south-west; West Mouse, west.	8	30	gr. & sab.	3	4	2	2	1	(Ab.) Modiola modiolus in nests of stones and byssus. A rolled fragment of Purpura lapillus.	"
1844.	Off Middle Mouse, north of Anglesey; in a line of strong current; slate and serpentine pebbles.	7	30	st.	1	2	3	3	1	No species abundant. Modiola modiolus and Crenella discrepans invested by nests. A rolled Purpura lapillus. Corallines.	"

South Wales and Bristol Channel.

Date.	Locality.	Miles from shore.	Depth.	Ground.	Univalves. Alive.	Univalves. Dead.	Bivalves. Alive.	Bivalves. Dead.	Echinodermata.	Remarks, especially noting the animals most abundant.	Observer.
1848.	Milford Haven.	...	3–6	m.	5	3	3	2	4	Comatula. Compound Ascidians.	"
1848.	Milford Haven.	...	8	gr. m.	4	4	5	8	1	Solen pellucidus, abundant.	"
1848.	Milford Haven.	...	10	gr. m.	7	4	8	6	4	Scalaria clathratulus. Northern limit of Calyptrea sinensis.	"
1848.	East side of Lundy Island.	½–2	7–25	s.&gr.	22	25	27	20	?	(Ab.) Mactra elliptica, Venus ovata, Pectunculus pilosus. Trochus ziziphinus and tumidus, and Murex crinaceus; alive and dead shells of Diplodonta rotundata, Rissoa parva and Turritella terebra.	"

Cornwall and Devon.

Date.	Locality.	Miles from shore.	Depth.	Ground.	Univalves. Alive.	Univalves. Dead.	Bivalves. Alive.	Bivalves. Dead.	Echinodermata.	Remarks, especially noting the animals most abundant.	Observer.
1846.	Reach of Dartmouth.	...	7–12	m. & st.	15	18	10	12	6	(Ab.) Nassa reticulata, Turritella terebra, Syndosmya alba, Corbula nucleus, Nucula nucleus, alive; dead shells of littoral mollusks. Comatula. Numbers of Cynthia aggregata. Chemnitzia fenestrata, new.	"
1846.	Off the mouth of the Ex.	4	10	s.	1	3	7	6	1	(Ab.) Solen pellucidus, Syndosmya alba, Nucula nucleus, Anomia aculeata, Mactra subtruncata, and Ophiothrix, all alive.	"

1846.	Off Teignmouth.	4	12	s.	3	3	1	5	3	(Ab.) Turritella communis, alive; valves of Montacutæ and Nucula nucleus, dead.	”
1846.	Off Teignmouth, clean sand.	15	25	s.	...	...	2	...	...	Corbula nucleus and Venus striatula only, both sparingly.	”
1846.	Between Penzance and Land's End.	3	20–25	sh. s.	11	23	18	27	11	(Ab.) Venus fasciata (remarkably brilliant in colour), Pectunculus glycimeris, Rissoa striata; alive and dead shells of Solecurtus candidus, Lutraria hians. Arca tetragona. Next in quantity were Tellina donacina, Venus ovata, Nucula nucleus, Pecten similis and sinuosus, Trochus tumidus, Rissoa parva, Aporrhais pes-pelecani, Nassa incrassata and Cypræa alive; many rarities. Zoophytes and Crustacea numerous.	”
1846.	Penzance Bay.	1	27	r.	2	1	1	7	...	(Ab.) Eupomatus on stones.	”
1846.	Off Plymouth Bay, half-way to Eddystone; gravelly sand, with a little mud.	...	20–25	gr. s.	3	6	5	18	9	(Ab.) Dead shells of Pecten opercularis, Venus ovata, Nucula nucleus and Turritella communis. Corallines. Ophiura texturata and Ophiothrix.	”
1848.	Off the Eddystone.	11	30–35	s. gr.	7	2	12	12	...	(Ab.) Balani, Dentalium tarentinum alive, Turritella communis dead. (R.) Adna anglica.	M'A.
1846.	Off Dartmouth.	8	27	s.	6	1	6	9	3	(Ab.) Dentalium tarentinum, Solen pellucidus, Nucula nitida alive; and dead shells of Syndosmya alba and Mactra subtruncata.	M'A. & E. F.
1847.	Sixty miles north-north-west from Land's End.	60	50	s.	2	17	8	14	?	(Ab.) Cardium suecicum and Corbula nucleus, alive. Among the species of which fewer were taken were Syndosmya intermedia and Nucula decussata.	M'A.
1847.	Sixty-five miles from Land's End.	65	50	s.	...	9	3	20	?	The species taken alive were Syndosmya prismatica, Corbula nucleus and Venus ovata. Among the dead shells were Neæra cuspidata, Lucina borealis, Psammobia ferroensis, Perna ingens, Scalaria Treveliana, Trochus millegranus and Ditrupa.	”
	Dorset and Hants.										
1846.	Bay of Weymouth.	1½	7	st. w.	15	2	9	2	3	(Ab.) Trochus cinereus and magus, Phasianella pulla, Acmæa virginea, Rissoæ, Chiton asellus, Crenella discrepans and marmorata, Anomia aculeata. Crustacea and Ascidiæ.	”
1846.	Bay of Weymouth.	2	7	m.	4	...	8	3	3	(Ab.) Turritella terebra and Corbula nucleus, and Ophiothrix, alive. Next in numbers Trochus cinereus, Syndosmya alba and Mactra subtruncata.	”
1846.	Bay of Weymouth.	2½	12	m.	4	...	1	2	2	Crustacea plentiful. Nassa pygmæa and Lucina flexuosa among the live shells; Lucinopsis undata and Tellina squalida among the dead.	”
1846.	East Bay of Portland.	1–2	8–12	m.g.n.	19	7	19	9	...	(Ab.) Venus ovata, Nucula nucleus, Crenella discrepans, Trochus tumidus and Anomia ephippium, alive. Cerithium reticulatum, dead.	”
1846.	West Bay of Portland.	2	15–20	gr.	15	13	20	17	9	(Ab.) Venus fasciata and ovata, Nucula nucleus, Crenella marmorata, Pecten opercularis, Anomia squamata, Chiton asellus, Trochus montacuti and ziziphinus; Ascidiæ, Serpulæ and Ophiothrix, alive. Crustacea and Corallines abundant. Zoanthus Couchii. Melibœa and Tritonia.	M'A. & E. F.
1848.	West Bay of Portland.	1	15–17	gr&st.	5	6	15	12	...	(Ab.) Pecten opercularis, Nucula nucleus, Pholas parva, Pholadidea papyracea, Saxicava rubra, Nassa incrassata, alive. Turritella communis, dead.	M'A.
1850.	Weymouth Bay, off Lulworth Cove.	1	15	n. st.	10	...	7	9	2	(Ab. alive.) Trochus tumidus, Acmæa virginea, Emarginula rosea, Pecten opercularis and Anomia; and, dead, Tapes virginea. Among frequent species were Arca lactea, Pecten varius and Buccinum undatum, Pleurobranchus plumula; eight species of Ascidia, Zoanthus Couchii, Crustaceans, Balani and Sponges.	E. F.

Table II.

Enumeration of the depths, &c. at which Species of Testaceous Mollusca were taken by the Dredge on the Southern and Western Coasts of England.

Species.	Around the Isle of Man.			North Wales.			South Wales and Bristol Channel.			Cornwall and Devon.			Dorset and Hants.			Range.
	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	
Gasteropoda.	fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.
Chiton asellus	15–18	....	gr.	7	....	gr.	10	....	m.& gr.	15	....	gr.	....	....	....	1–30
	20–25	....	sh.	7	....	w. & st.	7–25	....	s. gr.	20–27	....	s. st.	15	....	sh. n.	
				12	....	m. gr.	....	....	....	27	....	gr.	20–25	....	gr. st.	
				15–20	....	gr.										
				20	....	gr.										
													15	....	n.	0–30
Chiton fascicularis	15–18	....	nul.	15–20	....	gr.	10	....	m. gr.	....	....	....	15	....	gr.	
	20–25	....	sh.	....	....	....	....	....	....	....	....	....	20–25	....	gr.	
Chiton lævis	15–18	....	nul.	....	....	....	7–25	....	s. gr.	*	....	....	15	....	n.	7–30
	20–25	....	sh.													
Chiton ruber	7–12	....	n. st.	....	....	....	12	....	m. st.	....	....	....	7	....	w.	0–12
Chiton cancellatus	15–18	....	n.	....	....	....	....	....	....	*	....	....	*	....	....	10–30
	20–25	....	sh.													
Dentalium entalis	25	....	sh.	....	12	m. gr.	3–6	....	m. st.	27 ?	....	sand.	15	....	gr.	5–50 ?
							7–28	....	s. gr.	50 ?						
Dentalium tarentinum	....	....	....	....	....	....	7–25	....	s. gr.	8–12	....	s. gr.	*	....	....	7–20
										(12–15)	....	n.				
Patella pellucida	*	....	....	*	....	....	*	....	....	*	....	....	*	....	....	0–12
Emarginula Mulleri	15–18	....	n.	....	12	m. gr.	7–25	....	s. gr.	....	20–25	sh. s.	....	....	....	7–30
	20–25	....	sh.	20	....	gr.	....	....	....	....	27	st.				
				25	....	st.										
				30	....	gr.										
Emarginula rosea	....	....	....	....	....	....	*	....	....	....	20–25	sh. s.	15	....	gr. n.	7–20
													20	....	sh.	
Acmæa virginea	17–25	....	sh. n.	*	....	....	*	....	....	*	....	....	15	....	n.	0–30
Fissurella reticulata	15–18	....	n.	....	12	m. gr.	8	....	m. st.	15	....	w.	15	....	w. n.	7–30
	25	....	sh.	15–20	....	gr.	....	7–25	s. gr.	....	20–25	sh. s.				
					25	st.										
Pileopsis hungaricus	25	....	sh.	....	15–20	....	7–25	....	s. gr.	....	20–25	sh. s.	*	....	....	10–50
											50	s.				
Calyptræa sinensis	....	....	....	....	....	....	12	....	m. st.	7–12	....	st.	....	....	....	2–12

				....	15–20	....	7–25	....	s. gr.	....	7–12	st.	7	....	w.	0–20
											20–25	sh. s.	8–12	....	s. gr.	
													15	....	gr.	
Adeorbis subcarinatus	....	....	....	....	....	....	....	12	m. st.	....	7–12	st.	....	8–12	s. gr.	0– ?
								7–25	s. gr.	....	50					
Trochus striatus	....	....	....	....	....	....	....	....	....	....	15	s. sh.	....	....	....	0–15
Trochus exiguus	....	....	....	....	....	....	....	....	....	*	....	....	7	....	w.	0–12
														8–12	gr.	
Trochus Montagui	15–18	....	n.	....	12	m. gr.	....	3–6	m. st.	*	....	....	8–12	....	s. gr.	3–30
	25	....	sh.	15–20	....	....	7–25	....	s. gr.	....	....	....	15	....	gr.	
				20	....	gr.										
Trochus millegranus	*	....	....	....	15–20	gr.	....	7–25	s. gr.	....	50	s.	....	15–17	gr.	10–50
					30	gr.										
Trochus granulatus	25	....	sh.	....	....	....	12	....	m. st.	*	....	....	15	....	gr.	10–30
Trochus ziziphinus	15–18	....	n.	7	....	s. gr.	8	....	st. m.	7– 2	....	st.	....	....	....	0–50
	25	....	sh.	12	....	s.	10	....	st. m.	20–25	....	s. sh.	15	....	gr. n.	
				14, 16	....	st.	12	....	st.m.gr	27	....	s.	20	....	sh.	
				15–20	....	gr.	7–25	....	s. gr.	50						
				25	....	st.										
				30	....	gr.										
Trochus tumidus	15–18	....	m.	7	....	gr.	10	....	st.	7–12	....	st.	7	....	w.	3–50
	20–25	....	sh.	14,16,20	....	st.	12	....	gr.	20–25	....	s. st.	8–12	....	s. gr.	
				15–20	....	gr.	7–25	....	s. gr.	30–35	....	s. gr.	15	....	gr. n.	
				25	....	st.				50						
Trochus magus	15–18	....	m.	....	....	....	9	....	m.	....	....	....	7	....	w.	3–20
							12	....	gr.	....	....	....	8–12	....	s. gr.	
														15	gr.	
													15	....	sh. n.	
Trochus cinerarius (chiefly	7–12	....	s.	7	....	gr.	3–6	....	st. w.	7–12	....	st.	7	....	w. m.	0–15
Littoral and Laminarian)							8	....	st. m.	....	....	....	15	....	gr. sh.	
							10	....	st.							
							12	....	gr.							
Trochus pusillus	....	....	....	....	....	....	....	....	....	(10)	....	....	....	....	....	?
Cæcum trachea	....	....	....	....	....	....	....	....	....	*						
Cæcum glabrum	....	....	....	....	....	....	....	....	....	*						
Turritella communis	*	....	....	....	7	....	10	....	st. m.	7–12	....	st. m.	7	....	m.	5–50
								7–25	s. gr.	12	....	s.	8–12	....	s. gr.	
										20–25	....	sh.	....	15–17	gr.	
										30–35	....	gr. s.				
										27	50	s.				

Species.	Around the Isle of Man.			North Wales.			South Wales and Bristol Channel.			Cornwall and Devon.			Dorset and Hants.			Range.
	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	
GASTEROPODA.	fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.
Cerithium reticulatum								8	st. m.		7–12	st. m.		8–12	s.	0–50
											20–25	sh. s.				
											50	s.				
Cerithium adversum								12	st. m.		20–25	sh. s.				5–30
								7–25	s. gr.							
Aporrhais pes-pelecani	*			*			3–6	12	st. m.		20–25	sh. s.	*			3–50
											27	s.				
											50	s.				
Scalaria clathratulus								10	st. m.		20–25	sh. s.				5–25
								7–25	s. gr.							
Scalaria communis								8	st. m.		7–12	st. m.	*			7–30
								7–25	s. gr.		20–25	sh. s.				
Scalaria Treveliana											50	s.				50
Scalaria Turtonii				*			*			*						?
Cerithiopsis tubercularis								12	st. m.	*				15–17	gr.	5–30 ?
								7–25	s. gr.							
Chemnitzia fenestrata											7–12	st. m.				3–12 ?
Chemnitzia elegantissima	*			15–20		gr.		8	st. m.				8–12		s. gr.	1–20
													15–17		gr.	
Chemnitzia Jeffreysii					? 15–20	gr.	12		s. m.		7–12	st. m.				3–15 ?
Aclis simillima											7–12	st. m.				3–15 ?
Eulimella scillæ?										50		s.				50
Chemnitzia fulvocincta								7–28	s. gr.							7–30
Odostomia unidentata, and other species								7–25	s. gr.				8–12		s. gr.	1–30
Eulima distorta		30	gr.							*						15?–30
					12	s.										
Eulima polita		15	n.		15–20	gr.	10		st. m.	20–25	20–25	sh.		15	gr.	7–30
								7–25	s. gr.							
Eulima subulata	25		sh.					7–25	s. gr.	*						10–30
Littorinæ	*			*	7		*			*	7–12		*			lit.
Lacunæ	*			*			*			*			*			0–15
Rissoa interrupta	7–12		s.	*			*				7–12		7		w.	0–12
Rissoa parva		15–18	n.	*				12	st.	7–12			7		w.	0–30
								7–25	s. gr.	20–25		sh. s.	8–12		s. gr.	
[illegible]								12	st.	*						

Rissoa costata					10–20	gr.		12	st.		20–25	sh. s.	*			1–20
								7–25	s. gr.							
Rissoa labiosa								8	st. m.				1–5		w	0–5
Rissoa semistriata								12			7–12	st.				1–12
								7–25	s. gr.							
Rissoa striata	7, 20		n.		15–20		12			20–25		sh. s.				0–30
								7–25	s. gr.		7–12	st.				
Rissoa calathus											15–20	sh.	*			?
Rissoa punctura	20		s.					7–25	s. gr.		7–12	st.		15	gr.	5–50
											20–25	sh. s.				
											50	s.				
Rissoa Beanii					15–20					*						5–20
Rissoa crenulata								7–25	s. gr.		20–25	sh. s.		15	gr.	5–50
											50	s.				
Rissoa zetlandica										*						?
Rissoa striatula							*			*				7	w.	0–7
Natica monilifera	*				12	s.		10	st.	*				15	gr.	0–10 ?
				7	12	gr.										
Natica Alderi	20–25		sh.	12		s.	9		m.		20–25	sh. s.	*			7–30
				14–20		st.		10	st.							
				15–20		gr.		7–25	s. gr.							
Natica Montagui	20		sh.							30–35		s.				15–50
											50	s.				
Lamellaria perspicua		20	sh.					7–25	s. gr.	*			8–12		s. gr.	5–30 ?
Velutina lævigata	15, 20		sh.		15–20	gr.		3–6		*				15	gr.	5–30
					25	st.										
Purpura lapillus	*			6	30	gr.				*		*				lit.–7
Murex erinaceus	15–18		n.	15–20		gr.	10–12		gr.	7–12		m. st.	15		gr.	5–30
	20–25		sh.	25		st.	7–25		s. gr.	20–25		sh. s.				
Mangelia purpurea	25		sh.				12		gr.					15	gr.	
Mangelia linearis	20–25		sh.					12	gr.	7–12		m. st.		15	gr.	5–30
							7–25		s. gr.	20–25	20–25	sh. s.				
Mangelia nebula							*			*			7		m.	5–20
														15	gr.	
Mangelia costata								10	st.	12	20–25	s.				5–20
											7–12	st. m.				
Mangelia gracilis					12	s.		12	st. m.		30–35	s.				10–40
Mangelia septangularis					15–20	w.					20–25	sh. s.		8–12		5–30
Mangelia coarctata				15–20		gr.								8–12		5–30
Mangelia brachystoma											50	s.				?
Mangelia teres											50	s.				?

Species.	Around the Isle of Man.			North Wales.			South Wales and Bristol Channel.			Cornwall and Devon.			Dorset and Hants.			Range.
	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	
Gasteropoda.	fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms	fathoms.		fathoms.
Trophon Bamfius ...	20–25	...	sh.	12	14–20	gr.	...	...	...	...	...	...	...	...	...	10–30
				15–20	...	gr.										
				15, 25	...	st.										
				30	...	gr.& w.										
Trophon muricatus ...	15–18	...	n.	...	15–20	gr.	7–25	...	s. gr.	...	50	s.	15	...	gr.	15–50
	20–25	...	sh.													
Bela turricula ...	20	...	sh.	...	7	gr.	10	3–6	st.	...	...	...	...	...	...	5–30
								7–25	s. gr.							
Bela rufa ...	15	...	n.	16	...	st.	...	...	...	...	20–25	sh. s.	7	8–12	m.	5–30
				20	15–20	gr.										
Lachesis minima ...	...	...	...	...	...	...	...	...	...	...	20–25	sh. s.	...	...	...	0–20
Nassa pygmæa ...	*	...	...	...	...	...	8–12	...	m. st.	7–12	...	m. st.	7	...	w.	1–15
								7–28	s. gr.	...	...	...	8–12	...	s. gr.	
Nassa varicosa ...	...	...	...	...	...	...	...	...	...	...	7–12	m. st.	8–12	...	s. gr.	1–12
													12	...	m.	
Nassa incrassata ...	15–18	...	n.	7	...	w.	10	12	st.	7–12	...	m. st.	7	...	w.	1–40
	20–25	...	sh.	25	...	st.	7–25	...	s. gr.	20–25	...	sh. s.	8–12	...	s. gr.	
				15–20	...	gr.	...	...	...	30–35	...	s. gr.	15	...	gr.	
Buccinum undatum ...	15–18	...	n.	7	...	gr.	9	...	m.	7–12	...	m. st.	8–12	...	s. gr.	0–30
	20–25	...	sh.	12	...	st. gr.	10–12	...	gr. st.	10, 12	...	s.	15	...	gr. n.	
				20	...	gr. m.	7–25	...	s. gr.	20, 25	...	s.				
Fusus antiquus ...	...	15–18	n.	7	...	gr.	9	...	m.	...	...	...	...	...	...	5–30
	20–25	...	sh.	25	...	st.	10	...	st.							
				30	...	gr.	12	...	gr.							
Fusus gracilis ...	20–25	...	sh.	...	...	...	10	...	st.	...	27	s.	...	...	...	5–50
							7–25	...	s. gr.	...	50	s.				
Marginella lævis ...	...	*	...	...	...	...	...	7–25	s. gr.	...	20–25	s.	...	...	...	0–30
Cypræa europea ...	...	15–28	n.	...	25	st.	10	...	st. m.	7–12	...	m. st.	8–12	...	s. gr.	0–30
							7–25	...	s. gr.	20–25	...	sh. s.	15	...	gr.	
Volva patula ...	...	...	...	...	...	...	...	...	...	20–25	...	sh. s.	...	...	...	?
Volva acuminata ...	...	...	...	...	...	...	...	...	...	...	50	s.	...	...	...	?
Tornatella tornatilis ...	*	...	...	*	...	...	*	...	...	*	...	...	*	...	...	0–?
Bulla lignaria ...	*	...	...	3–6	...	w.	...	7–25	s. gr.	...	20–25	sh. s.	...	...	...	2–50
										50	...	s.				
Bulla truncata ...	...	...	...	...	...	...	...	12	st. m.	...	7–12	st. m.	...	...	...	3–30
								7–25	s. gr.	...	20–25	sh. s.				

Bulla cylindrica							7–25		s. gr.	27		s.				3–30
Bullæa aperta	*						7–25		s. gr.	12		m.				1–30
										8–12		s. gr.				
ACEPHALA.																
Pholas parva													15–17		gr.	0–20
Pholas crispata					12	gr.								15	gr.	0–20
Pholas dactylus														15–17	gr.	0–20?
Pholadidea papyracea													15–17		gr.	0–20
														15	gr.	
Gastrochæna modiolina													15–17	8–12	gr.	5–20
Hiatella arctica	7–12		s.	12		gr.	10		st.	7–12		st.	15		gr. n.	0–30
	20–25		sh.	15–20		gr.	7–25		gr. s.		27	gr.	20		sh.	
Hiatella rugosa				7		st.	9		m.	20–25		st.	15–17		gr. n.	0–30
				10		gr.	12		gr.							
				16		st.										
				25		st.										
Mya truncata		20–25	sh.		7	st. gr.		8	gr.	3	7–12	st.				0–30
Neæra cuspidata										50						50
Corbula nucleus				12		m. gr.	8		m.	7–12		n.	7		m.	5–50
								7–25	gr. s.	10–12		s.	7–12		s. gr.	
										25		s.	15		gr.	
										50		s.				
Sphænia Binghami	12		n.	15–20		gr.	3–6		m. st.				8–12		s. gr.	5–30
	20		sh.	25		st.										
Pandora obtusa	20		n.	12		gr.	10		m. st.		27	s.	7		m.	
							7–25		gr. s.	30–35		s.	8–12		s. gr.	
											50	s.	15		gr.	
Lyonsia norvegica	20			12		st.	7–25		gr. s.	10		s.		15	gr.	5–30
											20–25	sh. s.				
Cochlodesma prætenue	*										20–25	sh. s.	*			1–30
Thracia phaseolina								3–6		*						3–30
Thracia villosiuscula										*						?
Thracia distorta	18		n.				*				20–25	s. sh.				0–30
Thracia pubescens										*						?
Thracia convexa											20–25	s. sh.				?
Solen siliqua					12	s.		12			7–12					0–10?
Solen ensis	20	25	sh.		12	s.		12	s. m.	10		s.				5–20?
Solen pellucidus	18		n.	12		s.	8		m.		7–12	s.	7		m.	5–50
								7–25	s.	20–25		gr. s.	8–12		s. gr.	
										27		s.				
										50	50	s.				
Solecurtus coarctatus	25		sh.	*							25	s.		15	gr.	10–30

Species.	Around the Isle of Man.			North Wales.			South Wales and Bristol Channel.			Cornwall and Devon.			Dorset and Hants.			Range.
	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	
ACEPHALA.	fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.
Solecurtus candidus		25	sh.								20–25	sh. s.				20–30
Diodonta fragilis								12	st. m.							
Psammobia vespertina				*			*			*				15	gr.	0–15 ?
Psammobia costulata											20–25					20–30
Psammobia tellinella	20–25		sh.					8	m.	20–25		sh. s.		15	gr.	5–40
							7–28		s.		20–25	s.				
											30–35	s.				
Psammobia ferroensis	20–25		sh.		12	s.		8	m.		20–25	sh. s.		8–12	st.	5–50
											27	s.				
											50	s.				
Tellina crassa	*				15–20	gr.		9	m.		20–25	sh. s.	15–17		gr.	0–30
								12	m.		27					
								7–25	s.							
Tellina tenuis	*				7	s.										0–3 ?
Tellina fabula	*				7	s.										
					12	s.										0–3 ?
Tellina solidula	*				12	s.					27	s.				0–3 ?
Tellina donacina (with pygmæa).	*				12	s.	7–25		s.	20–25		sh. s.		8–12	st. m.	5–40
											27	r.		15	gr.	
											30–35	s.				
Tellina incarnata	*						*			*				7	m.	0–15 ?
Tellina balaustina										*						?
Scrobicularia piperata				*				3–6	m.							0–7
Syndosmya prismatica	20		sh.		12	s.		12	m.	50		s.	*			1–50
								7–28	s. gr.							
Syndosmya intermedia										50		s.				50
Syndosmya alba	20		sh.	7, 12		s.	10–12		m.	7–12		m. s.	7		w.	1–30
				12		m.	12		st.	10		s.	8–12		s. gr.	
				15–20		gr.	7–25		s. gr.					15	gr.	
				25		st.										
Donax trunculus	*			12	7	s.	*			*			*			0–12
Ervilia castanea											20–25	sh. s.				?
Mactra elliptica	15–18		n.		7, 12	s.		12	gr.	8–12		s. gr.	7		m.	5–40
	25		sh.		12	gr. m.	7–25		s. gr.	20–25		s. sh.	8–12		s. gr.	
				30		gr. st.					30–35	s.				
Mactra solida				*			*						15		gr.	0–15

Mactra stultorum					7	s.	*			*			*			0–12
Mactra subtruncata	*			12 15–20	12	s. gr.	*			10		s.	7		m.	0–20 ?
Lutraria elliptica		15–18	n.		12	gr.		12	m.	20		s.	8–12		s. gr.	0–20
Lutraria oblonga							*			*	7–12		20		sh.	0–25 ?
Tapes virginea	15, 25		sh. n.	12		gr.		12	m.		20–25	sh. s.	*			
Tapes pullastra	*			*			*			7–12	20	sh. s.	15		gr.	10–30
Cytherea chione								12	s.			sh.	*			0–7
Venus striatula	15, 25				7–12	s.	10	7–25	s. m. s. gr.	25 30–35	20–25 20–25 27	sh. s. sh. s. s. s.	8–12	15	s. gr. gr.	10–20 ? 0–50
Venus casina	15–18 20–25		n. sh.	15–20		gr.		12 7–25	s. m. s. gr.		50 20–25 30–35	s. sh. s. s.		15	gr. n.	7–50
Venus fasciata	15–18 20–25		n. sh.	12–20	7	s. gr.	9–10 7–25	8	m. st. s. gr.	50 20–25 30–35	50 27	s. sh. s. s.	8–12 15		s. gr. gr.	7–50
Venus ovata	15–18 20–25		n. sh.	12–20		m. gr.	10 7–25		m. gr. s. gr.	20–25 20–25 30–35 50	50 7–12 27	s. m. gr. sh. s. gr. st. s.	8–12 12 15–20	15	s. gr. m. gr. n.	7–50
Venus verrucosa				*				10	m. gr.		50 7	s. gr.		8–12	s. gr.	0–10
Artemis exoleta	15–18 20–25		n. sh.				9 12		m.	20–25		sh. s.	*			0–50
Artemis lincta	18		n.		12 15–20	s. m.		12 7–25	gr. m. s. gr.		50 20–23 20–35	s. sh. s. s.	*			5–50
Cyprina islandica		15–18	n.	*			*				50 30–35	s. s.	*			5–50
Circe minima							10 7–25		s. m. s. gr.		20–25	sh. s.				5–30
Astarte sulcata	15–18 20–25		n. sh.	15–20		gr.		12	m. st.		20–25 20–25	sh. s. s.				12–50
Astarte triangularis	20		m. st.	15–20		gr.		12 7–25	m. st. s. gr.		50 20–25 20–28	s. sh. s. s.				10–30
Isocardia cor																?
Cardium edule	*				7–12	s.				*						lit.

Species.	Around the Isle of Man.			North Wales.			South Wales and Bristol Channel.			Cornwall and Devon.			Dorset and Hants.			Range.
	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	
ACEPHALA.	fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.
Cardium echinatum	*			*				10–12	m.		27–35	s.	*			5–50
								7–25	s. gr.		50	s.				
Cardium pygmæum							8		m. st.	7		m. st.	*			
Cardium fasciatum	*							2–6	m.	7–12		m. st.	8–12		s. gr.	
							7–25		s. gr.	20–25		sh. s.		15	gr.	
										27	27	s. r.				
Cardium norvegicum	25		sh.		12	m.		8	m.		15–17	gr. s.		15	n.	7–50
								20–25	sh. s.							
							20–35		s.	50		s.				
									s.							
							7–25		s. gr.							
Cardium nodosum											20–25	sh. s.		7	m.	5–20 ?
													3–12	15–17	gr.	
Cardium rusticum											30–35	s.				0– ?
Cardium suecicum										50		s.				50
Lucina leucoma										*				8–12	s. gr.	0–15
Lucina borealis	12, 25		sh.		10			12	gr.		50	s.				10–50
Lucina flexuosa		12	n.	*			*			7–12		m.	12		m.	5–50
										50		s.				
Lucina spinifera										30–35	27	s.				15–30 ?
Lucina divaricata											20					?
Lucinopsis undata		12, 20	sh.		10	s.	*				27	s.		7, 12	m.	5–30
Diplodonta rotundata					12	s.		12	m.		20–25	sh. s.	*			7–30
							7–25		s. gr.							
Montacuta ferruginosa							*			7–12		m. st.				0–12
Montacuta substriata	25		sh.				*			20–25		sh. s.				10–30
Montacuta bidentata					12	s.										?
Galeomma Turtoni										1		w.				0–2
Kellia suborbicularis	25		sh.	25		gr.		7–25	s. gr.	20–25		sh. s.	15		n.	10–40
										30–35		s.				
Kellia rubra	*				12	s.	*			7		st.	*			0–7
Lepton squamosum					12	s. m. gr.		7–28	s. gr.		20–27	s.		8–15	s. gr.	5–30 ?
Pinna ingens							*			1	50	s.	*			0–50
Mytilus edulis	*				7	s. gr.	10		m. st.		7–12	m. st.	*			0–10

[illegible]						st.	7–25		s. gr.	*						5–25
					12	m. gr.										
				20	15–20	gr.					7–12	m. st.		8–12	s. gr.	
				25		m.								15	gr.	
Modiola modiolus	7–12		s.	7–25		gr.	9		m.		27	s.	*			0–30
	15–18		n.	30	14	st.	12		gr.							
	25		sh.	20		m.		7–25	s. gr.							
Modiola phaseolina								7–25	s. gr.		20–25	sh. s.				?
Modiola barbata							12		m.	*			7		w.	2–15
														15	gr.	
Crenella discors	*			7–12		s.	*				50	s.	12		s. gr.	0–30
				15–25		gr.							7		w.	
				30		st.										
Crenella rhombea										*				15–17	st.	
Crenella marmorata	*			15–25		gr.	12		m.	7–12		m. st.	7		w.	0–30
							7–25		s. gr.		20–25	sh. s.	8–12		s. gr.	
													15		gr.	
Arca tetragona	25		sh.				20				20–25	sh. s.				20–30
							27		s. gr.							
Arca lactea					15–20		7–25		s. gr.		20–25	sh. s.	15		gr. n.	10–50
											50	s.				
Pectunculus glycimeris	15–18		n.	15–20		gr.	12		m. st.		50	s.		15	gr. n.	5–50
							7–25		s. gr.							
Nucula radiata							12		m. st.	*						5–30 ?
							7–25		s. gr.							
Nucula nitida	15–18		n.				12		m. st.	20–25		sh. s.	15–17		gr.	5–30
							7–25		s. gr.	27		s.				
Nucula nucleus	20–25		sh.	7–12		s.	9		st.	7–12		m. st.	7		w. m.	5–50
				12		m. gr.	10		m.	20–25	20–25	gr. s.	8–12		s. gr.	
				14–30		gr.	7–28		s. gr.	30–35		s.	15		gr. n.	
				25		st.				50		s.				
Nucula decussata										50		s.				50
Leda caudata	*			15–20		gr.		12	m.	20			8–12		s. gr.	8–30
				25		st.										
Lima hians	25		sh.		12	m. gr.		7–25	s. gr.		20–25	sh. s.				0–30
Lima Loscombi	15–20		n.	20		gr.	10		gr.		20–25	sh. s.		15	gr.	0 ?–40
	25		sh.	25		st.		7–28	s. gr.		30–35	s.				
Lima subauriculata		15	n.								20, 28	s.				15–30
Pecten similis	25		sh.								20–25	sh. s.				20–50
											30–35	s.				
											50	s.				

Species.	Around the Isle of Man.			North Wales.			South Wales and Bristol Channel.			Cornwall and Devon.			Dorset and Hants.			Range.
	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	
ACEPHALA.	fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.
Pecten maximus	20–25	....	sh.	....	15–20	gr.	....	7–25	s. gr.	....	7–12	gr. st.	....	8–12	s. gr.	10–30
											20–25	sh. s.	....	20	st.	
											30–35	s.	....	15	n.	
Pecten opercularis	15–18	....	n.	7–12	....	gr. s.	7–25	....	s. gr.	7–12	....	m. st.	7	....	m.	5–50
	20–25	....	sh.	25	14–16	st.	....	....	....	10	....	s.	8–12	....	s. gr.	
				20	30	gr.	....	....	....	20–25	....	sh. s.	15	....	gr. n.	
										20–25	....	gr. s.				
										27–35	....	s.				
											50	s.				
Pecten sinuosus	20–25	....	sh.	25	14, 30	st.	10	....	st.	7–12	....	m. st.	*	....	....	10–30
				12–20	....	gr.	7–25	....	s. gr.	20–25	....	sh. s.				
										27–35	....	s.				
Pecten varius	20–25	....	sh.	7–12	....	gr.	10	....	st. m.	*	....	....	7	....	gr.	3–30
				15–20	....	gr.	....	7–25	s. gr.	....	....	....	15	....	gr. n.	
				25	....	st.										
Pecten tigrinus	15–18	....	n.	15–20	25	gr.	....	8	m.	20–25	....	sh. s.	15–17	....	gr.	5–50
	20–25	....	sh.	....	....	....	7–25	....	s. gr.	30–35	....	s.				
											50	s.				
Pecten striatus	....	....	....	....	....	....	....	....	....	....	50	s.	....	....	....	50
Ostrea edulis	15–18	....	n.	7–12	....	s.	9	12	m. st.	....	7–12	m. st.	8–12	....	s. gr.	0–30
	20–25	....	sh.	7–20	....	gr.	....	7–25	s. gr.	....	20–25	sh. s.	15	....	gr. n.	
											27	s.				
Anomia ephippium	15, 18	....	n. sh.	7	....	gr.	....	7–25	s. gr.	20–25	....	n.	8–12	....	s. gr.	0–50
										50	....	s.	15	....	n.	
Anomia patelliformis	25	....	sh.	12	....	gr.	....	7–25	s. gr.	....	....	....	....	....	....	0–50
				14, 20	....	gr.										
				25, 30	....	st.	....	....	....	50	....	st.				
Anomia aculeata	15–18	....	n.	....	....	....	8	....	w.	10	....	s.	7	....	w.	0–30
											20–25	sh. s.	15	....	gr.	

Enumeration of the depths, &c. at which species of Echinodermata were taken by the Dredge on the Southern and Western Coasts of England.

Species.	Around the Isle of Man.			North Wales.			South Wales and Bristol Channel.			Cornwall and Devon.			Dorset and Hants.			Range.
	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	
	fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.
Comatula europea	25		sh.				5–6		st. w.	7–12		s. gr.				1–30
										25		sh. s.				
Ophiura texturata	*			12		s. gr.	10		st. m.	20–25		s. gr.				7–30
Ophiura albida	20–25		sh.	12		s. s. gr.				20–25		s. gr.	7		m.	7–30
										25		n.	15–20		gr.	
										27		s.				
Ophiocoma rosula	15–18		n.	7		s.sh.gr.	3–6		w.	7–12		st. m.	7		m.	0–30
	20–25		sh.	10		st.	10		st. m.	10		s.	15–20		gr.	
				12		s.				25, 27		s.				
				20		gr.										
				30		gr.										
Ophiocoma neglecta	*			*									7		w.	0–20
													15–20		gr.	
Ophiocoma granulata	25		sh.										20–25		s. gr.	15–30
Ophiocoma bellis	25		sh.													15–30
Ophiocoma chiagii?													7		w.	7–?
Uraster rubens	20–25		sh.	7, 12		gr.				7–12		st. m.	7		m.	0–30
				10		st.				20–25		s.	15–20		gr.	
Uraster spinosa	18		n.							20–25		s.				10 ?–30
Solaster papposa	20–25		sh.	12		s. gr.	8		st. m.	20–25		s.	7		m.	7–30
				25		gr.							15–20		gr.	
Cribella oculata	20–25		sh.	25		gr.	3–6		w.							0–30
							10		st. m.							
Palmipes cartilagineus	20–25		sh.							20–25		s. gr.				20–30
Goniaster Templetoni	20–25		sh.													20–30
Asterias aranciaca	*			12		s.										1–20
Luidia fragillissima	20–25		sh.													7–30
Echinus milliaris	7		gr.	7, 9, 12		gr.	12		gr.	7–12		s. gr.	15		n.	0–30
	20		sh.	20									12		gr.	
													27		s.	

Species.	Around the Isle of Man.			North Wales.			South Wales and Bristol Channel.			Cornwall and Devon.			Dorset and Hants.			Range.
	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	
	fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.
Echinus sphæra	7, 20	....	sh.	....	....	....	....	....	....	20–25	....	n.	20–25	....	s. gr.	0–30
Echinocyamus pusillus	20	....	sh.	7, 20	....	gr.	....	....	....	20–25	....	n.	....	....	....	7–30
				10, 12	....	st.										
Spatangus purpureus	20	....	sh.	12	....	s.	....	....	....	20–25	....	n.	....	....	....	7–30
Amphidetus roseus	20	....	sh.	12	....	s.	....	....	....	20–25	....	n.	....	....	....	10–30
Cucumaria pentactes	20	....	sh.	....	....	....	....	....	....	20–25	....	n.	20–25	....	s. gr.	1–25
Cucumaria Montagui	....	....	....	....	....	....	....	....	....	7–12	....	s. gr.	....	....	....	7–12
Thyone Portlockii ?........	....	....	....	....	....	....	....	....	....	7–12	....	s. gr.	....	....	....	7–25
										20–25	....	n.				
Thyone papillosa........	....	....	....	....	....	....	12	....	gr.	....	....	....	15	....	gr.	1–15
Sipunculus Bernhardus	20	....	....	....	....	....	12	....	gr.	....	....	....	....	....	....	1–
Sipunculus Forbesi	....	....	....	25, 30	....	gr.										

Table IV.

Analysis of Dredging Papers drawn up on the Western and Northern Coasts of Scotland.

The depth is given in Fathoms.

Clyde District.

Date.	Locality.	Miles from shore.	Depth.	Ground.	Univalves.		Bivalves.		Echino-dermata.	Remarks, especially noting the animals most abundant.	Ob-server.
					Alive.	Dead.	Alive.	Dead.			
1839.	Rothsay Bay.	¼	7	m.	2	...	4	...	6	(Ab.) Corbula nucleus. (R.) Brissus lyrifer and Ophiocoma filiformis, the last very abundant.	E. F. & J. G.
1839.	Loch Ranza, Arran.	¼	6	m.	...	...	2	3	1	(Ab.) Syndosmya alba alive, Lucina flexuosa dead.	"
1839.	Lamlash Bay, Arran.	¼	15–20	sh.	12	12	10	22	9	No species very numerous. Serpulæ.	"
1839.	Whiting Bay, Arran.	¼	12	sh.	...	...	...	2	...	Only some valves of Pecten maximus and quantities of dead shells of Mactra subtruncata.	"
1845.	Loch Fyne.	1	20	m.	2	1	...	...	1	Emarginula crassa, dead.	M'A. & E. F.
1845.	Loch Fyne, near Tarbet.	1½	30	gr. st.	6	3	11	5	2	(Ab.) Dentalium entalis, Chiton asellus, Terebratula Caput-serpentis, Crania, Nucula nucleus, Astarte sulcata, all alive, and dead valves of Pecten danicus. Placostegus on stones.	"

1841.	Sana Island off Mull of Cantyre.	2	40	sh.	5	10	5	20	5	(Ab.) Dead valves of Lima hians, Pectunculus glycimeris, Pecten opercularis, Venus casina and Mactra elliptica. 26 species of Zoophytes and Bryozoa.	Hyndman & Getty.
1845.	Loch Fyne, below Tarbet.	...	40	s. m.	8	...	7	3	3	(Ab.) Astarte sulcata, Leda caudata, Nucula tenuis and Thyone fusus alive, and numbers of valves of Pecten danicus. (R.) Neæra costulata, new to Britain. No Corallines. Ear-bones of fish.	M'A. & E. F.
1845.	Loch Fyne, near Tarbet; dark mud.	...	50	m. st.	3	3	7	1	1	(Ab.) Dead valves of Pecten danicus.	"
1845.	South-west of Loch Ranza.	½	60	m.	1	...	1	...	...	Nucula nucleus and Rissoa abyssicola.	M'A.
1845.	Half-way between Loch Ranza and Skipnish.	...	40	s. & st.	3	2	8	4	1	Cup sponge. Placostegus, Cuvieria. Pecten islandicus. Dredged here dead valves.	"
1845.	Loch Fyne, middle of the Loch below Tarbet; fine brownish mud.	...	100	m.	1	...	4	3	2	(Ab.) Nucula tenuis and Leda caudata, both alive; dead valves of Nucula nucleus. (R.) Rissoa abyssicola and Lima subauriculata alive. Cardium suecicum dead. Brissus lyrifer and Ophiocoma filiformis. Crustacea.	"
1850.	Entrance of Loch Fyne, West Kyles of Bute.	¼–½	5–10	n.	17	4	8	17	?	(Ab. spec.) Dentalium entalis, Chiton asellus, Natica Alderi, Acmæa virginea, Trochus cinerarius and tumidus, Lima hians and Serpulæ, all alive; also Rissoa interrupta and Cerithium reticulatum dead. Acmæa testudinaria taken alive.	"
1850.	Glen Luce Bay.	½	15	gr.	12	13	8	16	?	(Ab. spec.) Modiola modiolus, Anomia ephippium and Chiton asellus alive; also dead, Emarginula Mulleri, Acmæa virginea, Trochus cinerarius and tumidus, Rissoa calathus and striata, Fusus Banffius. Balani and Serpulæ plentiful. Among remarkable species are Lepton squamosum and Trichotropis.	"
	HEBRIDES.										
1845.	Oban.	½	15	w.	11	4	16	2	6	(Ab.) Chiton asellus, Acmæa virginea, Pecten opercularis, Lima hians, Nucula nucleus, Anomia, Syndosmya alba, Crenella marmorata and Ascidiæ. Pecten niveus moored to Laminariæ here. Balani plentiful.	"
1845.	North of Oban, between Kerrera and Lismore; mud of bottom dark and slimy.	½–2	15	m.	4	2	13	7	4	(Ab.) Lima subauriculata, Corbula nucleus (in myriads), Syndosmya intermedia, Lucina spinifera; and dead shells of Aporrhais pes-pelecani, Nucula nucleus, Pecten opercularis, and especially Venus ovata. (R.) Isocardia cor alive. Pennatula and Pavonaria here; a single fish, Callionymus.	"
1845.	Off Mull.	...	15–20	s. gr. m	7	...	7	2	2	(Ab.) Chiton asellus, Turritella terebra, Astarte sulcata, Corbula nucleus, Nucula nucleus.	"
1845.	Off Armadale, Sound of Skye.	½	15–20	st. m. w.	10	1	6	6	...	(Ab.) Crania norvegica and Terebratula Caput-serpentis alive on stones. (R.) Nucula pygmæa. Ascidiæ, Zoophytes.	"
1845.	East of Mull.	...	-20	st. gr.	6	1	8	...	1	(Ab.) Chiton asellus, Terebratula Caput-serpentis, Leda caudata, Astarte sulcata. Ascidiæ, Ophiothrix rosula.	M'A. & E. F.

HEBRIDES (*continued*).

Date.	Locality.	Miles from shore.	Depth.	Ground.	Univalves. Alive.	Univalves. Dead.	Bivalves. Alive.	Bivalves. Dead.	E ci o-dermata.	Remarks, especially noting the animals most abundant.	Ob-server.
1846.	Between Lochnell Point and Lismore.	¼–1	20–30	s.m.gr & st.	...	2	12	7	2	(Ab.) Anomia undulata, Corbula nucleus, Nucula nucleus, Venus ovata, Terebratula Caput-serpentis, Crania norvegica, Odostomiæ, all alive. (R.) Pavonaria and Cuvieria.	M'A. & E. F.
1845.	Off Armadale, Sound of Skye.	1½	25	m. & st.	8	3	10	11	2	(Ab.) Chiton cinereus, Crania, Terebratula Caput-serpentis (very numerous), Anomia undulata and Leda pygmæa alive; and dead valves of Venus ovata and Nucula nucleus. (Z.) Sarcodictyon.	,,
1846.	North end of Island of Lismore.	¼–½	20–30	s.	7	4	17	4	...	(Ab.) Crenella marmorata, Corbula nucleus, Venus ovata, Terebratula Caput-serpentis, Crania, Turritella communis alive; and dead valves of Pecten danicus.	,,
1845.	Sound of Raza, just within western entrance; dark brown slimy mud.	1½	30	st. & m.	4	...	5		...	(Ab.) Dead shells of Turritella terebra, and valves of Venus ovata, Anomia and Nucula decussata. Cellepora cervicornis plentiful on the stones.	,,
1847.	Off Croulin Island, in the Sound of Skye.	¼	30	st. & m.	7	4	15	11	...	(Ab.) Terebratula Caput-serpentis, Megathyris cistellula, Lucina ferruginosa, Crania, all alive. Valves of Pecten islandicus and Arca raridentata.	M'A.
1845.	Sound of Skye in front of Kelmore House.	¼–½	15–40	s.	1	...	1	5	...	....	,,
1845.	Same locality, a mile more to the north.	¼–½	18	m.s.st	8	2	11	4	1	(Ab.) Anomiæ and Terebratula Caput-serpentis. (R.) Propilidium ancyloides, Leda pygmæa and Pecten danicus. Cuvieria.	,,
1845.	North of Raza; dark slimy mud.	2–3	150	m.	1	...	1	...	...	Rissoa abyssicola and Nucula polii.	M'A. & E. F.
1845.	East of Raza.	...	100	m.	...	...	...	...	1	Brissus lyrifer. No trace of shells.	,,
1845.	Entrance of Sound of Skye.	1	40	m.	...	...	1	...	3	(Ab.) Nucula pygmæa. (R.) Sepiola and Orbis taken here.	,,
1845.	Entrance of Sound of Skye.	½	20–30	st. m.	3	1	...	1	...	Cemoria, Sarcodictyon.	,,
1846.	Off Copenhaw Head, Skye.	4	40	s. gr.	8	3	13	9	...	(Ab.) Crania, Anomia, alive. Dead valves of Pecten danicus and Pecten islandicus here.	M'A.
1848.	Half-way between Skye and Raza at the entrance of the Sound; dark brown slimy mud.	1	45	m.	...	3	1	...	...	(Ab.) Dead shells of Turritella communis and valves of Nucula polii. Astarte sulcata and Natica grœnlandica.	M'A. & E. F.

1845.	Off Armadale, Sound of Skye.	2–3	40	m.	6	6	6	12	2	(Ab.) Turritella terebra, Dentalium entalis. Lucina ferruginosa next in number. Astarte crebricosta (dead) here. Fragments of Patella vulgata and Littorina obtusata.	"
1845.	Off east coast of Mull.	...	40–80	gr.	2	...	2	...	...	Cemoria, Propilidium, Nucula nucleus and Astarte sulcata. Plumularia pennatula the only zoophyte.	"
1845.	Off east coast of Mull.	½	90–95	gr. s.	5	4	10	5	4	(Ab.) Leda caudata alive, and dead valves of Venus ovata. Plumularia myriophyllum, Balani and Serpulæ.	"
1850.	Loch Kishon (north side).	50–100 fathoms	20–25	gr. s.	22	5	22	6	7	(Ab. alive.) Nucula nucleus, Cardium fasciatum, Crania, Terebratula Caput-serpentis, Chiton cinereus, Trochus millegranus; also Crenella marmorata, Nassa incrassata, Dentalium entalis and Echinus sphæra. (Rare sp. alive.) Thracia convexa, Syndosmya intermedia, Arca raridentata, Leda pygmæa, Pecten danicus, Chiton latus, Cemoria, Pilidium fulvum, Eulimella MacAndreæ, Natica sordida, Margarita undulata?, Trophon Barvicense, Clavatula Boothii, and Trichotropis borealis. Character of the assemblage, boreal.	M'A.
1850.	South coast of Mull, west of Loch Spettive.	0–½	12–16	s. st.	12	6	11	8	?	(Most frequent sp.) Corbula nucleus, Astarte sulcata, Nucula nucleus, Chiton cinereus, Trochus tumidus and Lacuna vincta. Of the rarer and more peculiar shells Cochlodesma prætenue, Chiton lævis, Scalaria Turtoni and Trichotropis were taken.	"
1850.	Kyleakin, north entrance of Sound of Skye.	0–¼	4–5	w.	16	1	26	3	5	No particular species prevailing. The majority belonged to the families Veneridæ and Trochidæ. The species most characteristic of the depth belonged to Tellina, Trochus and Margarita; those of the region were Margarita carnea, Astarte elliptica and Crenella decussata. Among soft Mollusks, Aplysia and Polycera occurred. Laminariæ were plentiful.	M'A. & E. F.
1850.	Oban, off Dunolly Castle.	0–½	10–12	m.s.& w.	8	6	9	11	3	Sp. most abundant was Turritella terebra. Among local species were Syndosmya intermedia, Fusus Barvicensis, Pecten danicus (dead), and Clavatula rufa. Balani abundant. Ophiocoma chiagii, Plumularia cristata, Spongia suberia. Ascidiæ. Red fuci.	"
1850.	Oban, off Dunolly Castle.	0–½	12–15	gr. m. st.	5	8	10	12	3	Sp. abundant. Astarte sulcata. Local forms alive, Lucinopsis undata, Neæra cuspidata: dead, Nucula polii and Clavatula brachystoma. Zoophytes, Pavonaria and Corallines.	"
1850.	Entrance of Portree Harbour, Skye.	0–¼	20	m.	2	2	5	10	1	The only abundant shell was Turritella communis dead, a few alive. Of local species there were Syndosmya intermedia, Cardium Loveni and Clavatula brachystoma alive; Thracia convexa, Lucinopsis undata, Solecurtus antiquatus and Pecten striatus dead. Ophiocoma filiformis (veris) plentiful. No Articulata.	"
1850.	West of Tobermorey Mull.	0–¼	22	gr. s.	1	4	7	6	3	(Ab.) Alive, Astarte sulcata; local forms, Brachiopoda. The only gasteropod was Chiton asellus. Balani common.	"
1850.	Aros Bay, Sound of Mull.	1	25	st. s.	9	7	12	8	6	(Ab.) Alive, Modiola modiolus, Pecten opercularis, Nucula nucleus, Chiton asellus. Cyprina islandica of full size but dead; large Fusi and Buccinum undatum alive. Ascidiæ, Sponges, Alcyonium, Sarcodictyon, Crabs (Ebalia).	"
1850.	Aros Bay, Sound of Mull.	1¼	30	st.	1	...	3	1	3	Crania and Terebratula, Modiola modiolus, Chiton asellus and Balani.	"
1850.	Off Croulin Island.	¼–1	25	gr.&s.	11	9	8	9	9	No species remarkably abundant; many local forms, as Chiton Hanleyi, Leda pygmæa, Arca raridentata, Lucina ferruginosa, Cemoria, Trichotropis alive, and Pilidium fulvum, Eulima bilineata, Eulimella MacAndreæ, Marginella lævis dead. Among the Echinoderms were Asteropsis, Cuvieria squamata, and a large Fistularia. Among Zoophytes, Sarcodictyon, several Annelides, including Aphrodite, and Placostegus. Four or five species of Ascidia.	"

Hebrides (*continued*).

Date.	Locality.	Miles from shore.	Depth.	Ground.	Univalves. Alive.	Univalves. Dead.	Bivalves. Alive.	Bivalves. Dead.	Echinodermata.	Remarks, especially noting the animals most abundant.	Observer.
1850.	Off Croulin Island.	½	30	st. gr.	1	2	6	3	4	The living univalve was Trochus ziziphinus. Arca raridentata and Pecten similis were among the bivalves alive, and large Cyprina dead. Three species of Ascidiæ and a new Sarcodictyon.	M'A. & E. F.
1850.	Off Loch Laigh, Ross of Mull.	2	30–40	m.	4	5	5	8	1	None plentiful; general assemblage very boreal; characterized by Syndosmya intermedia, Lucina ferruginea, Rissoa abyssicola, Cardium Loveni, Bullæ, Brachiopoda. Alecto petasus.	"
1850.	Off Sound of Scalpa.	1½	30–40	st. & sh.	6	3	5	10	8	None peculiarly plentiful. Brachiopods, Chiton Hanleyi, Leda pygmæa, Arca raridentata, Lucina ferruginosa, Trichotropis and large and waved Buccinum undatum alive. Pecten islandicus and danicus (probably fossils), and Pilidium fulvum dead. Asteropsis and Palmipes, Comatula, Ascidiæ, Serpulæ.	"
1850.	Off Loch Staffin, Skye.	4	35	gr.	1	6	4	15	...	None abundant: among the living species were Circe, Venus fasciata, Crania, and Chiton asellus. Flustra truncata and another.	"
1850.	Off Loch Laigh.	2½	50	m. & st.	...	...	2	1	...	Terebratula Caput-serpentis in abundance; two specimens of Anomia undulata; a dead valve of Astarte sulcata. Retepora and Cynthia echinatâ alive.	"
1850.	Off Croulin Island.	1	50	m. & gr.	...	3	2	12	1	The living species were Lima subauriculata, Leda pygmæa and Ophiocoma chiagii. The dead bivalves were almost all pleistocene fossils; as Pecten obsoletus and danicus, Astarte elliptica and crebricostata, Leda oblonga and thraciæformis (first time in Europe), and large form of Hiatella rugosa. An otolite of a fish was taken.	"
1850.	Off the Storr, Skye.	2	70	m.	2	...	1	5	1	The living species taken were Ophiocoma chiagii, an Odostomia, Turritella terebra (the only abundant dead shell, a few living), and Syndosmya intermedia. Nucula decussata and Thracia convexa among the dead valves.	"

North Western District.

Date.	Locality.	Miles from shore.	Depth.	Ground.	Univalves. Alive.	Univalves. Dead.	Bivalves. Alive.	Bivalves. Dead.	Echinodermata.	Remarks, especially noting the animals most abundant.	Observer.
1850.	Off Stornoway.	...	8	w.	4	1	3	1	3	Cerithium reticulatum and Comatula.	"
1850.	Off Stornoway.	0–½	18	s.&gr.	4	2	4	9	3	Most abundant species were Dentalium entalis alive, and Artemis lincta dead. Of scarce species, Syndosmya prismatica and Rissoa zetlandica were taken.	"
1850.	Off Stornoway.	0–½	18	st.&n.	5	13	7	12	5	Most abundant species were Chiton cinereus and Venus fasciata; of scarce species, there were Chiton lævis, Trophon Barvicense, Circe minima, Pandora oblonga alive, and Solecurtus antiquatus, Arca tetragona, Erato lævis and Trichotropis dead. Among Radiata were Palmipes and Zoanthus Couchii.	"
1850.	Off Stornoway.	1	18	s. m.	9	2	8	7	2	None abundant. Of scarce species, there occurred alive Pilidium fulvum, Bullæa scabra and Syndosmya intermedia, and a young Buccinum Humphreysianum; and of dead shells, Lucinopsis undata and Bulla cranchii.	"
1850.	Off Stornoway.	1	20	m. s.	3	6	4	14	2	None abundant. Of scarce species, Lucina ferruginosa and Fusus Barvicensis occurred alive; Arca tetragona, Lima subauriculata, Thracia convexa, Solecurtus antiquatus, Leda pygmæa and Bulla cranchii dead.	"

1850.	Off Stornoway.	1	15–20	gr. n.	9	3	2	4	4	None abundant. The bivalves taken alive were Lyonsia and Pecten maximus; a Sepiola was taken; also a Caryophylla.	"
1850.	Off Stornoway.	1	15	n.	3	3	3	9	1	Erato alive.	"
1850.	Off the Shiant Isles.	6	60	s.	...	3	11	1	...	The only living species taken was Leda caudata.	"
1850.	Off Stornoway.	2	30	m.	1	...	5	2	2	Almost all the species boreal; Nucula tenuis, Syndosmya intermedia, Montacuta bidentata, Lucina ferruginea, Solen pellucidus, Brissus lyrifer and Ophiocoma chiagii alive. Nucula sulcata and Lucina sinuosa dead.	"
1845.	Stornoway Lough.	...	4	s. &w.	16	1	2	1	...	(Ab.) Trochus cinerarius, Rissoæ, Lacuna fasciata, Patella pellucida, Cardium nodosum.	M'A.
1845.	Cape Wrath, bearing E.N.E.	9	55	c. s. & st.	5	4	10	4	...	(Ab.) Mactra elliptica, Venus ovata, Tellina donacina, Astarte triangularis, Crenella decussata, all alive.	"
1845.	Cape Wrath, bearing S.S.E.	5	50	gr.	5	12	9	15	...	(Ab.) Venus ovata, Circe minima, Mactra elliptica alive. Pecten tigrinus, Tellina crassa (odd valves), Natica Alderi, Trochus millegranus dead. Two valves of Pecten islandicus dredged here.	"
1846.	In the Minch, ten miles east of the Shiant Isles.	10	50	s. & g.	6	1	5	14	2	(Ab.) Leda pygmæa and Dentalium entalis alive. Venus ovata and Cardium suecicum dead. (A.) Orbis and Ditrupa, both dead. (R.) Comatula, nov. sp.	"
	Orkneys and Extreme North-east Coast.										
1839.	Stromness.	...	5–8	s.	6	3	4	6	6	Corymorpha nutans.	E. F.
1839.	Stromness.	...	10–20	s. sh.	14	3	12	7	8	Ascidiæ abundant.	"
1847.	North side of Shapinsha.	1	12	s. n.	18	16	16	16	...	(Ab.) Tellina donacina, Trochus tumidus, Acmæa virginea, Fusus gracilis, alive.	M'A.
1847.	Off Duncansby Head.	15	35–40	s.	8	7	16	7	3	(Ab.) Dentalium entalis and Lacuna crassa alive; and dead shells of Emarginula Mulleri. Ascidia vitrea and others.	"
	The Zetland Isles.										
1845.	Hillswick Voe, west coast; a land-locked creek.	...	4–7	m. w.	7	1	6	7	1	(Ab.) Trochus cinerarius, Turritella communis, Rissoa interrupta, Venus gallina, Modiola vulgaris and Anomia squamula. Balani, Ascidiæ, Ophiothrix fragilis. (Z.) Lucernaria fascicularis. (Pl.) Laminaria digitalis.	M'A. & E. F.
1847.	Balta Sound, Unst.	$\frac{1}{4}$–$\frac{1}{2}$	5–10	s.	15	7	30	2	2	(Ab.) Bulla akera. Most of the bivalves, especially Cardium pygmæum and Crenella decussata.	M'A.

The Zetland Isles (*continued*).

Date.	Locality.	Miles from shore.	Depth.	Ground.	Univalves.		Bivalves.		Echinodermata.	Remarks, especially noting the animals most abundant.	Observer.
					Alive.	Dead.	Alive.	Dead.			
1847.	Bressa Sound, North Entrance.	¼–½	15–30	n.st.s.	22	4	14	9	7	(Ab.) Lucina sinuosa, Chiton asellus, Dentalium entalis, Fusus antiquus, alive; Artemis exoleta and Pullastra virginea dead. Buccinum undatum of large size.	M'A.
1845.	St. Magnus Bay, west of Zetland.	0–½	20	s.	1	1	4	4	1	(Ab.) Dead valves of Mactra elliptica, Syndosmya prismatica and Venus ovata. Cynthia tubularis abundant; also Ophiocoma filiformis.	M'A. & E.F.
1845.	Off Papa Stour in St. Magnus Bay; on a bottom of broken Barnacles and Serpulæ in a strong tideway.	0–¼	25	sh.	...	4	5	12	3	(Ab.) Dead valves of Arca tetragona. (E.) Comatula europæa.	”
1845.	St. Magnus Bay.	1	30–35	s.gr.s.	2	8	3	4	...	Valves of Balani, and fragments of Serpulæ.	”
1845.	St. Magnus Bay.	¼	35	s.	...	5	1	1	...	Valve of Solecurtus strigillatus; a living Syndosmya intermedia; a dead Marginella lævis. Two specimens of the Nudibranch Idalia.	”
1845.	St. Magnus Bay, in a strong tideway.	½	35	sh. gr.	1	...	2	*	...	Fragments of Balani, Serpulæ and broken bivalves in quantity. (Ab.) Venus fasciata alive.	”
1845.	Off Papa Stour.	1½	40	sh. gr.	1	1	4	...	1	(Ab.) Trochus tumidus, Psammobia tellinella, Venus fasciata and Cardium fasciatum. Cynthia tubularis.	”
1845.	Off Fitful Head, a tideway. The gravel here not always rounded.	2	40	gr.	3	5	5	6	1	(Ab.) Chiton cinereus alive. Dead valves of Pectunculus glycimeris and Venus cassina. A single Crania.	”
1847.	Fair Island bearing south-west by south; bottom of coarse sand.	10–12	45	s.	4	18	8	18	1	No species abundant. Cerithium metula and Fusus albus taken. Dead Crania and Terebratula Caput-serpentis.	M'A.
1847.	Off Foula Island, bearing south.	4	45	s.&gr.	4	19	8	18	3	(Ab.) Dentalium entalis and Mactra elliptica alive.	”
1845.	Between Fair Island and Fitful Head. This locality was fertile in rare species, and several new Mollusks and Zoophytes were added to the British fauna on this occasion.	12	50	gr. sh. c.	6	10	9	9	4	(Ab.) Dentalium entalis and Emarginula Mulleri; dead single valves of Tellina donacina, Venus ovata, Mactra elliptica, and Psammobia tellinella. Dead specimens of Pleurotoma purpurea and Natica Alderi. (M.) Meliboea and Eolis; nine species of Tubuligerous Annelides; two Sponges; nine Hydroid and Helianthoid Zoophytes; above fifteen Bryozoa.	M'A. & E.F.

1845.	Off Mousa Island, east coast.	1½	50	gr. m. s. & r.	5	12	9	11	3	(Ab.) Dentalium entalis, Chiton asellus and Natica Alderi alive. Dead valves of Venus striatula, Venus ovata, Pecten tigrinus, Anomiæ and Psammobia tellinella. Shelled Annelides abundant. Virgularia and Caryophyllia. Tubularia indivisa abundant.	,,
1845.	On the Ling Bank, forty miles west of the mainland of Zetland.	40	50	s. st.	15	11	13	11	7	No species particularly abundant; many rare forms; shelled Annelides numerous; Crania; a peculiar variety of Natica Alderi. Comatula and Cuvierla squamata. Balani, Zoophytes, numerous.	,,
1845.	Fair Island, bearing south-east half east, ten miles.	10	60	hard.	2	2	6	...	...	(Ab.) Modiola modiolus.	M'A.
1845.	St. Magnus Bay.	...	60	s.	6	4	5	8	1	(Ab.) Dentalium entalis, Trophon turricula and Psammobia ferroensis alive. Cynthia tubularis.	M'A. & E. F.
1847.	Fishing-ground, west of Zetland.	20	60	c. s. st. gr.	8	8	11	22	2	(Ab.) Dentalium entalis; also many specimens of Crania and Aporrhais pes-pelecani. (A.) Ditrupa and Serpula serrulata here. Many rare species.	M'A.
1845.	Off west coast of mainland.	8	70	m. s. & gr.	3	10	8	16	3	Dentalium entalis alive, and dead valves of Lucina sinuata; most plentiful species. Also numerous dead valves of Venus striatula and ovata, Artemis exoleta and Psammobia tellinella. Modiola nigra taken alive here, and Pecten danicus dead.	M'A. & E. F.
1847.	East-south-east from Bressa.	21	70–80	f. s.	3	2	4	8	3	(Ab.) Dentalium entalis alive, and valves of Lucina borealis. Syndosmya intermedia, Neæra cuspidata, Cardium Loveni, all taken alive, and Aporrhais pes-carbonis dead. Caryophyllia, Virgularia, and an Actinea alive.	M'A.
1847.	East of the Noss, Zetland; bottom of sand with some small stones.	25	70–80	s. st.	...	1	3	3	...	This and the next observation were made during a strong wind and heavy sea, and are consequently imperfect.	,,
1847.	East of the Noss, Zetland.	40	70–80	s. st.	1	...	...	5	...	The living Univalve was Chiton Hanleyi.	,,
1845.	Off Burra Island, on west coast.	10	80	m. s.	9	7	9	13	4	(Ab.) Dentalium entalis alive; dead shells of Solen pellucida, and valves of Lucina borealis, spinifera and sinuosa, Venus striatula and ovata, Pecten opercularis, Hiatella rugosa, Montacuta oblonga and the fry of Cyprina islandica. Pennatula taken here.	M'A. & E. F.
1845.	Foula Island, bearing south-west. Papa Stour, south-east by south.	10 ?	80	s.	3	2	4	11	1	(Ab.) Dentalium entalis alive, and the annelid Ditrupa coarctata, but dead. Three species of Astarte, including the new Crebricostata all taken, but as dead valves. Cynthia tubularis.	,,
1845.	West coast of Zetland; Foula, bearing N.N.W.; Somburgh Head, S.E. by S.	10–12	80	s.&gr.	1	3	1	9	...	(Ab.) Dead shells of Dentalium entalis.	,,
1845.	Off west coast of Zetland.	10	80	m. s.	13	6	16	7	4	(Ab.) Dentalium entalis, Chiton asellus, Venus striatula, Lucina spinifera alive. Dead shells of Bulla cylindrica, Pleurotoma turricula and linearis; valves of Pecten opercularis, Venus ovata, Artemis lincta, Lucina borealis and sinuata, Montacuta oblonga, Astarte sulcata, Psammobia ferroensis and Nucula nucleus. Nodosaria taken alive.	,,

The Zetland Isles (*continued*).

Date.	Locality.	Miles from shore.	Depth.	Ground.	Univalves. Alive.	Univalves. Dead.	Bivalves. Alive.	Bivalves. Dead.	Echinodermata.	Remarks, especially noting the animals most abundant.	Observer.
1845.	Between Foula Island and the Ling bank.	...	80	c.s. & st.	4	8	5	3	...	(Ab.) Venus ovata alive, and dead Ditrupæ in vast quantities.	M'A. & E.F.
1847.	East of Zetland.	30	82	s.	9	13	6	6	3	Eulima subulata var. stenostoma, first taken. Pecten danicus, Syndosmya intermedia, Neæra cuspidata, Cerithium metula, Aporrhais pes-carbonis, Pilidium fulvum, Cemoria noachina, Brissus lyrifer and Placostegus serrulatus give a character to this assemblage; also Echinus norvegicus. Two species of Cypridina taken.	M'A.
1847.	East of Zetland.	30	90	s.	10	9	11	8	5	Assemblage of the same character with the last.	"
1847.	East of Noss.	25	100	s. & s. m.	7	7	7	16	2	The specimens of Venus ovata and striatula and of Turritella communis taken alive on this occasion were remarkably colourless. A single valve of Pecten islandicus was dredged. Several specimens of Aporrhais pes-carbonis.	"

TABLE V.

Enumeration of the depths, &c. at which species of Testaceous Mollusca were taken by the Dredge on the Northern and Western Coasts of Scotland.

Species.	Clyde Province. Alive.	Clyde Province. Dead.	Clyde Province. Ground.	Hebrides. Alive.	Hebrides. Dead.	Hebrides. Ground.	North-Western Province. Alive.	North-Western Province. Dead.	North-Western Province. Ground.	Orkneys. Alive.	Orkneys. Dead.	Orkneys. Ground.	Zetlands. Alive.	Zetlands. Dead.	Zetlands. Ground.	Range.
GASTEROPODA.	fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.
Dentalium entalis	5–10	....	n.	....	....	....	....	....	....	....	....	....	15–20	....	n.	5–100
	15–20	....	sh.	15	....	m.	18, 20	....	s. m.	....	....	....	20, 45	....	s.	
	30	....	gr.	25, 30	....	m.	....	....	....	35	....	s.	50	....	s.m. gr.	
				20–25	....	gr. s.										
	40	....	sh.	30	....	s. m.	....	....	....	....	....	....	50–60	....	gr.	
	40, 50	....	m.	40	....	m.	50	....	s. gr.	....	....	....	60	....	s.	
				90–95	....	s. m.	60	....	m.	....	....	....	70	....	m. s.	
													70–80	....	s.	
													80	....	m. s.	
													82	....	s.	
													90	....	s.	
													100	....	s. m.	

Chiton Hanleyi	...	...	...	15	...	w.	...	...	...	...	...	...	70–80	...	st.	15–80
				20, 30–40	...	st.										
				25	...	gr. m.										
Chiton ruber	5–10	...	n.	20–25	...	gr. s.	15	...	w.	6	...	sh.	...	15–20	n.	0–20
										12	...	n.				
Chiton fascicularis	*	...	...	*	...	...	...	...	...	*						
Chiton cancellatus	...	...	...	15	...	w.	4–5	...	w.	...	...	...	...	15–20	n.	2–50
Chiton albus	...	...	...	18	...	m.	...	...	...	...	...	...	...	40	gr.	
				20–25	...	gr. s.										
Chiton asellus	5–10	...	n.	10, 15	...	w.	4–5	...	w.	5–8	64	s.	5–10	...	s.	2–100
	40	...	m.	15–20	...	s. m.	15, 18	...	n. sh.	10	...	sh.	15–20	...	n.	
	15, 30	...	gr.	12, 15–20	...	st.	15–20	...	gr. st.	12	...	n.	40	...	gr.	
				20, 25	...	st.	...	...	...	35	...	s.	45, 50	...	s.	
				30	...	m.	50	...	gr.	...	...	...	50	...	m. gr.	
				20, 35	...	gr.	...	...	...	...	...	...	80	...	m. s.	
				30–40	...	gr. sh.	...	...	...	...	...	...	100?	...	s. m.	
Chiton lævis	40	...	sh.	12–16	...	s. & st.	18	...	n. sh.	12	...	n.	15–20	...	n.	2–50
				30–40	...	st. sh.										
Chiton marmoreus	5–10	...	n.	20–25	...	gr. s.	...	...	...	...	...	...	7	...	w.	1–20
Patella vulgata	...	...	...	...	40	...	...	...	...	...	...	...	...	5–10	w.	lit.
Patella pellucida	*	...	...	5	10	w.	4	...	w.	...	6	st.	15	...	w.	0–15
Acmæa testudinalis	*	5–10	n.	*	...	...	4	...	w.	12	...	n.	...	...	...	0–12
											6	s.				
Acmæa virginea	5–10	...	n.	...	...	...	...	...	...	...	...	...	...	...	...	0–50
	15–20	...	sh.	5, 15	...	w.	4	...	w.	5–8	...	sh.	4–7	...	w.	
	15	...	gr.	20–25	...	gr. s.	18, 20	...	n.	12	...	n.	5–10	25	st.	
													15–20	...	n.	
														50	m. gr.	
Pilidium fulvum	40	50	st.	18	25, 40	m.	18	...	s. m.	...	...	...	...	50	st.	15–90
				20–25	...	gr. s.										
				20–30	40	m. st.	...	...	...	...	...	...	...	50	m. gr.	
				40	...	st.	...	...	...	...	...	...	...	70	m. s.	
				40	20–30	s. gr.	...	...	...	...	...	...	...	82	s.	
Cemoria noachina	30	...	gr.	20–30	20–30	s. m.	...	...	...	80	...	st.	50	...	st.	20–100
				25	...	gr. m.										
	40	...	st.	30	30	m. st.	...	...	...	...	...	...	60	...	st.	
	40	...	m.	40	...	gr.	50	50	gr.	...	...	...	...	45	s.	
														100	s. m.	
Propilidium ancyloides	...	15–20	sh.	18	...	m.	...	...	...	...	...	...	...	...	...	15–100?
				40	90–95	gr.										
					20–30	s.										

Species.	Clyde Province.			Hebrides.			North-Western Province.			Orkneys.			Zetlands.			Range.
	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	
GASTEROPODA.	fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.
Emarginula reticulata		5–10	n.													1–100
	15–20	40	sh.	15		w.	15–20		n.		(25-50)		15–20		w.	
		15	gr.	12, 15–20		st.				12		n.	50–60	50	gr.	
				20, 25, 30		m. st.					35	s.	60		st.	
				25–30		s.					40, 80	st.		45, 50, 60	s.	
				40		s. g.								80	m. s.	
				90–95		s. m.										
Emarginula crassa	25		st.	20	25	gr.										?
Fissurella reticulata	*			*			*						10		sh.	5–40
Pileopsis Hungaricus	5–10		n.				18		n.							5–90
		40	sh.	18	5	m.	55		s.		15			45	s.	
		15	gr.	30	90–95	m.					25, 40			70	m. s.	
					25	st.					80					
Sassurella crispata	*										7	n.	50 ?		st.	?
Trochus ziziphinus	5–10		n.	3, 10, 15		w.		50	gr.	12		n.	5–10	25, 45, 50	s.	0–80
				18		m.		55	s.	(0–50)			50		m. gr.	
				25	35	s. st.							50–60		gr.	
													60		r.	
Trochus alabastrum										(40–80)		st.	50		st.	40–80
														50–60	gr.	
														45	s.	
Trochus millegranus	15–20	5–10	sh.	10, 12, 15		w.	15, 18		n.	(30–100)						5–100
	20		sh.	18, 15–24, 15–20		m.										
	40		sh.	15–20		st.		50	gr.				50		st.	
		30	gr.	20–30, 25	35	m. st.								45, 60	s.	
				25–30		s.										
				90–95		gr. m.										
Trochus montacuti		5–10	n.	15–20	12–14	s. m.	50		gr.	7, 15, 40		st.		35	sh.	5–60
				20–30		m. st.		4	w.	20		sh.		45	s.	
								55	s.		12	n.				
Trochus tumidus	5–10		n.													1–80
	15–20		sh.	12, 15		w.	4		w.				5–10		s.	
		40	sh.	20		st.	55	55	s.	12		n.	18–20		n.	
	15		gr.	20–30	30	m. st.		50	gr.	(4–80)				35	st.	
							15–20		n.					45, 60	s.	
														70	m. s.	

Trochus magus	....	15–20	sh.	4	....	w.	4, 8	....	w.	12	....	n.	4–7	....	w.	1–20
	15	....	gr.	15–20	....	st. m.	....	18	m. s.	....	5–8	sh.				
Trochus cinerarius	5–10	....	n.	4	....	w.	4	....	w.	5–8	....	sh.	4–7	....	w.	0–18
	15	....	gr.	12, 15, 20	....	s. m.	18	....	n.	12	....	n.	3–10	....	s.	
													15–20	....	n.	
Trochus helicinus	*	....	....	4	....	w.	....	....	....	5–8	....	sh.	1	....	w.	0–12
											12	n.	5–10	....	s.	
										*	....	w.				
Trochus undulatus	....	....	....	4, 15	....	w.	....	....	....	*	....	n.	1	....	w.	0–50
				20–25	....	gr. s.	....	....	....	....	....	....	15–20	....	s.	
														35	st.	
														45 ?	s.	
Trochus pusillus	....	....	....	(10–40)	....	....	....	....	....	....	....	....	....	....	....	10–40
Phasianella pullus	15	....	gr.	1	....	w.	....	....	....	....	....	....	....	....	....	0–15
				12–16	....	s. st.	....	....	....	....	12, 15	n.				
Littorinæ	....	15, 20	....	....	25, 40,	....	....	....	....	....	....	....	....	....	....	lit.
					50											
Skenea serpuloides	....	....	....	*	....	....	....	....	....	7	....	c.				
Skenea divisa	....	....	....	*												
Rissoa zetlandica	....	....	....	....	....	....	....	18	s. gr.	(20–50)	....	....	35	70	st.	15–70
										(40–65)						
Rissoa crenulata	....	....	....	*	....	....	*	....	....	*	....	....	....	....	....	?
Rissoa punctura	5–10	....	n.	....	....	....	....	....	....	....	....	....	....	....	....	7–60
	15	....	gr.	....	....	....	50	....	gr.	....	7	sh.	15–20	....	n.	
							55	....	s.	....	12, 15	n.	....	45	s.	
											50	sh.				
Rissoa abyssicola	60	....	m.	150	30	m.	....	....	....	....	....	....	....	50 ?	s.	30–100
	100	....	m.													
Rissoa striata	....	15, 40	gr. sh.	....	40	n.	*	....	....	4	....	w.	50	....	gr.	0–80
				30	25	m.	....	....	....	....	12	n.	....	15–20	n.	
														30–35	sh.	
														45, 80	s.	
Rissoa rufilabrum	....	....	....	*	....	....	....	....	....	....	....	....	15–20 ?	....	n.	0–15 ?
Rissoa parva	*	....	....	....	35	....	....	55	s.	4	....	w.	5–10	25, 45	s.	0–50
											40	....	50		gr.	
Rissoa interrupta	5–10	....	....	*	....	....	*	....	....	4	....	w.	4–7	....	w.	0–10
Rissoa vitrea	....	....	....	15, 30	40	m.	....	....	....	....	40	sh.	....	....	....	15–40
Rissoa costata	....	15	gr.	*	....	....	....	....	....	(7)	....	c.	....	....	....	0–15
										(15)	....	c.				
Rissoa labiosa	....	....	....	*	....	....	....	....	....	....	....	....	....	....	....	0–5
Rissoa semistriata	....	....	....	*	....	....	....	....	....	....	....	....	....	....	....	?
Rissoa ulvæ var. Barleei	....	....	....	20–40	....	m.										

Species.	Clyde Province.			Hebrides.			North-Western Province.			Orkneys.			Zetlands.			Range.
	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	
GASTEROPODA.	fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.
Lacuna crassior	*									(0–50)						0–50
										35		s.				
Lacuna fasciata		15–20	sh.	12–16		w.	4		w.	7		w.		5–10	s.	0–15
Lacuna pallidula	*			*			4		w.	7		w.				0–10
Turritella terebra	*			6, 12, 15		w.				(2–100)			4–7		w.	2–100
				15–20,		s. m.	18		n.				5–10		s.	
				15–24												
				15–20		st.				12		n.	80, 90	82	s.	
				20, 25		st. m.	50		s. gr.		5–8	s.	100		s. m.	
				20–30		m. gr.	60		s.		60	s.				
				30		st.										
				20, 45, 70	30, 50	m.										
				90–95		gr. m.										
Cerithium reticulatum	5–10						4, 8		w.					50	s.	0–50
Cerithium metula													82	50, 45	s.	40–90
														50–60	gr.	
Cerithium adversum										(7–40)						?
Aporrhais pes-pelecani	7		m.	15–24	20	m.	18	18	s. gr.	5–8		sh.	4–7		w.	3–100
	15–20		s.	25	18–20	m. st.				7		st.	60	45, 50	s. st.	
	40		m.								12	n.	80, 90	70–80	s.	
		30	gr.										100		s. m.	
Aporrhais pes-carbonis													90	70–80,	s.	70–100
														82		
													100		s. m.	
Scalaria Turtoni		15–20	sh.		12–16	s. st.										
											15	w.				
Scalaria Treveliana											40	st.	80	70–80	s.	30–100
										80–100		m.		82, 90	s.	
														100	s. m.	
Scalaria grœnlandica											35	s.				?
Scalaria communis		5–10	n.													?
Eulima polita	20		gr.	25		gr. m.		18	s. m.	(7–50)		sh. st.	15–20		n.	7–50
								50	gr.				35		gr. s.	
													45		s.	
Eulima distorta	*									12		n.	15–20		n.	10–90
													90	82	s.	
										(20–50)						

Eulima subulata	*			*							12	n.	5–10		s.	5–100
													80	45, 90	s.	
										80		m.				
Eulima var. stenostoma														82	s.	
Eulima bilineata	*				25	n.							*			?
Aclis ascaris														80, 82	s.	?
Aclis nitidissima	*			40		m.										?
Chemnitzia elegantissima	*			15		w.	*									0–15
Chemnitzia fulvocincta	40		m.	15–20		st.	18		n.	(20–50)		s.	80		s.	7–100
				8, 10–12	15	w.							90		s.	
					25, 30	m. st.							40			
Chemnitzia rufescens							*						80 ?		s.	?
Chemnitzia indistincta				*									40			?
Eulimella MacAndreæ	30		gr.	25	25, 30	m. st.	*	18	sh.					60	s.	15–60
		50	m.	20–30		st. gr.										
Eulimella affinis	*				30	m.							40			?
				(70)												
Odostomia spiralis					*								5–10		w.	1–40
													40			
Odostomia unidentata				20–30		m. s.	52		s. gr.					80	s.	?
				30		m.							40			
Odostomia plicata	7		m.	20–30		s.		18	s. gr.							?
				40	15–24	m.					40	sh.	5–10		w.	
Odostomia eulimoides				20–30		s.	*						40			?
Odostomia notata													40			
Odostomia nitida				*												
Odostomia dubia				*												
Odostomia albella				*												
Odostomia acuta	*			30		m.										
Odostomia turrita	*												40			
Odostomia conoidea	*			10		w.										
Odostomia obliqua				*												
Odostomia insculpta	*			*			*						40			
Odostomia interstincta				*			*						5		r.	
Odostomia decussata				*									5–40			
Cerithiopsis tuberculare	*			*												
Natica monilifera	*									4		w.				0–5
Natica Montagui	5–10		n.	4–5	w.											
	15–20	40	sh.	20–25	25	m. st.	15, 18		n. s. m.	15			15–20		n.	3–100
	30		gr.		20–30	st.				25		r.	50, 60	45	s.	
	40		m.	25	45	s. gr.				50			50–60		gr.	
				40		sh.	50		gr.	40–100		st.	82	80	s.	

Species.	Clyde Province.			Hebrides.			North-Western Province.			Orkneys.			Zetlands.			Range.
	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	
GASTEROPODA.	fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.
Natica Alderi	5–10	…	n.	4–5	…	w.	…	…	…	…	…	…	…	…	…	3–80
	15, 20	…	gr.	15–20	…	st.	4	…	w.	…	…	…	4–7	…	w.	
	40	…	m.	20, 25	…	m. st.	58	…	s.	…	12	n.	5–10	20	s.	
		40	sh.	30, 40	…	m.	…	50	gr.	…	35	s.	15–20	…	n.	
				48	25	s. gr.	15	18	n. s. m	…	…	…	35, 45	45	s.	
													50	…	st.	
													60, 80	…	s.	
													80	50–60	s. gr.	
Natica helicoides	…	…	…	…	…	…	…	…	…	…	7, 15	n.	…	45	s.	5–40
											12	n.				
											38	s.				
											40					
Natica sordida	20	40	m. sh.	20–25	…	gr. s.	25	20	s. m.	…	…	…	…	90 ?	s.	20–90 ?
Natica grœnlandica	…	…	…	45	…	m.	…	…	…	…	…	…	100 ?	…	m.	?
Lamillaria perspicua	…	…	…	…	25–50	sg. r.	…	…	…	…	15	s.	…	…	…	0–40 ?
											40	s.				
Velutina lævigata	15–20	…	sh.	12–15	10, 12-16	s. st.	15–20	…	n.	…	…	…	10	…	w.	7–50
	50	…	m.	20–25	…	gr. s.	…	…	…	7–15	…	w.	15–20	…	n.	
											12	n.	50	…	st.	
											35	s.	50	…	m. gr.	
														45	s.	
Velutina flexilis	20	…	st.	*	…	…	…	…	…	10	…	w.	…	…	…	10–20
										15	…	s.				
Trichotropis borealis	…	…	…	…	…	…	…	15, 18	n.	…	…	…	…	…	…	5–100
	15–20	…	st.	15	…	w.	…	50	gr.	…	7–15	st.	6	35	st.	
		15	gr.	20	…	st.	…	…	…	12	…	n.	15–20	…	n.	
				20–25	45	s. gr.	…	…	…	…	40	st.	50–60	40	gr.	
					30–40	st. sh.	…	…	…	…	40–80	st.	70	…	s.	
													80	90	s.	
Murex erinaceus	…	15	gr.	…	25	s. st.	…	…	…	…	…	…	…	…	…	10–90
					90–95	gr.										
Fusus gracilis	5–10	…	n.	…	…	…	…	…	…	…	…	…	…	…	…	5–100 ?
	20	…	gr.	25	…	s. st.	…	…	…	…	…	…	15–20	…	n.	
	40	…	sh.	…	…	…	…	…	…	12	…	n.	45, 60	…	s.	
										35	…	s.	80, 82	…	s.	
													90 ?	100 ?	s.	

	15	15–20	sh.	15–20	10, 60	s. m.	*									10–80
		40	sh.	20–30		m. st.				12		n.	15–20		n.	
										35		s.	45–60		s.	
													80		s.	
Fusus decemcostatus													70–80		gr.	
Fusus albus														100	s. m.	?
Fusus propinquus					50	m.								45	s.	?
Fusus islandicus																?
													50		st.	40–60
Buccinum undatum	5–10	15–20	n. sh.	4,5,12–16		s. st.	25	80	gr.				50	45, 50	s.	
				25									15–20		n.	0–80
		40	sh.	12–15	30, 40	st. m.					5–8					
	15		gr.											5–10	s.	
														45, 60	s.	
														80		
Buccinum Humphreysianum				*			18		gr. s.					82	s.	
Nassa reticulata	15		gr.													?
Nassa incrassata	50		m.													0–15
		15–20	sh.	20–25	22, 45	s. gr.	15–20	18	n.	(0–50)			5–10	4–7	s. w.	0–60
	15	30	gr.	25		s. st.		50	gr.				50		st.	
													50–60		gr.	
Trophon Bamfium				12–16	25	s. st.							60		r.	
	15		gr.	15–20		s. m.		50	gr.				50		sh.	10–60
				20–30	20	m. st.				12		n.	50–60	40	gr.	
				20, 45		s. gr.								45	s.	
					15	w.										
Trophon Barvicense	*			15–20		st.	18		n.		15		50		sh.	15–100
				20–30		m. s.	20		s. m.		40		80	70, 82	s.	
				25		m. st.							100		s. m.	
				90–95		s. w.										
					15	w.										
Trophon muricatum	*			40		m.		50	gr.				70		s.	15–70
					45	s. gr.		18	n.					40	gr.	
Bela turricula				4, 5		w.										
	*			10, 20–30	10	m. st.	50		gr.	(80–100)		w.	60		s.	10–100
				25		m. st.				12		n.	80	60	s.	
				20–30		s.				55		s.		15–20	n.	
Bela Trevellyana					12–16	s. st.										
Purpura lapillus	*				45	r.	*			*	15	s.	*	50–60	gr.	10–60
																0–5

Species.	Clyde Province.			Hebrides.			North-Western Province.			Orkneys.			Zetlands.			Range.
	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	
GASTEROPODA.	fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.
Bela nebula				20–30	80	m. st.								35	st.	15–80 ?
														50–80	s.	
Bela rufa	*			10		s m.										?
Bela gracilis		15–20	st.								? 40	s.				15–40 ?
Bela coarctata	15–20		sh.	10, 40		m.		25	gr. st.							10–30
				25	20–25	s. gr.										
Bela septangularis	*			*												?
Bela brachystoma					12–14	s. m.										10–60
	*				20–30	s.								50–60	gr.	
				20	30, 40	m.										
Mangelia purpurea		15–20	sh.				4		r.		40	sh.		35	m.	3–70 ?
										15		s.		50,	gr.	
														50–60		
														70	s.	
Mangelia linearis	5–10		n.	4–5		w.										3–90
	15–20		sh.	15–20		sh.	4, 8		w.	(7–80)			15–20		n.	
					22	s. gr.	18	55	s. s. gr.	12		n.	50		s. gr.	
							18, 20		n. s. m.	35		s.		45–70	s.	
										40		s.		80, 90	s.	
Mangelia alternata				18		m.					? 40	s.				?
Mangelia costata								55	s.		30–50		80	45, 60	s.	?
											80			50	gr.	
Mangelia Boothii							15		w.							5–60
	5–10		n.					15	gr. st.		15	st.	50		st.	
				20–25		s. gr.								50–60	gr.	
Mangelia scabra														80	s.	?
Mangelia teres	*												50–60		gr.	15–100
										50		s. gr.		35	sh.	
											15, 40	st.		50	st.	
											80	m.		70, 80, 90	s.	
														100	s. m.	
Marginella lævis				*			15, 18	15–20	n.					35	sh.	10–50
											40	st.		45	s.	
											50	st.				

		15	gr.	15	12–16 90–95	w. w. gr. m.		15, 18	n.	7	50	w.	15–20	45 50	n. s. st.	0–50 ?
Tornatella fasciata		15–20	st.		15–24	m.		20	s. m.		15 35 40	s. s. s.	5–10 60	20, 45, 60	s. s.	0–60
Bulla lignaria		15–20	sh.	*				20	s. m.		40, 80	m.		80, 82, 90 15–20 50	s. n. st.	10–50
Bulla cylindrica	40		m.	7		w.	18 18		s. gr. n. s. m.		30, 40 80	m. m.	5–10 60	60, 80 90	s. s.	5–90
Bulla umbilicata	*			*			30 *		m.		7	s.		5–10 15–20 80, 90	s. n. s.	5–90
Bulla truncata	*			*			*									2–15
Bulla obtusa					30	m.				12 7–15		n. w.		5–10	s.	2–30
Bulla hyalina	*			*									7		w.	1–30
Bulla Cranchii		50	m.					18, 20	s. m.					30 60 80, 90 100	s. s. s. s. m.	20–100
Bulla akera										10 15		w. n.	5–10		s.	3–15
Bullæa quadrata										12	40	n.	70 82 100	80	s. s. s. n.	10–100
Bullæa punctata				*									*			?
Bullæa pruinosa	*			70		m.							*			?
Bullæa scabra	*			30	7 30	m. m.	18	20	s. m.				*			5–40
Bulla mammillata	*						*						*			?
Aplysia punctata				4, 5		w.				5–10		w.				0–10
ACEPHALA.																
Hiatella arctica and rugosa	15	30	gr.	4–5 10, 25 30, 40	20 25	s. w. st. m. s. gr.	50	18	gr.				7 15–20 50 80	25 100	w. n. st. s. m.	0–100

Species.	Clyde Province.			Hebrides.			North-Western Province.			Orkneys.			Zetlands.			Range.
	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	
ACEPHALA.	fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.
Mya truncata				12–14		st. m.										0–?
	7		m.	20–25		gr. s.		20	m. s.	12		s.	1		s. gr.	
		5–10	n.	4–5		s. w.		18	s. gr.				5–10	70–80	s.	
														15–30	n.	
														100	s. m.	
Panopæa arctica?														82	s.	60–100?
Corbula nucleus	7		m.	10, 15, 30	25–30	m.	18		s. gr.				5–10		s.	3–80
	20		sh.	7, 12		s.	25, 18,		s. m.				80	80	m. s.	
				20–30			20									
Poromya granulata					50	m.										?
Pandora obtusa	*			20–30	12		18	50	gr.					50	s.	10–80?
				25	10	m. st.								80	s.	
					15	m.										
				30	25, 40	s. gr.										
					35											
Lyonsia norvegica	40		s. m.	12–14		st. m.	15–20		gr.	*			82		s.	10–100
													100		s. m.	
Neæra cuspidata	20		m.	30		m.							80	50	m. s.	10–80
					25	s. gr.							70–80		s.	
				15		st. m.										
Neæra abbreviata	40		m.													?
Neæra costellata	40		s. m.													?
Sphenia Binghami	*															?
Cochlodesma prætenue		20	sh.		40?	m.					12	s.	60	45	s.	0–80?
				4–5	12–16	s. st.							?80		s.	
Thracia phascolina		?40	s.	4–5	7	s. w.				*			20, 50		s.	0–80?
		5–10	n.										?60	?80	s.	
	15		gr.,				*									
Thracia villosiuscula	?20		sh.	*							35	s.		?5–10	s.	0–80?
Thracia convexa					15	s. m.	25	20, 60	s.					?70–80		10–70
					20–25	gr. s.										
					20, 50,	m.										
					70											
Thracia distorta		5–10	n.		35	gr.				*				15–20	n.	0–20
Solen ensis	*				4–5	s. w.		18	s. gr.	*			5–10		s.	2–20
[illegible]				*			*			12	35–40	s.	5–10	4–7	s.	0–12

Solen pellucidus	20	....	sh.	20	....	m.	18	....	s. m.	12	....	s.	60, 70	....	s.	7–100
		....		8	....	s.	30	....	m.	....	....	....	80, 90	....	s.	
													100	....	s. m.	
														4–7	w.	
Solecurtus antiquatus........	*	....	....	25	20	m. st.	....	18	gr. n.	....	....	....	....	50	s.	15–50
					30–40	st. sh.	....	20	m. s.							
Solecurtus candidus	....	....	....	*	....	....	....	....	....	....	35–40	s.	....	35	s.	20–50
Psammobia ferroensis........	*	....	....	7	30	s.	....	18	gr.	12	5–8	s.	5–10	....	s.	3–90
										35–40	....	s.	20	50	s.	
													40	70–80	gr.	
													60,70,80	80, 82	s.	
													90	....	s. m.	
Psammobia tellinella	....	40	s. sh.	4–5	....	s. w.	55	....	s.	12	....	s.	5–10	....	s.	3–70
								50	gr.	35–40	....	s.	25	....	sh.	
							8	4	s. w.	....	....	....	40	45	gr. st.	
													50	60, 70	s.	
														15–30	n.	
Tellina crassa	....	....	....	....	4–5	s. w.	....	....	....	....	....	....	....	....	....	0–70 ?
		40	sh. s.	....	40	s. gr.	....	50	gr.	35–40	12	s.	40	....	gr.	
		5–10	n.	....	....	....	....	18, 55	s.	25	....	....	....	15–30	n.	
														30–35	sh.	
														45, 50	s.	
														55	gr.	
Tellina proxima	....	*	....	....	53	....	....	60 ?	s.	....	....	....	....	100	s. m.	50–100 ?
Tellina donacina and pygmæa	....	5–10	n.	....	....	....	....	....	....	....	....	....	....	....	....	1–80
		20	sh.	40	....	s. m.	5	....	gr.	12	....	s.	5–10	30–35	s.	
				4, 7	30	s.	8, 55	....	s.	35–40	....	s.	45	50	s.	
											1, 5	w.	55	....	gr.	
														60, 80	s.	
Tellina fabula	....	5–10	n.	....	....	....	....	....	....	....	....	....	....	....	....	0–7
		15	sh.	....	7	s.	....	....	....	*						
Tellina tenuis	*	....	....	*	....	....	*	....	....	12	....	s.	5–10	....	s.	0–12
Tellina balaustina	....	....	....	....	70	m.	*	....	....	....	....	....	....	....	....	?
Diodonta fragilis........	....	....	....	....	....	....	....	....	....	....	....	....	5–10	....	s.	?
													4–7	....	w.	
Syndosmya intermedia	....	....	....	10, 15, 30,	....	m.	30	60	m.	....	....	....	35	....	s.	15–100
				70												
		100	m.	20, 25	....	m. s.	18	....	s. m.	....	....	....	70–80	82	s.	
				40	50	m.	....	....	....	....	....	....	90	....	s.	
													100	....	s. m.	

Species.	Clyde Province.			Hebrides.			North-Western Province.			Orkneys.			Zetlands.			Range.
	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	
ACEPHALA.	fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms	fathoms.		fathoms.
Syndosmya alba	6, 7	100	m.	15	10	w. m.	....	18	s. m.	*	....	....	4–7	....	w.	3–40
				20–30												
				40	20	m.										
Syndosmya prismatica	50	....	m.	....	7	s.	18	....	s. gr.	....	....	....	20	5–10	s.	5–100
										12	....	s.	80	45, 50	s.	
										35–40	....	s.	100	60	s. m.	
Mactra elliptica	....	40	s. s.	7,	25	gr. s.	50	....	gr.	12	....	s.	20	28	s.	5–80
		15	gr.	12–16												
				22	35	gr. s.	58	....	s.	....	....	....	40, 50	....	s.	
													55, 60	80	gr. s.	
Mactra solida	*	....	....	*	....	....	*	....	....	*	....	....	....	....	....	?
											35–40	s.				
Mactra subtruncata............	....	12	s.	*	....	....	*	....	....	*	....	....	4–7	....	w.	0–12
Mactra stultorum	*	....	....	*	....	....	*	....	....	*	....	....	4–7	....	w.	0–7
Lutraria elliptica..............	*	....	....	*	....	....	*	....	....	*	....	....	....	5–10	s.	0–10
Tapes decussata	....	....	....	*	....	....	....	5–8	w.	....	....	....	1	....	s. gr.	0–7
Tapes pullastra	*	....	....	*	....	....	*	....	....	*	....	....	5–10	....	s.	0–7
Tapes virginea..................	....	....	....	4–5	....	s. w.	....	....	....	....	....	....	....	....	....	5–60
		5–10	n.	15	10,15,	s. m.	....	18	gr.	35–40	12	s.	5–10	4–7	s. w.	
					20–30											
		15	gr.	....	20–25	gr. s.	....	....	....	....	....	....	25	15–20	sh. n.	
													45	35, 60	s.	
Venus ovata.....................	....	....	....	4–5, 8	....	s. w.	....	....	....	....	....	....	....	....	....	5–100
	12, 30	15	gr.	10, 15	35	s. m.	50	18, 20	s. gr.	12	....	s.	5–10	....	s.	
	40		s. m.	20	15–20	st.	....	....	....	35–40	....	s.	15–20	....	n.	
		40	sh. s.	40	....	s. w.	55	....	....	45	....	s.	20	25	s. sh.	
				22	90	gr. s.	....	....	....	....	....	....	50,55,	60	s. gr.	
													60			
													70,80,	....	s.	
													82			
													90	....	s.	
													100	....	s. m.	
Venus fasciata..................	5–10	....	n.	....	....	....	....	....	....	....	....	....	....	....	....	5–90
	40	15	sh. s.	40	....	s. gr.	4, 8	....	w.	12	....	s.	15–20	....	n.	
				12–14	30	m.	18, 50	....	gr.	16	....	s.	28–35	....	sh.	
				20–25, 35	90–98	gr. s.	55	....	s.	38–40	....	s.	35	....	s.	
				4–5	7, 30	s.	15	....	n.	....	....	....	40, 55	....	gr.	

Venus cassina	....	5–10	n.	....	....	....	....	....	....	....	....	....	....	....	....	5–70
	40	15	sh. s.	25–50	25	m. st.	....	18, 50	s. gr.	12	....	s.	80	....	s.	
		30	gr. m.	....	22,40,	s.gr.m.	....	55	s.	....	....	....	....	15–20	n.	
					35									25	sh.	
														35,50,	s.	
														70		
														40, 55	gr.	
Venus striatula	15	....	s. m.	....	12–16	s. st.	....	18	s. gr.	12	....	s.	5–10	20	s.	0–100
					70	m.	....	70	s.	....	....	....	4–7	....	w.	
				4, 8	....	s. w.	18	....	s. m.	....	....	....	50,60,	70–80	s.	
													70, 80			
													90	....	s.	
													100	....	s. m.	
Artemis lincta	20	5–10	sh.	20–30	12–16	gr.	....	18	s. gr.	1	....	w.	5–10	....	s.	0–80
					15–20	st.	25	70	s.	35, 40	....	....	50,60,	....	s.	
													80			
					10,25,	m.										
					30, 40											
				7	....	s.										
Artemis exoleta	20	5–10	sh.	7, 20–30	....	s.	*	....	....	*	....	....	5–10	....	s.	0–70
		6	m.	4–5	....	s. w.	....	....	....	....	....	....	70	50, 60	s.	
														4–7	w.	
														15–30	n.	
Cyprina islandica	20	5–10	sh. n.	7, 20–30	30–40	s.	....	18	s. gr.	(7–40)	12	s.	5–10	45	s.	0–100
		15	gr.	20, 38	10, 15	m.	25,18,	....	s. m.	....	....	....	50, 80	60	s.	
							20									
					18–20,	st.	....	....	....	....	....	....	....	100	s. m.	
					25											
Circe minima	5–10	....	n.	4, 15	....	w.	18, 50	50	gr.	12	....	s.	15–30	....	n.	3–80
				20, 25	12–14	m. st.	....	....	....	25	....	sh.	25, 45	20	s.	
				35, 40	25–40	s. gr.	....	....	....	....	....	....	50	80	s.	
					35	s.	....	....	....	....	....	....	....	40	gr.	
Astarte compressa	20	....	sh.	....	30, 40	m.	8	50	s.	....	....	....	18–30	....	n.	3–80
				20–25	12,40,	s. gr.	15	....	n.	35–40	12	s.	....	40	gr.	
					25											
				4–5	....	s. w.	....	....	....	....	....	....	....	50,70,	s.	
														80		

Species.	Clyde Province.			Hebrides.			North-Western Province.			Orkneys.			Zetlands.			Range.
	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	
ACEPHALA.	fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.
Astarte sulcata	30, 15	....	gr.	12, 15	....	w. m.	20	50	gr.	*	....	....	70–80	60	s.	10–100
	40	....	s. m.	25	....	m. st.	....	....	....	....	....	....	80, 90	....	s.	
				20, 30, 80	....	gr.	....	....	....	....	....	....	100	....	s. m.	
				40	20, 50	m.	....	....	....	....	....	....	....	15–30	n.	
				22, 90–95	....	gr. s.										
Astarte elliptica	20	....	sh.	4–5, 15	....	w.	....	50	gr.	*	....	....	*	....	....	3–50
	30	30	gr.	....	30, 50	m.										
	40	....	s. m.	....	40	s. gr.										
Astarte crebricostata	....	....	....	....	40, 50	m.	....	....	....	....	....	....	....	80	s.	?
Astarte arctica	....	....	....	....	....	....	....	....	....	....	....	....	....	80	s.	?
Astarte triangularis	....	40	sh. s.	5	....	w.	55	....	s.	35–40	12	s.	5–10	45	s.	5–60
													50	60	s.	
													40	55	gr.	
Isocardia cor	....	....	....	24	15,30,	m.	....	....	....	....	....	....	....	....	....	15–50 ?
					40, 50											
					20–30	s.										
Cardium echinatum	....	20	sh.	....	10, 15	n.	....	18	s. gr	60	....	....	5–10	60, 70	s.	5–100 ?
	5–10	....	n.	....	7	s.	....	20, 70	s.	....	....	....	....	80, 90	s.	
	20–25	....	gr. s.	....	....	....	18	....	s. m.	....	....	....	....	100	s. m.	
														4–7	w.	
Cardium pygmæum	....	6	m.	*	....	....	*	....	....	....	....	....	5–10	....	s.	3–15
Cardium fasciatum	30	15	gr.	4, 10, 15	....	w. m.	18	50	gr.	12	....	s.	5–10	....	s.	5–100
	20	....	sh.	20–30	....	....	....	....	....	....	....	....	40	55	gr.	
				20, 40, 35	....	s. gr.	....	....	....	....	....	....	45, 50	....	s.	
				8	....	s.	....	....	....	....	....	....	60, 80	70	s.	
													100	....	s.	
Cardium norvegicum	....	5, 20	sh.	....	15–20	st.	....	18, 50	gr.	7, 15	....	....	....	80	s.	5–80
Cardium nodosum	5–10	20	sh.	4, 8	....	s.	4	....	w.	....	....	....	....	50, 70, 80	s.	5–80
Cardium suecicum	30	....	gr.	30	30	m.	....	50	gr.	....	35–40	s.	5–10	....	s.	5–100
	50	100	m.	25–50	30	s.m.gr.	....	18	s. m.	....	....	....	70–80	90	s.	
														55	gr.	
														100	s. m.	
Cardium edule	*	....	....	*	....	....	*	18	s. gr.	....	....	....	....	....	....	0–1

Lucina ferruginosa	20	100	m.	25, 30	....	m.	25, 20, 30	....	m. s.	....	....	....	? 90	....	s.	
				30–40	....	st. sh.										
Lucina borealis	20	5–10	st. n.	....	12–16	s. st.	....	18	s. gr.	15–40	12	s.	25–30	....	n.	0–100
					4–5	s. w.	....	70	s.	....	5–8	w.	80, 90	45, 50	s.	
								15	n.	....	....	....	....	70–80	s.	
								50	gr.	12	....	s.	....	100	s. m.	
Lucina flexuosa	....	....	....	4–5	....	s. w.	....	....	....	....	....	....	....	....	....	3–100
	6	5–10	m.	30	40, 50	m.	....	30	m.	40	....	....	15–30	....	n.	
	20	....	sh.	20, 25	12–14	gr. s.	....	18, 70	s.	....	....	....	80	45, 50	s.	
								15	n.	....	....	....	....	4–7	w.	
														70	s.	
														100	s. m.	
Lucina spinifera	....	20	sh.	30, 40	12–14,	m.	....	18	s. gr.	*	....	....	15–30	....	n.	10–100
					20, 70											
				20, 90, 95	25	gr. s.	18	15	s. m. n.	....	....	....	80	60	s.	
Lucinopsis undata	....	40	sh. s.	....	20	m.	25	18	s. m.	1	....	w.	....	4–7	w.	1–40
				15	....	st. m.	....	....	....	15						
Montacuta bidentata	....	20	sh.	4, 8	....	s.	20	18	s. gr.	....	....	....	5–10	....	s.	1–80
							30	....	m.	....	....	....	80	....	s.	
Montacuta substriata	*	....	....	40	....	s. gr.	....	....	....	....	....	....	5–10	....	s.	5–60
													45, 80, 90	....	s.	
Montacuta ferruginosa	30	5–10	gr. n.	....	10	s.	....	....	....	5–8	....	w.	*	....	....	1–30
		20	sh.													
Kellia suborbicularis	....	40	s. sh.	4–5	....	s. w.	18	....	gr. n.	7	....	w.	5–10	....	s.	0–90
													15–30	....	n.	
													60, 82	....	s.	
Lepton squamosum	....	15	gr.	*												
Pinna pectinata	....	....	....	....	....	....	....	....	....	....	....	....	70 ?	....	....	?
Modiola modiolus	5–10	....	n.	....	....	....	....	....	....	....	....	....	....	....	....	0–100
	15, 30	....	gr.	4, 15, 30	....	w. sm.	....	18	s. gr.	....	12	s.	1	....	w.	
		40	sh. s.	25, 90–95	....	gr. s.	....	20	m. s.	....	35–40	s.	4–7	....	w.	
													15–30	....	n.	
													45, 50, 60	70, 80	s.	
														....	r.	
														100	s. m.	
Modiola tulipa	15	....	gr.	....	....	....	....	....	....	....	....	....	....	45	gr.	10–50
Modiola phaseolina	....	....	....	12–14	....	s. m.	....	....	....	....	....	....		....	....	10–50
	*	....	....	20–30	....	s.	....	50	gr.	*	....	....	....	45	s.	

Species.	Clyde Province.			Hebrides.			North-Western Province.			Orkneys.			Zetlands.			Range.
	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	
ACEPHALA.	fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.
Crenella decussata				4, 5		w.	55	20	s.	4		s.	5–10		s.	0–80
								50	gr.	7–15			15–30		n.	
										12		s.	30–35		sh.	
													55	40	gr.	
													60	45, 50, 80	s.	
Crenella discrepans	15		gr.	4, 15–16		s.	*			*			*			0–20
Crenella marmorata				12–14		s. m.										0–40
	*			30, 20–25		gr. s.	*			*			*			
Crenella nigra				15, 18		w.					35–40		70, 90		s.	10–100
Arca raridentata				22, 30–40	30	m.	50		gr.					45, 60	s.	20–60
				20–25		gr. s.										
Arca tetragona				30	25–50	s. gr.		20, 58	s.		12	s.	50		st.	10–60
								18	gr.	17		w.	60		r.	
														20, 45	sh.	
														45	gr.	
														60	s.	
Pectunculus glycimeris				4–5		s. w.										5–80
		40	s. s.	25, 40	35	s. gr.	55		s.	*			45	60, 80	s.	
		15	gr.					50	gr.				50	50	s.	
														40, 55	gr.	
Nucula decussata	*			15, 45	15, 30	m.		30	m.							15–100?
					11, 50, 70	m.										
				20–30	25–50	s.										
Nucula nitida	5–10		n.													5–60
	20	15	sh. gr.	4–5		s. w.	18, 50		gr.				60		s.	
							18, 25		s. m.							
Nucula tenuis	40	5–10	s. m. n.							40		s.	80		s.	5–100
	50		m.				25, 30		m.							
	100		m.													
Nucula radiata	*															
Nucula nucleus	7		w.	10, 15		w. m.	*									
	15		s. m.	20, 25		st.				*			15–30		n.	5–100
	20	40	sh.	20, 30, 40		m.							60		r.	
	30	15	gr.	40–80		gr.							80	45, 70	s.	
	100		m.	90–95	7, 35	gr. s.								100	s. m.	

Leda pygmæa	....	....	....	30, 40, 50	....	m.	50	18	gr.	....	....	....	....	60	s.	15–90
				30–40	15–20	st.	....	15, 20	m. s.	....	....	....	....	90	s.	
				20–25	....	gr. s.										
Leda caudata	30	15	gr.	15	10, 30	w. m.	50	....	gr.	*	....	....	....	70	s.	15–100
	40	....	sh. s.	20	....	st.	70	20	s.	....	....	....	....	82	s.	
	50, 100	....	m.	20–30	....	s.	15	....	n.	....	....	....	....	100	s. m.	
				25, 90–95	....	gr. s.										
Lima hians	5–10	20	n. sh.	15	....	r.	....	....	....	....	15	....	....	45	s.	5–50
		40	sh. s.	20–30	....	s.										
Lima Loscombi	15	20	gr. sh.	*	....	....	20, 50	....	gr.	*	....	....	15–20	....	n.	15–80
		40	sh. s.	....	....	....	....	....	....	....	....	....	55	....	gr.	
														45, 50	s.	
														70, 80	s.	
Lima subauriculata	50	....	m.	4, 15	....	w.	50	20	s.	*	....	....	55	....	gr.	4–100
	100	....	m.	10, 15, 50	15	m.	....	50	gr.	....	....	....	....	45, 50,	s.	
														60		
		30	gr.	....	20–30	s.										
		40	sh. s.	....	22, 30	gr. s.										
Ostrea edulis	15	....	gr.	15	....	w.	....	....	....	....	....	....	....	....	....	0–20
Pecten striatus	....	15	gr.	20–30	....	s.	20	50	gr.	35–40	12	s.	50	70, 82	s.	10–70
				30	20	m.	....	....	....	....	....	....	....	25	sh.	
				40	35	s. gr.										
Pecten similis	30	....	gr.	15–20	28	st.	....	18, 50	gr.	2	....	w.	30–38	....	sh.	2–80
	20	....	sh.	....	20–30	s.	....	20, 70	s.	....	....	....	35	45, 60,	s.	
														80		
		40	s. m.	....	12, 30	m.	....	....	....	....	....	....	60	....	r.	
		6	m.	25, 30	40, 35	s. gr.										
Pecten maximus	20	12	s.	....	18, 20	m.	15–20	50	gr.	4, 7–15	....	sh.	....	25	sh.	2–40
		5–10	n.	....	28, 30	m. gr.	....	18	s. m.	....	5, 12	s.	....	60	s.	
					40	s. gr.										
Pecten niveus	....	....	....	15	....	w.	*	....	....	....	....	....	....	....	....	1–15
Pecten danicus	....	30	gr.	20–25	20–30	s.	....	....	....	....	....	....	82	70 80,	s.	10–100
														90		
		40, 50,	....	....	10, 30,	m.	....	....	....	....	....	....	....	100	s. m.	
		100			40, 90											
Pecten tigrinus	15, 20	5, 40	gr. sh.	15	10	s. m.	18, 50	....	gr.	....	14	s.	25	....	sh.	5–80
				20–30	30	s.	....	80, 70	s.	....	35–40	s.	40	55	gr.	
				30	15	m.	....	....	....	....	....	....	45, 50,	5,70,80	s.	
													60			
					25, 40	s. gr.										

Species.	Clyde Province.			Hebrides.			North-Western Province.			Orkneys.			Zetlands.			Range.
	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	
ACEPHALA.	fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.
Pecten opercularis	5–10	....	n.	....	....	....	....	....	....	....	....	....	....	....	....	2–100
	40	15	sh.s.gr.	15	....	w. m.	....	18, 50, 70	gr.	5–8	....	r.	15–30	....	n.	
				20	....	st.	....	....	....	25	12	s.	....	45, 60, 80	s.	
				20–30	....	s.	....	....	....	35–40	....	....	....	55	gr.	
				40	35	s. gr.	....	....	....	....	....	....	....	100	s. m.	
					70	m.										
Pecten pusio	20	40	sh.	15	....	w.	....	....	....	....	12	s.	50	20	s.	2–90
		15	gr.	....	90–95	gr. s.	....	....	....	(2–40)	....	st. sh.	60	....	r.	
					30–40	gr. st.	....	....	....	15	....	c.	....	25	sh.	
Pecten varius	....	15	gr.	*	....	....	....	....	....	7, 15	....	....	*	....	....	3–20
Anomia ephippium	15	....	gr.	15–16	....	s.	....	....	....	....	....	....	80	....	s.	0–80
													25	....	sh.	
Anomia undulata	*	....	....	15–20, 30	....	st.	....	....	....	12	....	s.	50	55	st. gr.	10–70
				25, 40	....	s. gr.	50, 18	....	s. gr.	....	....	....	....	70	s.	
				50	....	m.										
Anomia squamula	20	40	sh.	15	....	w.	....	....	....	....	....	....	5–10	....	s.	0–20
				10	....	m.	....	....	....	....	....	....	4–7	....	w.	
Anomia striata	....	....	....	*												
Terebratula Caput-serpentis	30	....	gr.	15	....	w.	....	50	gr.	....	....	....	40, 60	....	st.	0–90
	50	....	m.	15, 30, 50	....	m.	....	....	....	....	....	....	....	45	s.	
				15, 20, 25, 40	....	st. gr.										
Megathyris cistellula	....	....	....	30, 40	....	m.	....	....	....	....	....	....	80?	....	....	?
Crania norvegica	20	....	st.	15, 20, 30	....	st.	55	50	st.	....	....	....	40	....	gr.	20–100
	30	....	gr.	25, 35, 40	....	gr.	....	....	....	....	....	....	50	....	st.	
	50, 80	....	m.													
				90–95	....	gr. s.	....	....	....	....	....	....	....	45, 80	s.	

TABLE VI.—Enumeration of the depths, &c. at which species of Echinodermata were taken by the Dredge on the Northern and Western Coasts of Scotland.

Species.	Clyde Province.			Hebrides.			North-Western Province.			Orkneys.			Zetlands.			Range.
	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	
	fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.
Comatula europea ...	...	...	...	20–25	...	gr.	8	...	w.	7–15	...	w.	7	...	w.	5–50
				30–40	...	sh.	...	...	...	...	...	...	25	...	sh.	
Comatula petasus? ...	...	...	...	30, 40	...	m.	50	...	s.	...	...	...	...	...	...	25–50
Ophiura texturata ...	7	...	w.	15	...	w.	18	...	n.	...	...	...	...	...	...	5–40
	20	...	sh.	25	...	gr. m.										
				40	...	m.										
Ophiura albida ...	20	...	sh.	15	...	w.	18	...	n.	5	...	w.	4–7	...	w.	4–90
				22, 90	...	gr. s.	18, 15	...	gr.	7–15	...	s.	25	...	sh.	
				30, 40	...	sh. m.	18	...	s.m.m.	80	...	s.				
Ophiocoma neglecta ...	...	...	...	...	...	...	...	...	...	...	...	...	4	...	w.	0–10?
Ophiocoma filiformis ...	7	...	m.	20	...	m.	...	...	...	...	...	...	...	...	...	5–100
Ophiocoma chiagii ...	30	...	gr.	10, 12, 15	...	st. m.	18	...	n.	...	...	...	20, 70	...	s.	5–100
	50, 100	...	m.	40, 70	...	m.	20, 30	...	m.	...	...	...	80	...	m. s.	
Ophiocoma granulata ...	7	...	m.	4–5, 15	...	w.	15–20	...	gr.	7–15	...	s.	20	...	sh.	5–50
	20	...	sh.	10, 30	...	s. m.	...	...	...	...	...	...	50	...	st.	
				22	...	gr. s.										
Ophiocoma bellis ...	7	...	w.	4–5	...	w.	20	...	gr.	...	...	...	20	...	sh.	5–50
	20	...	sh.	25, 30	...	st.	...	...	...	...	...	...	50	...	st.	
				30–40	...	st.										
Ophiocoma Goodsiri ...	...	...	...	...	...	...	...	...	...	...	...	...	50	...	gr.	?
Uraster glacialis ...	...	...	...	20–25	...	gr.	18	...	n.	...	...	...	...	...	...	10–30
Uraster rubens ...	7	...	w.	40	...	m.	...	...	...	5–8	...	s.	...	...	...	0–50
	20, 45	...	sh.	...	...	...	...	...	...	7–18	...	w.				
Uraster violacea ...	...	...	...	25, 30	...	s.	15–20	...	gr.	...	...	...	...	...	...	0–40
Cribella oculata ...	...	...	...	20–25	...	gr.	15	...	n.	...	...	...	1	...	w.	0–60
													20, 60	...	st.	
Solaster endeca ...	...	...	...	15–20	...	gr. m.	...	...	...	...	...	...	...	20	s. sh.	5–90
				30, 90	...	gr. s.										
Solaster papposa ...	...	...	...	...	...	...	15	...	gr.	35–40	...	s.	...	...	...	5–50
Palmipes cartilagineus ...	...	...	...	30–40	...	sh.	18	...	n.	...	...	...	...	...	...	15–50
Goniaster pulvillus (Templetoni).	20	...	sh.	25	...	gr. m.	...	...	...	...	...	...	...	...	...	15–50
				30–40	...	sh.										
Asterias aurantiaca ...	...	...	...	25	...	gr. m.	...	...	...	5–10	...	sh.	20,	...	n.	5–80
													15–30			
										15	...	s.	70–80	...	s.	

Species.	Clyde Province.			Hebrides.			North-Western Province.			Orkneys.			Zetlands.			Range.
	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	Alive.	Dead.	Ground.	
	fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.	fathoms.		fathoms.
Luidia fragilissima	....	....	....	....	....	....	50	....	gr. s.	15	....	s.	5–45	....	s.	5–50
Echinus sphæra	20	....	st.	4–5, 15	....	w.	18	....	n.	5–8	....	s.	15–30	....	n.	0–40
	40	....	sh.	20–25, 25	....	gr. m.	15–20	....	gr.	15	....	s. w.	25	....	sh.	
				30, 30–40	....	sh.										
				30	....	s.										
Echinus miliaris	40	....	sh.	4–5, 15	....	w.	8, 20	....	w.	....	....	....	15–30	....	n.	0–40
				20–25	....	gr.	18	....	s. gr.							
				25	....	gr. m.										
Echinus norvegicus	....	....	....	....	....	....	....	....	....	....	....	....	40, 50	....	gr.	40–100
													45, 70	....	s.	
													82, 100	....	s.	
Echinus neglectus	....	....	....	....	....	....	....	....	....	7	....	w.	4	....	w.	0–10?
Echinocyamus pusillus	40	....	sh.	12–14	....	st. m.	18	....	n.	7–15	....	w.	50	....	gr.	5–90
				22, 90	....	gr. s.	....	....	....	....	....	....	70	....	s.	
				25	....	gr. m.										
Spatangus purpureus	40	....	sh.	....	....	....	....	....	....	35–40	....	s.	5–10	....	s.	5–80
										5–8	....	s.	15–30	....	w.	
													45, 60, 80	....	s.	
													50, 60	....	gr.	
Amphidetus roseus	40	....	s. m.	7	....	s.	18	....	n.	35–40	....	s.	15–30	....	n.	7–90
				30–40	....	st.	....	....	....	....	....	....	45, 70, 90	....	s.	
													80	....	m. s.	
Brissus lyrifer	6, 7, 15	....	m.	100	....	m.	30	....	m.	....	....	....	80	....	m. s.	6–100
	100	....	m.	....	....	....	....	....	....	....	....	....	70, 80, 90	....	s.	
Cucumaria pentactes	9	....	m.	....	....	....	15	....	gr.	....	....	....	....	....	....	?
Cucumaria frondosa	....	....	....	....	....	....	....	....	....	....	....	....	7	....	w.	Lam.
Cucumaria pellucida	....	....	....	....	....	....	....	....	....	....	....	....	7	....	w.	Lam.
Ocnus lacteus	20	....	sh.	....	....	....	....	....	....	....	....	....	7	....	w.	?
Ocnus brunneus	7	....	m.	....	....	....	....	....	....	....	....	....	7	....	w.	?
Thyone papillosa	....	....	....	....	....	....	....	....	....	....	....	....	40	....	gr.	0–40
Thyone raphanus	40	....	s. m.	20	....	m. s.	....	....	....	....	....	....	45	....	sh.	20–50
Fistularia, sp.	....	....	....	25	....	gr. m.	....	....	....	....	....	....	....	....	....	?
Sipunculus Bernhardus	20	....	sh.	....	....	....	....	....	....	....	....	....	60	....	sh.	?
Sipunculus, sp.	20	....	sh.	15, 18	....	w. m.	....	....	....	....	....	....	....	....	....	?
Priapulus caudatus	....	....	....	....	....	....	....	....	....	....	....	....	7	....	w.	Lam.

Record of Classes and Tribes partially observed.

The enumeration of species in each dredging paper is complete so far as the Testaceous Mollusca are concerned, and usually, also, the Echinodermata. Other tribes of animals, as well as plants, in consequence, in most cases, of the impossibility of determining all the species at the time, and partly from the great amount of labour required to register completely the tribes above noted, did not receive the same degree of attention. In most instances they were, however, carefully collected; and in the works of Bell and Johnston especially, many records of depths and localities will be found which were derived from specimens collected and transmitted to those eminent naturalists during the course of these researches. In the majority of the dredging papers, there are, however, memoranda of various extent, noting the more remarkable instances of every tribe found, and often their comparative abundance. These I shall now proceed to abstract.

Mollusca Nudibranchiata.

The small number of these beautiful creatures recorded in the dredging papers is not to be attributed to their having been unobserved, but rather to their absence from the ground usually examined. The majority of species inhabited the shallower parts of the Laminarian zone, and very numerous forms are littoral—hence living without the region assigned for this inquiry. In the magnificent work of Alder and Hancock on the British Nudibranchia, published by the Ray Society, the distribution and localities of this tribe have been most carefully attended to.

Those noted in the papers are,—

Melibœa coronata, Dorset, in 15–20 f. s. gr.
—— *fragilis*, Isle of Man, 20–25 sh. Cornwall, 25 sh. s. Dorset, 20–25 s.
Tritonia, sp., Dorset, in 15–20 gr.
—— *Hombergi*, Isle of Man, in 25 sh.
—— *plebeia*, Isle of Man, in 28 sh.
Eolidiæ, Isle of Man, in 18–25 f. Clyde, in 20 f. Zetland, in 7 f.
Polycera, Hebrides, in 4–5 f.
Idalia, Zetland, in 35 f. s.

Mollusca Cephalopoda.

Cephalopods are difficult to take with the dredge on account of the rapidity of their motions. The following instances are recorded:—

Sepiola, 15–20 f. gr. and 40 m. Hebrides; and its spawn, in 25 s. s. Cornwall.
Octopus, 30 f. gr. Hebrides, and 25 f. sh. Isle of Man.

Mollusca Ascidia.

These are rarely recorded in detail, because the difficulty of determining the species in the present state of our knowledge of the tribe is very great. Such records however as are given are important:—

Cynthia microcosmus is recorded from 10 f. s. m. and 25 f. st. s. in the Hebrides.
—— *echinata*, from 50 f. m. in the Hebrides, and 80 f. sand in Zetland, where it also occurs among weed in 7 f.
——, a new species from 30 f. gr. Croulin Island.
—— *aggregata*, from 7–12 f. st. gr. Dartmouth.
—— *tessellata* and *morus*, Devon, in 20–25 f. Localities for other members of this genus may be found in the 'British Mollusca,' vol. i. part 1 and 2.

Ascidia grossularia, Devon, in 12 f. Clyde, in 30 gr., 40 m. Hebrides, in 20 gr.
—— *prunum*, Devon, 20–25 f. Hebrides, 25 gr. m. and 30 gr.
—— *intestinalis*, Dorset, in 15–20 gr. Hebrides, in 30–40 sh. Orkneys, in 7 w.
—— *communis*, Dorset, in 7 w. and 15–20 gr. Isle o fMan, in 15–18 m. Clyde, in 30 gr. Hebrides, in 15 w., 25 gr. n., 30 gr., 30–40 sh., 50 m.
—— *scabra* ?, Dorset, in 15–20 gr.
—— *vitrea*, Clyde, in 30 gr. Hebrides, in 30–40 sh., 25 gr. m. Orkneys, in 35–40 sh.
—— *rosea*, Hebrides, in 30 gr. Zetlands, in 4–7 w.
—— *canina*, Orkneys, in 7–18 weed.
Molgula tubularis, Clyde, in 9 and 18 m. Zetlands, in 20 s., 40 gr., 60 and 80 m. s. Hebrides also.
—— *oculata*.
Pelonaia glabra, in 9 m. Clyde.
Syntethys hebridicus, 30 f. Croulin Island.
Compound Ascidians in all depths of the Laminarian zone, rarely lower.

Mollusca Bryozoa.

So many of the specimens of these curious pseudo-zoophytes procured during these researches were transmitted to Dr. Johnston for publication in his most valuable 'History of British Zoophytes,' that the few memoranda made in the dredging papers of the more striking species at the time of capture, can give but little insight into their distribution. The following notes of depth may serve as contributions to future histories of them.

Diastopora obelia, 14 f. st. Anglesey ; 40 f. Clyde district.
Tubulipora patina, 20, 27 f. Cornwall ; 50 f. gr. Zetland.
—— *truncata*, 50, 80 f. st. Zetland.
—— *serpens*, 15–20 gr. Dorset ; 20–25 and 27 sh. Cornwall. Clyde, 40. Zetland, 7 w., 50 gr.
—— *hispida*, Clyde, 40.
Idmonea atlantica, Zetland, 50 gr., 80 s.
Pustulipora proboscidea, Zetland, 50 gr.
—— *deflexa*, Cornwall, 20–25 sh. s.
Alecto major, Clyde, 40.
Crisia, sp., Dorset, 12 s. gr., 15–20 gr. Anglesey, 14 st., 30 gr. Clyde, 40. Zetland, 50 gr.
Hippothoa, sp., Cornwall, 20–25 sh. s. Anglesey, 14 st. Zetland, 40 gr., 50 gr.
Cellepora pumicosa, Dorset, 15–20 gr. Devon, 20–25 gr. s. Cornwall, 20–25 sh. s. Anglesey, 7 st., 30 gr. Isle of Man, 18 n., 25 sh. Clyde, 40 sh. Hebrides, 10 s. m., 28 gr. s. Zetland, 50 gr.
—— *ramulosa*, Dorset, 25 gr. Clyde, 40 sh. Zetland, 50 gr., 80 m. s.
—— *skenei*, Dorset, 18–20 gr. Cornwall, 20–25 sh. s. Zetland, 25 sh., 80 m. s.
—— *cervicornis*, Hebrides, 15–20 st., 25 gr. n., 30 st. Zetlands, 50 gr.
Lepralia, sp., Dorset, 15–20 gr. Devon, 12 s. gr. Cornwall, 20–25 sh., 27 s. Devon, 20–25 gr. s. Isle of Man, 15–18 n. &c.
Flustra foliacea, Dorset, 15–20 gr., 25 gr. Anglesey, 12 st., 30 gr. Isle of Man, 15–18 n. Clyde, 40 st. Hebrides, 15–20 st. Zetland, 50 gr.

Flustra truncata?, Dorset, 15–20 gr. Devon, 7–12 st. gr. Clyde, 40 sh. Hebrides, 20 gr., 25 gr., 15–20 st. Orkneys, 35–40 st.
—— *avicularis*?, Dorset, 15–20 gr.
—— *Murrayana*, Hebrides, 15–20 st. Zetland, 50 gr.
—— *coriacea*, Isle of Man, 25 sh.
Membranipora pilosa, 7 gr.
Eschara foliacea, Dorset, 15–20 gr. Cornwall, 20–25, 27 sh.
—— *bidentata*, Cornwall, 20–25 sh.
Retepora Beaniana, Hebrides, 50 m. Zetlands, 50 gr., 70 s., 80 sh.
Salicornaria farcimioides, Dorset, 15–20 gr. Devon, 12 st. Devon, 20–25 gr. s. Cornwall, 20–25. Isle of Man, 25 sh. Clyde, 40 sh. Hebrides, 15–20 s. Outer Hebrides, 20 m. s. Zetlands, 50 gr.
Alcyonidium, Dorset, 12 s. gr. Anglesey, 20. Orkneys, 35–40 s. Zetlands, 20 s.
Sertularia lendigera, Dorset, 7 m. Anglesey, 7 sh. s., 12 st.
Beania mirabilis, Cornwall, 20–28.

Crustacea.

In Professor Bell's 'History of British Crustacea,' numerous localities derived from the dredging expeditions which furnished the matter for this Report are inserted. And in the volume of the British Association Reports for the Meeting at Southampton in 1846, there is an abstract of a paper read by Professor Bell, in the Natural History Section, containing an account of the Crustacea procured by Mr. MacAndrew and the reporter during their voyages. These need not be here repeated. A few notes of localities contained in the papers themselves, may, however, be indicated with advantage.

Stenorhynchus phalangium, Anglesey, 7–9½–12 gr. s. Dorset, 12 m., 15–20 gr. Hebrides, 15 m. Isle of Man, 25 sh.
Inachus Dorsettensis, Dorset, 7 m., 12 m., 15–20 gr. Anglesey, 7–12 gr. Isle of Man, 25 sh.
Pisa tetraodon or *Gibbsii*, Isle of Man, 25 sh.
Hyas araneus, Dorset, 12 m.
—— *coarctatus*, Isle of Man, 28 sh.
Eurynome aspera, Dorset, 12 m., 15–20 gr. Isle of Man, 25 st. Loch Fyne.
Pilumnus hirtellus, Dorset, 7 w., 15–20 gr. Isle of Man, 18, 25 sh.
Perimela denticulata?, Dorset, 12 m., 15–20 gr. Cornwall, 25 sh.
Portunus, sp., Dorset, 15–20 gr. Cornwall, 20–25 sh. Isle of Man, 25 sh.
Pinnotheres, Isle of Man, 18, 25 sh., &c.
Ebalia, sp., Dorset, 12 m., 15–20 gr. Devon, 10 s., 27 s. Anglesey, 12 s. Isle of Man, 25 sh. Mull, 25 st. m.
Atelecyclus heterodon, Cornwall, 20–28 n.
Pagurus Forbesii?, Dorset, 20–25.
—— *lævis*?, Dorset, 20–25.
—— *Prideauxii*, Clyde, 25, 30. Isle of Man, 25.
—— *Bernhardus*, Anglesey, 7, 12, 12 gr. Dorset, 15–20 gr. Cornwall, 20–25 sh. Devon, 27 s. Orkneys, 5–8. Shetland, 50 gr., 80 s.
Porcellana longicornis, Dorset, 7–12 s., 15–20 gr. Anglesey, 7, 12 gr.
Galathea strigosa, Dorset, 20 n.
——, sp., Dorset, 7 w., 15–20 gr. Cornwall, 20–28 sh. Zetland, 50 gr.
Calocaris MacAndreæ, Loch Fyne, 100 m. Mull, 30 mud.
Crangon vulgaris, Anglesea, 7 w.
Pandalus annulicornis, Dorset, 7 w., 15–20 gr. Anglesey 7.

Arcturus, sp., Hebrides, 15 m.
Pycnogonum, large species, Zetlands, 50 gr.
Cypridina MacAndrei, Hebrides, 70 f.
—— *Brenda*, Zetland, 80 f.

Cirripedes.

Until Mr. Darwin's researches on the Cirripedes be published, there can be no certainty in the determination of the species of this difficult group. The leading forms, however, are usually noted in the dredging papers.

Balanus scoticus, Anglesey, 25 gr. Isle of Man, 25 sh. Clyde, 15 gr.
Balanus sulcatus, Dorset, 7 w., 12. Cornwall, 28 sh. Milford, 8 w. Anglesey, $9\frac{1}{2}$, 12 gr. Isle of Man, 18 n., 28 sh. Clyde District, 15 gr., 30 gr., 20 sh. Zetlands, 25 st. Hebrides, 10 s. m., 15–20 st., 15 sh., 25 gr. s., 30, 35 gr., 90 st. Outer Hebrides, 18 s. gr., 15–20 gr.
Clitia verruca, Dorset, 15–20 gr. Devon, 7–12 s. gr. Anglesey, 30 gr. Isle of Man, 25 st. Hebrides, 15 w., 15–20 w. gr., 25 gr. s., 90 gr. s. Zetlands, 50 gr.
Adna anglica, Cornwall, 12 gr., 25 sh. s.
Scalpellum vulgare, Dorset, 15–20 gr. Cornwall, 27. Devon, 20–25. Isle of Man, 25 sh.

Annelida.

This department of the British Fauna is the one requiring most elucidation. The researches of Dr. Johnston have done much, and those of Dr. Williams promise much; but until we have some available manual of species, the progress will not be sufficient to bring it up to a level with the other sections of British marine zoology. The entries of worms in the dredging papers are, except for the more striking species, only occasional.

Michelia trilineata, Clyde dist. 20 st. Hebrides, 25 gr. n.
Planaria rosea, Anglesey, 12 gr. Zetland, 60 s., 80 m. s.
——, sp., Dorset, 12 m.
Pontobdella muricata, Isle of Man, 28 sh.
Trophonia Goodsiri, Zetlands, 7 w.
Pectinaria belgica, Anglesey, 7 w. Clyde, 30 gr., 50 m. Hebrides, 90 gr. s. Stornoway, 18 s. m. Zetland, 50 gr., 80 m. s., 80 s.
—— (large species), Hebrides, 15 m.
Sabellaria alveolata, Anglesey, 12 s., 14 gr., 25, 30. Hebrides, 8 s. Clyde district, 15, 20 sh.
Terebella conchilega, Cornwall, 20–25 sh. Devon, 20–25 s. Hebrides, 15 w. Zetlands, 50 gr.
—— *compressa*, Cornwall, 20–25. Devon, 20–25 s. Zetlands, 50 gr. 60 s., 80 m. s.
—— (convoluted sp.), Hebrides, 12–14 st. m.
Pomatoceros tricuspis, Dorset, 7 w., 15–20 gr. Devon, 20–25 s., 27 s. Anglesey, 12 st., 14 s., 20 gr., 25 gr. Isle of Man, 28 sh. Clyde district, 5–10 n., 20 sh. Hebrides, 15 w., 25 s. gr., 18 n., 30–40 sh., 90 gr. Zetland, 50 gr., 60 gr., 70 s.
Eupomatus, sp., Dorset, 7 w., 15–20 gr. Cornwall, 27. Devon, 25–27. Clyde district, 30 gr., 20 sh. Hebrides, 15 w., 15–20 s., 25 gr. s., 90 gr. Zetlands, 50 gr., 60 s., 70 s.
Serpula vermicularia, and *tubularia*, Dorset, 15–20 gr. Anglesey, 25 gr., 12 s. Isle of Man, 25 sh. Clyde district, 5–10 n., 18 m., 20 st., 30 gr. Hebrides, 30–40 sh., 28 s., 15 m., 18 n., 90 gr. Zetlands, 50 gr.
Spirorbis, Dorset, 15–20 gr. &c.

Placostegus vitreus, Clyde district, 30 gr., 40 st. Hebrides, 15–20 st., 25 st., 25 gr. m., 30 st., 30–40 sh., 90 gr. Zetlands, 50 st.
Filograna implexa, Isle of Man, 28 sh. Hebrides, 25 gr. m. Zetlands, 80 s.
Ditrupa subulata, Zetland, 50 gr., 60 s.
Onuphis tubicola, Clyde, 20 sh. Stornoway, 18 gr. Zetlands, 50 gr. 60 s., 80 m. s.
Siphostoma? (Lancelet-like worm), Clyde district, 9 m., 6 m., 60 m. Zetlands, 50 gr.
Aphrodite aculeata, Isle of Man, 18 n. Hebrides, 15 w.
—— *histrix?*, Dorset, 12 m. South Wales, 10 m. Isle of Man, 25 sh.
——, sp., Hebrides, 15 w., 25 gr. m.
Polynoe, sp., Anglesey, 12 s. Dorset, 7 w. Clyde, 50 m.

Zoophyta.

This department is in the same position as some of the preceding, so far as our lists are concerned, but the accumulation of authentic localities in Dr. Johnston's History is such as fully to remedy any deficiencies. In the supplement of that work, a most valuable paper on the distribution of Zoophytes in depth, on the north and east coasts of Britain, by Lieut. Thomas, R.N., should be consulted and taken in connection with the following record of localities.

Hydractinia echinata, South Wales, 10 gr. Anglesey, 12 s. gr. Isle of Man, 25 sh.
Eudendrium rameum, Clyde, 20 sh.
Tubularia indivisa, Dorset, 15–20 gr. Clyde, 40 st., 7 m. Hebrides, 30 m., 40 m. Zetlands, 50 gr.
—— *larynx*, Anglesey, 12.
Corymorpha nutans, Orkneys, 10 f. Zetlands.
Halecium halecinum, Dorset, 15–20 gr.
Sertularia polyzonias, Anglesey, 12 gr. Devon, 7–12 gr. Clyde, 40 sh.
—— *rosacea*, Dorset, 15–20 gr. Hebrides, 90 gr. s., 15, 20 gr. m. Zetlands, 50 gr.
—— *pinaster*, Clyde district, 40 sh.
—— *abietina*, Devon, 10–12 gr. Anglesey, 12 f. gr. Clyde, 40 sh. Hebrides, 12–14 s. m., 15–20 st. Orkneys, 35–40 sh. Zetlands, 50 gr.
—— *argentea*, Dorset, 15–20 gr. Anglesey, 7 gr., 12 s., 20 gr., 20 m., 30 gr. Isle of Man, 25 sh. Zetlands, 80 s.
—— *cupressina*, Dorset, 15–20 gr. Devon, 7–12 m. s.
Thuiaria articulata, Clyde, 40 sh. Isle of Man, 25 sh.
Antennularia antennina, Dorset, 15–20 gr. Cornwall, 27 st. Devon, 20–25 s.
—— *ramosa*, Anglesey, 12 gr. Isle of Man, 15–18 n., 25 sh. Clyde, 40 sh. Hebrides, 25 s. st., 25 gr. m., 20 gr., 15–20 gr. m. Stornoway, 18 n. Zetlands, 50 gr.
Plumularia falcata, Devon, 7–12 st. Anglesey, 7 s. s., 12, 14 st., 20 gr. Clyde, 40 sh. Zetlands, 50 gr., 80 m. s.
—— *cristata*, Hebrides, 10 m., 20 gr., 15–20 sh., 30 gr. Dorset, 15–20 gr. Cornwall, 20–25. Devon, 27 s.
—— *catherina*, Clyde, 40 sh. Isle of Man, 25 sh.
—— *myriophyllum*, Cornwall, 20–25 sh. Dorset, 15–20 gr. Isle of Man, 25 sh. Clyde, 40 sh. Hebrides, 12–14 st. m., 15 m., 15–20 sh., 90 gr.
Laomedea, sp., Dorset, 15–20 gr.

Campanularia volubilis ?, Dorset, 15–20 n. Clyde, 40 sh.
—— *verticillata*, Clyde, 15 m.
—— *dumosa*, Devon, 20–25 sh. Isle of Man, 25 sh. Hebrides, 25 sh. Zetlands, 50 gr.
Pennatula phosphorea, Clyde, 9 m. Hebrides, 15 m. Zetlands, 80 m. s.
Virgularia mirabilis, Clyde, 9 m. Zetlands, 70–80 s. Hebrides, 28 m.
Pavonaria quadrangularis, Hebrides, 12–14 st. m., 15 m., 20–30 m.
Gorgonia verrucosa, Cornwall, 20–25 sh.
—— *pinnata*, Hebrides, 30 st.
Alcyonium digitatum, Dorset, 15–20 gr., 21 sh. Devon, 7–124. Cornwall, 20–25 sh. Anglesey, 12 gr. Isle of Man, 18 n., 25 sh. Clyde, 30 gr. Hebrides, 25 st.
Sarcodictyon catenata, Clyde, 20 st. Hebrides, 20 st., 15–20 sh., 25 gr. n., 25 st., 20–30 st.
—— *agglomerata* (new), Hebrides, 30 st.
Turbinolia milletiana, Cornwall, 20–28.
Caryophyllia Smithii, Cornwall, 20–25 sh., 27 gr. Hebrides, 7 s., 10 s., 25 gr. s., 40 gr., 30 st. Outer Hebrides, 18 n., 15–20 gr. Zetlands, 50 gr., 70–80 s.
Zoanthus Couchii, Dorset, 15–20 gr. Cornwall, 20–25 st. Devon, 20–25 gr. Outer Hebrides, 18 n.
Capnea sanguinea, 18 n. Isle of Man.
Adamsia maculata, Anglesey, 12 gr. Isle of Man, 15–18 n., 25 sh. Hebrides, 15–20 st. Outer Hebrides, 25 s.
Actinea vermicularis, Zetlands, 50, 80 sh.
—— *crassicornis*, Anglesey, 16 st., 20 m. Isle of Man, 18 n.
—— *bellis*, Isle of Man, 18 n.
—— *dianthus*, Anglesey, 12 s. gr.
—— other species, Anglesey, 7 s. Dorset, 7 m.
Iluanthos scoticus, Clyde region, 4 m.
Lucernaria fascicularis, Zetlands, 4–7 w.

Amorphozoa.

Halichondria oculata, Dorset, 7 w.
—— *cervicornis*, Zetland, 80 st.
—— *infundibuliformis*, Clyde district, 40 st.
—— *ventilabrum*, Hebrides, 30, 40 st.
—— *suberea*, Dorset, 15–20 gr. Isle of Man. 25 sh. Hebrides, 10 s. m.
—— *ficus*, Isle of Man, 25 sh.
—— *hispida*, Cornwall, 20–25 sh.
Cliona celata, Anglesey, 12 s. South Wales, 12 gr. Isle of Man, 18, 25 st. Hebrides, 18 n. and m.
Spongia pulchella, Isle of Man, 25 st.
Grantia ciliata, Devon, 7–12 m. st. Cornwall, 20–25 st. Anglesey, 9½ gr. Isle of Man, 15–18 n. Hebrides, 25 gr. s.? Zetlands, 50 gr.
Duseidea fragilis, Isle of Man, 25 sh.

Plants.

The greater part of these dredgings are beyond the region of the majority of algæ. Between 0 and 10 fathoms, numerous fuci were taken, olivaceous species prevailing in the lesser depths, red ones in the greater. *Delesseria* and *Desmarestia* are the genera of which species were met with at most considerable depths, *i.e.* at 15 and 18 fathoms (Hebrides). A straggling *Laminaria* was once taken as deep as 18 fathoms in the Zetlands. Beyond

15 fathoms, and between that depth and 20 fathoms, we have the region of *Nullipora*. Below 20 fathoms, unless it be an occasional straggling *Nullipora*, no decided algæ were met with.

Traces of Vertebrata and land animals.—Had we no other evidence of the inhabitants of the sea than that afforded by the contents of the dredge, we might be tempted to infer a great rarity, almost amounting to an absence, of vertebrate marine animals within our area. Possibly such an inference would be quite as warrantable as the negative conclusions assumed from comparable observations by many palæontologists and geologists, who sometimes go so far as to infer an entire absence of terrestrial creatures during some of the more ancient geological epochs, because no traces of them can be found in sedimentary strata of marine origin, and announce the laws which regulated the order of creation of animated beings accordingly. During the 145 detailed observations which form the bases of this Report, fishes were taken by the dredge not half-a-dozen times, and in three instances the fish taken was one of the rarest and most curious of British vertebrata, the *Amphioxus lanceolatus*. Although always carefully looked for and noted, the bones of fishes were never observed among the contents of the dredge above three times, and in two of those instances (at a depth of 40 and 50 fathoms mud in the western coast of Scotland) the remains consisted of otolites only, reminding us of similar relics in the crag of the east of England. Of terrestrial vertebrata I have never seen a trace; and though no small number of the human race have diffused their bodies over our sea-bed, no human bone has occurred to me in dredging; when very near shore and in the immediate neighbourhood of a town, broken bottles and old shoes have strewn the sea-bed, affording unquestionable evidence of the presence of man on the neighbouring shores. Doubtless by dredging close to towns, in harbours and in estuaries, like the Mersey, where there are great cities on the banks, numerous relics of such a description, as well as the bones of animals, might be taken, but immediate proximity to towns is avoided by the dredger.

On one occasion, recorded in the dredging papers from the Anglesey coast, the shell of a common snail (*Helix aspersa*) was dredged at some distance from shore in the entrance of the Menai Straits. It was covered by *Balani* and *Serpulæ*, and inhabited by a hermit crab. Naturalists familiar with the active movements of the *Paguri*, can readily conceive to what a distance a land shell may be transported under such circumstances, and at length become imbedded along with the remains of creatures of very different origin and habits.

Fossil remains taken in the dredge.—In no instance have we taken the remains of fossil vertebrata when dredging on the western shores of Britain, but many times have met with fossil testacea. These are of the pleistocene epoch, and often it requires a practised eye to distinguish between them and the dead shells of existing mollusca associated with them; indeed there are some species, as *Astarte crebricostata*, *Natica grœnlandica*, *Panopæa norvegica*, *Tellina proxima* and *Scalaria grœnlandica* enumerated in the preceding pages, which, whilst from various considerations we hold the weight of evidence to be in favour of their presence as living species in our seas, are yet under suspicion, and are not admitted by all British conchologists. In several localities among the Hebrides, especially in the Kyles of Bute, and in the sea between Raza and Applecross, quantities of pleistocene fossils may be dredged; at the former place, *Panopæa norvegica* is common, as pointed out by Mr. Smith; and in the latter there occur numerous fossil valves of *Pecten islandicus* and *danicus*, the large sulcated variety of *Saxicava rugosa*, *Astarte elliptica*, *Leda truncata* and *oblonga*, and very lately *Leda thraciæ-*

formis: of these, *Pecten danicus* and *Astarte elliptica* are living inhabitants of the Scottish seas, the latter in places still abundant, the former very rarely taken alive, though the dead shells occur in such vast quantities, that we cannot but regard it as a species which has lived on since the glacial epoch, though gradually becoming reduced in numbers, and now very nearly extinct. These shells often occur at considerable depths, and almost always on a bottom of dark pleistocene sand. *Pecten islandicus* is enumerated in Hebridian and Zetland dredging papers from depths of 30, 40, 50 and 90 fathoms. That this remarkable species is extinct in our seas we can scarcely doubt, but I have good reasons for surmising that its extinction has taken place at a period considerably later than that of several of its glacial companions. The colours of this *Pecten*, as well as of some other pleistocene fossils, are beautifully preserved, and the general aspect of the shells is very deceptive.

Occasionally, fossils of older date, but in such a condition of petrifaction as can lead to no mistake respecting their origin, are brought up in the dredge. Thus Mr. MacAndrew has dredged the loose joints of Liassic pentacrinites off the Shiant Islands, and we have seen Oolitic testacea dredged in the sound between Scalpa and Raza.

General Considerations.

Numerical distribution of species in depth.—Of the species of Testaceous Mollusca enumerated in the preceding tables, I have assigned a range to 188 in the Scottish, and 183 in the English sections. Of the 188 Scottish sublittoral species, whose range in depth I venture to state, 96 are Gasteropodous Testacea, and 92 Acephala. Of these, 17 univalves and 11 bivalves inhabit the region between low-water mark and 15 fathoms, *i. e.* the Laminarian zone; 8 univalves and 7 bivalves extend their range from within the Laminarian zone to a depth between 15 and 30 fathoms; 26 univalves and 11 bivalves from the Laminarian zone to between 30 and 60 fathoms; and 25 univalves and 53 bivalves, from the Laminarian zone to a depth between 60 and 100 fathoms: 3 univalves and 4 bivalves are confined in their range between 15 and 30 fathoms, *i. e.* to the Coralline zone; 1 univalve to between 30 and 60 fathoms; 4 univalves and 1 bivalve to between 30 and 100 fathoms; and 1 univalve and 1 bivalve to between 60 and 100 fathoms.

Of the 183 in the English tables, 19 univalves and as many bivalves are from the Laminarian zone only; 45 univalves and 46 bivalves range from some point within the Laminarian zone to between 20 and 30 fathoms; 16 univalves and 28 bivalves extend their range from the same region to between 30 and 60 fathoms.

It is evident that the capacity of bivalves to enjoy a great bathymetrical range exceeds considerably that of univalves. This power of enduring many conditions of depth, implies the power of adapting themselves to varying circumstances, which cannot be supposed to exist without considerable variation in the features of the individuals of such wide-ranging species. The rules which should guide us in determining the selection of diagnostic characters from the shells of Acephalous mollusks, must consequently be less strict than those which should determine our selection of characters for the majority of Gasteropoda, and in the determination of fossil species this should constantly be borne in mind. The difference of power to range presented by univalves as compared with bivalves, has a further important bearing on palæontological inquiries, for it would indicate the probability of our not unfrequently finding geological formations connected together by the fossils of the one class of mollusca, whilst those of the other are altogether distinct, even in strata proximate in time. It is possible also, that by a careful determination of the relative proportions of bivalves to univalves in ancient sea-beds, all mineral indications of the nature of the sea-bed being at the same time noted, we may get at an additional clue to the determination of the depth of the ancient sea in which such animals lived.

The distribution of the sub-littoral forms of testacea, as shown by our dredging papers, may be illustrated by the following examples:—

Certain species are common to the Laminarian, Coralline and Deep-sea Coral Zones, as—

Psammobia ferroensis.
Syndosmya intermedia.
Venus striatula.
Venus cassina.
Venus ovata.
Venus fasciata.
Cardium suecicum.
Cardium fasciatum.
Lucina borealis.
Lucina flexuosa.
Kellia suborbicularis.
Crenellæ.
Nuculæ.
Pinna ingens.
Pecten similis.
Turritella communis.
Cerithium reticulatum.
Natica Alderi.
Natica montacuti.
Nassa incrassata.
Aporrhais pes-pelecani.
Buccinum undatum.
Fusus antiquus.
Fusus gracilis.
Trophon Barvicense.
Clavatula linearis.
Trichotropis borealis.
Eulima distorta.
Eulima subulata.

Some of them, under rare circumstances, as in a few localities (Skye and the lochs of Ross-shire) in the West Highlands, are found occasionally living at low-water. I have before called attention to this fact, and to the circumstance that on the neighbouring shore in such localities the alpine plants descend from the mountains and are distributed along the water's edge. I am strongly impressed with the suspicion that this curious phænomenon, so far as I have observed it, always seen in connexion with the neighbourhood of outliers of the glacial submarine fauna, has a relation, as yet unexplained, with the history of the changes in the configuration and elevation of land at the close of the glacial epoch.

Certain species are common to Laminarian and Coralline Zones, and indifferently inhabit both, as—

Cypræa europæa.
Natica helicoides.
Eulima polita.
Velutina lævigata.
Mactra elliptica.
Artemis exoleta.
Artemis lincta.
Circe minima.
Tellina donacina.
Lucinopsis undata.
Lepton squamosum.
Lima hians.
Lima Loscombi.
Modiola modiolus.
Ostrea edulis.
Pecten varius.

Certain species commence their range in the Coralline Zone, as—

Rissoa abyssicola.
Pleurotoma teres.
Cemoria noachina.
Propilidium fulvum.
Pilidium ancyloides.
Nucula tenuis.
Arca raridentata.
Cerithium metula.
Trochus alabastrum.
Fusus islandicus.
Neæra costellata.
Neæra abbreviata.
Leda pygmæa.

And it is curious to observe that all these are members of the Scandinavian fauna.

A few species appear to be confined to the region of deep-sea corals; as *Apor-*

rhais pes-carbonis, *Poromya granulata*, *Tellina proxima*, probably *Terebratula cranium*, and a few Echinoderms and Zoophytes.

Certain species which enjoy a great vertical range in the north, extending through the second, third, and in part the fourth regions of depth, are in the south found only within limited tracts of deep-sea, as—

Cardium suecicum.	Syndosmya intermedia.
Nucula polii.	Terebratula Caput-serpentis.
Pecten fuci.	Scalaria Trevelyana?.

These species are essentially members of the boreal or glacial fauna, and their presence in the south is dependent, if my views be correct, on the former spread of the glacial sea, and the preservation of its inhabitants at the existing epoch in many isolated and distant localities, where they live usually at considerable depths in the midst of, and mixed up with an assemblage of creatures of a Celtic and often a much more southern character.

How far the nature of the sea-bottom determines the number and diffusion of species.—In the preceding tables, the nature of the sea-bed is expressed by letters representing the several mineral characters of the bottom, whether sand, sandy mud, mud, rock, stones, gravel, muddy gravel, shelly, shell-sand, or nullipore; the last kind of bottom being that commonly called "coral" in the charts of the European seas.

Now, though our evidence certainly goes to show that the range of species in depth and distance from shore is often considerably extended by a continuity, whether vertical or horizontal, of the same kind of ground, yet assuredly ground alone will not determine the extension of any species; for otherwise we should have the stone- and gravel-inhabiting species of the Littoral zone carried in many places into the Laminarian and Coralline zones, and the peculiar inhabitants of the muddy and sandy tracts in the Laminarian zone carried far into the depths of the sea, since in very many places these kinds of sea-bed range without interruption from shallows to great depths. But this is not the case; no continuity of mud, for instance, enables *Scrobicularia* to live beyond its bounds, or the characteristic *Rissoæ* of the gravelly parts of the Laminarian zone to extend themselves into the deep sea.

The conditions of the sea-bottom which are most favourable to variety of species may best be illustrated by referring to those dredging papers in which the number of species of either univalve or bivalve testacea taken alive exceeded ten. In the southernmost of the districts within the area under consideration, out of eighteen papers ten come under this category. Three of these belong to the Laminarian zone, five to the Coralline region, and two to the upper region of deep-sea corals. The three first-mentioned are all from a muddy and stony or gravelly bottom with weed, and within two miles of the shore; their number of univalves exceeds that of bivalves; in all three the number of living univalves is very high, being 15 and above; and in two of them the numbers of living bivalves are respectively 10 and 19, and of dead 9 and 12. Of the five papers from the Coralline zone, four are within three miles from the shore; three of these are from bottoms more or less stony and gravelly, in one instance mingled with nullipore; and one is from a floor of shell sand. They are also very prolific; one in dead and living univalves, one in dead and living bivalves, and two equally so in bivalves and univalves. The fifth of these coralline papers is from a depth of 30 fathoms and under, and a bottom of sand and gravel at a distance of 11 miles from shore; it exhibits a great preponderance of bivalves, and an equal number of species taken dead and alive. The two deep-sea papers are from a depth of 50 fathoms, on a sandy bottom, 60 miles from land; they scarcely come under the head of prolific papers, since few living species were taken, though many dead, the number of dead univalves predominating in the one instance, and of dead bivalves in the other, respectively 17 and 20, both high numbers.

Twenty-six papers from the Irish sea relate to a sufficiently limited range in depth to admit of a similar inquiry. Of these, eight included more than 10 species of univalves and bivalves, or both. Two are from the Laminarian zone, and within 2 miles from shore; in the one instance, where the bottom was gravelly and stony, univalves prevail, and those alive; in the other, where it was sandy, bivalves prevail, and those mostly dead. The remaining five papers are from the Coralline zone; in three of them, where the bottom was a scallop bank several miles from shore, the number of both bivalves and univalves taken alive was very considerable, reaching in one instance respectively to 21 and 27. In one, from a nullipore bottom one mile from shore, univalves prevail, but bivalves are also abundant. In one, on a gravelly and stony bottom near shore, bivalves prevail (the numbers being 24 living and 25 dead), but univalves are also plentiful.

Among sixty-four dredging papers from the Clyde district and the Hebrides, twenty-two exhibit numbers either of bivalves or univalves above 10; of these three come within the Laminarian division, and one from depths very close to shore; in two of these the number of species of living univalves prevails; in one, of the bivalves. From the upper part of the Coralline zone there are eleven papers, in six of which the bivalves prevail, all from muddy or sandy bottoms, sometimes mixed with stones, close to shore; in two, univalves prevail over bivalves, in gravelly and stony bottoms near shore; and in two, the numbers are nearly equal on stony and mixed bottoms near to shore. From depths between 40 and 60 fathoms, there are six prolific papers, all richer in bivalves than in univalves, and all from sandy, gravelly or muddy beds, varying from two to ten miles from shore. A bottom of gravel and sand in 90 fathoms, close to shore, is richest in bivalves.

Of thirty papers from the Zetlands, sixteen are rich in species; one only is from the Laminarian zone, on a sandy bottom, especially rich in living bivalves (30), and having many (15) univalves also. Of two, from the upper part of the Coralline zone close to shore, one, with a nullipore and stony bottom, is richest in univalves; the other, from a shelly bed, in bivalves. Of the thirteen remaining papers from depths between 40 and 100 fathoms, eight present considerable numbers of both univalves and bivalves, and in five (all from depths below 60 fathoms) bivalves prevail. The numbers of species of bivalves are high in the depths at a considerable (30 to 100 miles) distance from shore. The bivalves are also predominant at these great depths on more or less muddy bottoms, and at the farther distances; the univalves most numerous alive where the bottom is more or less stony.

Gregarious and prolific species.—Many of our littoral mollusca, as the shore-living species of *Littorina*, *Purpura*, *Trochus*, *Cardium*, *Donax*, *Scrobicularia*, *Mya*, *Pholas*, &c., are truly gregarious, and the individuals of each are constantly found assembled together in considerable numbers. This is not so commonly the habit among sub-littoral species; among them, however, there are some habitually gregarious (as *Ostrea edulis*, *Pecten opercularis*, *Corbula nucleus*, *Syndosmya alba*, *Pectunculus glycimeris*, *Modiola modiolus*, and *Turritella terebra*; and among radiata, *Ophiura rosula*, *Uraster rubens*, *Comatula europæa*, *Echinus sphæra*), though with this difference as compared with most littoral gregarious forms, that whereas the individuals of the latter are always assembled together, the sub-littoral species are gregarious in some zones of depth, and under certain conditions of sea-bottom, whilst they are at the same time diffused in small numbers, or even as solitary individuals in situations where the conditions do not seem so favourable to fecundity. Many species also, not at all gregarious in the true sense of the word, having a very wide range in depth, are not equally prolific throughout that range, but are developed in much greater numbers in one region than in another, or in different parts of the same region according to the conditions of the sea-bed. Climatal differences also have a considerable effect in determining the prolific or non-prolific character of a species, and this may be observed clearly, even in such a limited area as that under review. Hence, when we state of many species that they are diffused throughout all the provinces of that area, it is not to be understood that they are equally abundant, so far as their individuals are concerned in all. Thus, for example, *Dentalium entalis* is distributed throughout the British seas; but, whilst it is so abundant as to be almost gregarious in the northern provinces, it becomes scarce and solitary in the southern. Many examples of this may be seen by consulting the analysis of dredging papers in the preceding tables, and afterwards comparing them with the tables of enumeration of localities of species.

In the Littoral region, as mentioned already, the species of *Littorina*, *Trochus*, *Patella* and *Purpura* are most abundant, and among bivalves, *Mytilus edulis*, *Cardium edule* and *Kellia rubra*. These, with many other animals, and with peculiar marine plants, which it is not the province of this Report to enumerate, give a character to the sea-belt between tide-mark*.

In the Laminarian region, extending from low-water mark to 15 fathoms or thereabouts, *Lacunæ* and *Rissoæ* are abundant. The species observed to be most prolific within this region during the dredging researches on the English shores, were *Rissoa parva* and *interrupta*; in Laminarian shallows, *Lacuna puteolus*, *Rissoa labiosa* and *Phasianella pullus*, where Zostera prevailed; *Trochus cinereus*, *Magus* and *Ziziphinus*, *Acmæa virginea*, *Modiola modiolus*, *Nucula nucleus* on muddy gravelly bottoms; *Turritella*, *Corbula nucleus*, *Syndosmya alba*, *Dentalium tarentinum*, *Ophiocoma rosula* in *sandy* and *muddy* places; *Solen pellucidus* and *Mactra subtruncata* where sand prevailed; *Chiton asellus* everywhere where shells or stones were present; *Echinus miliaris* on many bottoms; *Ascidiæ* and *Crustacea* everywhere.

On the Scottish shores in like depths, most of the above-named forms (except the *Rissoa labiosa*, *Phasianella*, *Lacuna* and *Dentalium tarentinum*) were equally prolific, whilst others seldom observed in great numbers in the south became very plentiful, as *Dentalium entalis*, *Lucina flexuosa*, *Lima hians*, *Venus striatula*, *Ophiocoma chiagii*; and in places, *Cardium pygmæum*, *Crenella decussata* and *Bulla akera*.

Between 15 and 25 fathoms in the upper part of the Coralline zone, *Trochus ziziphinus* and *tumidus*, *Chiton asellus*, *Acmæa virginea*, *Nassa reticulata*, *Turritella*, *Venus ovata* and *V. fasciata*, *Pecten opercularis*, *Modiola modiolus*, *Crenellæ*, *Pectunculus*, *Nucula nucleus*, abound in individuals on the English shores. The same species, with the addition of *Astarte sulcata* and *A. elliptica*, *Syndosmya intermedia*, *Lima subauriculata*, *Leda caudata*, *Cardium fasciatum* and *Lucina sinuata*, mark the same region in the Scottish seas. In both north and south *Echinus sphæra* and *Ophiocoma* are very prolific in this belt.

Between 25 and 40 fathoms, in the middle and lower sections of the Coralline region, the species observed most prolific in individuals on the English coast were few, comprehending *Solen pellucidus*, *Pecten varius*, *Modiola modiolus* and *Dentalium tarentinum*.

* For a tabulated view of the subdivisions and inhabitants of this zone, see the first volume of the Memoirs of the Geological Survey of Great Britain.

On the Scottish coast this region is remarkable for prolific and peculiar species. Great numbers of Brachiopoda (*Terebratula Caput-serpentis*, and *Crania norvegica*) are found in gravelly and stony places. *Dentalium entalis*, *Nucula nucleus*, *Astarte sulcata*, *Leda caudata*, and (in places) *L. pygmæa*, *Mactra elliptica* and *Modiola modiolus*, are all very prolific.

Between 40 and 60 fathoms, on the verge of the region of deep-sea corals, we have too little experience on the English coast to judge. *Cardium suecicum*, however, essentially a northern form, was noted as abundant at a depth of 50 fathoms between Cornwall and Ireland.

In the Scottish seas between these depths, besides most of the species noted as prolific in the last region, we find *Nucula tenuis*, *Cardium suecicum*, *Nucula decussata* (locally) and *Venus fasciata* abundant; also *Turritella* in places. Below that depth, *Leda caudata*, *Syndosmya intermedia*, *Venus ovata* and *striatula* (var.), *Lucina spinifera*, *Dentalium entalis*, *Turritella*, *Ditrupa* and *Echinus norvegicus*, have been taken in considerable numbers in several Scottish localities. Widely diffused species of *Turritella*, *Dentalium*, *Modiola*, *Nucula*, *Venus* and *Astarte*, appear to be most prolific throughout the range of their distribution.

Generic and subgeneric groups confined to particular zones in depth.—In the Littoral and Laminarian zones, we find all the species of certain well-marked natural groups assembled, but very few, if any, of those which are distributed in the regions of corallines and of deep-sea corals are peculiar, the species of mollusks in the lower zones especially, being members of genera which have representatives in the Laminarian or in both Littoral and Laminarian zones. Within the two higher zones we find all the British species of *Patella*, *Purpura*, *Littorina*, *Otina*, *Conovulus*, *Truncatella*, *Calyptrea*, *Lacuna* (except *L. crassior*), *Aplysia*, *Scrobicularia* and *Donax*. Almost, though not entirely confined to them, are also the genera *Phasianella*, *Mya*, *Lutraria*, *Mytilus*, *Pholas* and *Cytherea*. Some important genera, such as *Rissoa*, *Chiton*, *Trochus*, *Mactra*, *Venus*, *Bulla* and *Cardium*, are mainly developed in the Laminarian zone. In the genus *Patella* we have one section, that of *Patella* proper, confined to the Littoral zone, and another, *Patina*, confined to the Laminarian zone. The subgenus *Hydrobia* of *Rissoa* is almost wholly littoral. Very rarely do we find instances of a species strictly littoral descending far into the Laminarian zone or below it; on the west coast of Anglesey *Purpura lapillus* was dredged in 10 fathoms, and three specimens taken at that depth were remarkable for the development and perfection of the crenulated laminæ of growth on the surface of the shell. *Rissoa Barleii* of Jeffreys appears to be a variety of the littoral *Rissoa ulvæ*, descending below its usual level. More frequently do we find mollusks and radiata of the Laminarian zone and the upper part of the region of Corallines ascending into the littoral belt. This is especially the case in certain localities on the Hebrides, as in Skye and on the west coast of Argyleshire; and very generally is it to be observed, as the registrar pointed out to the Natural History Section in 1836, in the immediate neighbourhood of those localities where alpine plants, such as *Silene acaulis* &c., are found abundantly near the water's edge.

Certain genera, such as *Neæra*, *Crania*, *Pilidium*, *Cemoria* and *Propilidium*, have, so far as the area under review is concerned, a range in depth entirely confined to the Coralline region and that of deep-sea corals. But elsewhere species of these genera ascend into the Laminarian, and possibly some of them into the Littoral zones, so that great stress cannot be laid upon their distribution as genera indicative of depth. Very important, however, are the facts stated with regard to the Laminarian and Littoral genera; and the geologist will do well to bear in mind that *entire well-marked generic groups of testacea are confined to, and indicate with certainty, the space between tide-marks and the sea-bed to a depth of about* 15 *fathoms below low-water mark.*

Relation of colour to distribution.—Although the extent and depth of our seas scarcely afford sufficient data for illustrating the influence of light in the colouring of marine animals, yet some facts bearing on this subject may be gathered from the papers before us. In the horizontal diffusion of species, several, as some of the *Trochi* and *Veneridæ*, exhibit a distinct influence of light upon the brightness of their hues, in the south, as compared with the dull aspect of specimens from the north, and this in individuals of the same species. It is easy for the practised conchologist to distinguish specimens of most painted shells, gathered on the southern coasts of England, from those taken on other parts of our shores. We have evidence also of the distinct effect of depth in the defacing of the hues of the same species, when it has a great bathymetrical range. Thus the examples of *Venus striatula, Venus ovata* and *Turritella terebra* (all having a range from the Laminarian zone to the deepest recesses of the British seas), taken alive at a depth of 100 fathoms off the Zetland Isles by Mr. MacAndrew, were colourless; whilst those from more moderate and shallow depths are almost always conspicuously coloured. Between 60 and 80 fathoms in the Scottish seas, dirty white, dull red, yellow or brown, rarely broken into stripes or bands, are the prevailing hues of the testacea; though at 50 fathoms, shells painted in patterns and vividly coloured (as *Natica Alderi* and *Clavatula purpurea*), exhibit their hues unimpaired. At the same time it must not be forgotten that the vividly painted animal of the coral *Caryophyllia* thrives at a depth of 80 fathoms. A curious phænomenon apparently connected with depth is the blindness of the crustacean *Calocaris.*

Condition of the exuviæ of marine invertebrata taken in the dredge.—In the great majority of instances and places, the dead shells of mollusca are taken nearly entire, or, in the case of the bivalves, with the valves disunited but not broken. This applies especially to all localities of a considerable depth, and where strong currents are not in action. Very near the shore, broken shells are not uncommon; and in current-ways, even at the depth of 30 fathoms, the bottom may be composed in great part of triturated shells. Lieut. Thomas, R.N., observes, when communicating his lists of Testacea dredged around the Orkney Islands, that "between Fair Island and the Orkneys, the bottom near the latter islands is either rocky or composed of large pieces of *Modiola modiolus* or *Pectunculus glycimeris.* I make no doubt," he remarks, "that these are broken by some large species of Crustacea (?); their freshness of fracture is astonishing, as if the creature feeding had been disturbed at his meal." Among bivalves, besides those mentioned, the shells of *Thracia, Cyprina, Isocardia,* and the larger species of *Cardium* are most frequently found broken; among univalves, those of *Buccinum* and *Fusus.* Some few bivalves are frequently dredged dead, yet with their valves united; such are *Lucina radula,* the *Neæræ, Mactra elliptica, Psammobiæ, Venus ovata* and *striatula, Tapes virginea, Tellina donacina, Thracia phaseolina, Lucinopsis, Nucula pygmæa, Solens, Syndosmyæ* and *Pectunculus pilosus,* this last open and gaping. The monomyarious bivalves are often found dead in quantities, but almost always with valves disunited; and this may be said of the great majority of dimyarious bivalves also. Echinoderms fall to pieces when dead, or if taken entire have lost their spines.

Phænomena of the horizontal distribution of species on the western shores of Great Britain.—In the older accounts of British marine animals, the phrase "from Devon to Zetland" was frequently given as marking their range, and the natural inference from such statement was that such species were universally diffused through our seas. The researches embodied in this Report, however, put beyond question the fact that there are marked peculiarities in the distribution of British marine animals, and that though there are numerous species common to the whole area, there are also numerous species peculiar to parts of that area. We have clear evidence of more elements than one contributing to the composition of our submarine population, of a southern element, derived from the Lusitanian provinces of the European seas, of a northern element introduced from the Scandinavian seas, of a Celtic element having its centre within our own region, of an oceanic element manifested by the floating Gasteropoda and the Pteropoda that reach our shores, and of an arctic element due to causes which were in action before the British Isles had assumed their present conformation *. The following statements, founded mainly on the data contained in the preceding tables, will servé to illustrate the phænomena, so far as this Report is concerned.

The northern and southern provinces of the western coast of Great Britain may be distinguished by certain Mollusca of the Littoral Zone.—Thus, in the extreme south, along the shores of the English Channel, we find *Truncatella truncatula*, and there only. *Trochus lineatus* commences its range to the west of Portland Island, and is found around the coasts of Devon, Cornwall and the Bristol Channel, until it ceases in Cardigan Bay or a little higher up; a similar cessation of its diffusion taking place on the opposite shores of Ireland. *Acmæa testudinalis*, on the other hand, appears in the Orkneys (its presence in the Zetlands is doubtful), and ranges through the Hebrides and the Clyde region until it reaches the northern shores of Ireland and the northern coast of the Isle of Man; but it is not found on coasts southwards of those points. *Chiton marmoreus* ceases sooner; *Littorina petræa* is abundant in the British Channel, and equally plentiful in the Hebrides, but rare in the central part of the Irish sea. All the other *Littorinæ*, *Chiton marginatus*, *Rissoa parva* and *cingillus*, *Patella vulgata*, *Trochus cinerarius*, *Purpura lapillus*, *Skenea planorbis*, *Mytilus edulis* and *Kellia rubra*, are common throughout the area, even as they are all round the shores of the British Isles. *Trochus umbilicatus* is equally abundant throughout the area, whilst on the other hand it is entirely absent from the eastern coast of Britain.

The differences between the northern and southern provinces are equally shown by the sublittoral testacea.—These are evident,—1st, in the presence of a number of species in the south which are not found in the north, and *vice versâ*; and 2nd, in the greater frequency of the individuals and localities of certain species as we proceed from south to north, and *vice versâ*; thus—

1. The following testacea are confined to the extreme south; they are all Spanish or Mediterranean species:—

Trochus striatus.	Pholas parva.
Trochus exiguus.	Ervilia castanea.
Chemnitzia fenestrata.	Cardium rusticum.
Volva patula.	Crenella rhombea.
Pholadidea papyracea.	

2. The following species are peculiarly southern, but more general than the former; they are also species of the Mediterranean and Lusitanian type:—

* See the Memoir on the British Fauna and Flora, in the first volume of the Memoirs of the Geological Survey.

Dentalium tarentinum.	Modiola barbata.
Emarginula rosea.	Arca lactea.
Adeorbis subcarinatus.	Cytherea chione.
Calyptræa sinensis.	Cardium aculeatum.
Scalaria clathratulus.	Diplodonta rotundata.
Nassa varicosa.	Venus verrucosa.
Chemnitzia scalaris.	Gastrochæna modiolina.

3. The following species increase in frequency of occurrence as we proceed from north to south:—

Chiton fascicularis.	Cerithiopsis tubercularis.
Trochus granulatus.	Clavatula rufa.
Rissoa crenulata.	Modiola tulipa.
Scalaria clathrus.	Mactra subtruncata.
Cerithium adversum.	Pecten varius.

4. On the other hand, a greater number of species become more frequent in proceeding from south to north, showing thereby the more powerful influence of the Scandinavian element in our fauna:—

Dentalium entalis.	Tapes pullastra.
Chiton cancellatus.	Cyprina islandica.
Emarginula Mulleri.	Astarte danmoniensis.
Trochus millegranus.	Astarte compressa.
Lacuna crassior.	Lucina borealis.
Chemnitzia fulvocincta.	Lucina flexuosa.
Eulimella MacAndrei.	Modiola vulgaris.
Natica Montagui.	Leda caudata.
Fusus gracilis.	Lima subauriculata.
Trophon Bamfium.	Pecten tigrinus.
Bela turricula.	

5. The power of the Scandinavian element is still more strongly shown in the number and character of species, which are peculiarly northern:—

Chiton Hanleyi.	Bulla akera?.
Acmæa testudinalis.	Bullæa quadrata.
Propilidium ancyloide.	Bullæa scabra.
Scissurella crispata.	Pecten danicus.
Chemnitzia rufescens.	Pecten striatus?.
Natica grœnlandica.	Crenella decussata.
Velutina plicatilis.	Crenella nigra.
Trichotropis borealis.	Pecten niveus.
Trophon Barvicense.	Astarte elliptica.
Bela decussata.	Astarte crebricostata.
Mangelia brachystoma.	Lucina ferruginosa.
Mangelia Boothii.	Poromya anatinoides.
Bulla hyalina.	Neæra costellata.
Bulla Cranchii.	Neæra abbreviata.

To which may be added certain species found in the southern part of the British seas only in a few isolated patches, spaces which I regard as "glacial outliers," as—

Pilidium fulvum.	Nucula decussata.
Emarginula crassa.	Nucula tenuis.
Rissoa abyssicola.	Leda pygmæa.
Scalaria Trevelyana.	Neæra cuspidata.
Terebratula Caput-serpentis.	Syndosmya intermedia.
Crania norvegica.	Cardium suecicum.
Arca raridentata.	

6. There are also a number of species confined to the extreme north; as—

Trochus alabastrum.	Natica helicoides.	Astarte arctica.
Cerithium metula.	Fusus albus.	Tellina proxima.
Aporrhais pes-carbonis.	Fusus decemcostatus.	Terebratula cranium.
Scalaria grœnlandica.		

7. A few, of which *Rissoa vitrea*, *Isocardia cor* and *Ostrea edulis* are examples, are very local in various degrees of abundance, the cause of their localization being obscure.

8. Certain species are more or less common at *both ends* of the area under exploration, though very rare or not found at all in the Irish sea; they can, most of them, however, be tracked making their way northwards along the western coast of Ireland.

Rissoa costata.	Marginella lævis.	Cardium pygmæum.
Rissoa zetlandica.	Psammobia costulata.	Lucina spinifera.
Cerithium reticulatum.	Diodonta fragilis.	Pinna pectinata.
Mangelia teres.	Tapes decussata.	Arca tetragona.
Mangelia costata.	Circe minima.	Pecten similis.
Mangelia attenuata.		

9. Not a few species appear to be equally diffused everywhere throughout our area; of these, there may be cited as examples,—

Chiton asellus.	Mangelia linearis.	Tellina crassa.
Acmæa virginea.	Cypræa europæa.	Tellina donacina.
Trochus cinerarius.	Crenella discrepans.	Syndosmya alba.
Trochus tumidus.	Crenella marmorata.	Mactra elliptica.
Trochus ziziphinus.	Pectunculus glycimeris.	Tapes virginea.
Rissoa parva.	Nucula nucleus.	Venus ovata.
Rissoa striata.	Lima hians.	Venus fasciata.
Turritella terebra.	Lima Loscombi.	Venus cassina.
Aporrhais pes-pelecani.	Pecten maximus.	Venus striatula.
Natica Alderi.	Pecten pusio.	Artemis exoleta.
Buccinum undatum.	Pecten opercularis.	Artemis lincta.
Fusus antiquus.	Solen pellucidus.	Cardium fasciatum.
Trophon muricatum.	Psammobia ferroensis.	Kellia suborbicularis.

The harder Echinodermata exhibit similar phænomena of distribution.—Thus, *Cidaris histrix*, *Echinus norvegicus*, *Echinus neglectus* and *Euryale verrucosa*, are peculiarly and extreme northern species, and all of Scandinavian origin.

Brissus lyrifer (which occurs also in glacial outliers in the south), *Ophiocoma filiformis*, *Comatula petasus*, *Goniaster Templetoni* (i. e. *pulvillus*), and *Uraster rosea* (=*Cribella rosea*), are peculiarly northern.

Echinus Flemingii is northern and southern, but deficient in the interval.

Echinus sphæra and *Echinus miliaris*, with many of our starfishes, are general throughout the area.

Echinus Melo and the extra-limital *Echinus lividus* are peculiarly southern.

Similar peculiarities of distribution are shown by the soft Echinoderms, by the soft Mollusca and by the Zoophytes.

Numerical comparisons of the Testacea and hard Echinodermata inhabiting the regions explored, with the total number of British species.—In the following table, one of the striking features is the small number of testacea and hard echinoderms inhabiting the British seas, which do not live upon the western shores of Great Britain; such as are beyond their limits, are either of excessively southern and scarcely British character, as *Haliotis tuberculata*, *Jeffreysia opalina*, *Rissoa lactea* and *Murex corallinus*; or oceanic forms of *Ianthina*, *Hyalæa* and *Spirialis*; or species probably of arctic origin, extending only to our north-eastern coasts, as *Fusus norvegicus* and *Turtoni*, *Natica Kingii*, *Hypothyris psittacea* and *Goniaster equestris*. The number of doubtful or not sufficiently investigated forms is also very small. A considerable number of genera have no, or few, representative members in the Scottish and English columns of western sublittoral species; these are either extra-limital, as *Hyalæa*, *Haliotis* and *Hypothyris*; or excessively rare in our seas, as *Avicula*, *Stylifer*, *Cidaris* and *Astrophyton*; or oceanic, as *Ianthina* and *Spirialis*; or wholly or mainly littoral, as *Littorina*, *Otina*, *Conovulus*, *Truncatella*, *Jeffreysia*, *Skenea* (proper), *Patella*, *Pleurobranchus*, *Teredo*, *Xylophaga*, *Petricola*, *Venerupis*, *Ceratisolen*, *Turtonia*, *Galeomma*, *Mytilus*, *Asterina*. In *Odostomia* we have a genus which is not fairly represented on account of the excessively critical character of its species. Five genera of Gasteropoda, three of Lamellibranchiate acephala, three of Palliobranchiate acephala, and three of hard Echinodermata, all having members in the Scottish portion of the regions explored, are without representatives in the English western and southern provinces. On the other hand, seven genera of Gasteropoda and eight of Lamellibranchiate acephala having English representatives, are altogether wanting on the western and northern coasts of Scotland. All our brachiopods found within the area explored are Scottish species; the number of monomyarious Lamellibranchiata is slightly in favour of Scotland over England, which, however, shows a considerable majority of dimyaria. The proportion of Gasteropoda in the Scottish seas is, however, so great, that the total number of testacea is in favour of the north. This is to be attributed partly to the greater variety of depths and ground, and partly to the presence in the north of isolated colonies of arctic forms which swell the ranks of the inhabitants of those regions to beyond their natural proportions.

This table shows the total number of species of each genus of British testacea and hard Echinodermata, compared with the number of species recorded in the following tables of depths; the Scottish and English regions of the areas to which this Report is devoted, having the number of their species dredged in separate columns. In order to facilitate the comparison, and to show cause for the differences between the latter or district columns and the first or general enumeration, columns showing the number of species normally living in the Littoral and Laminarian zones, of obscure forms said to live within the area explored, and of British species found only beyond the limits of these areas, are inserted between. I have added for general comparison a column showing the number of species identical with existing British forms, of which we find fossil remains in the later British tertiaries, taking my data from the valuable monographs by Mr. Searles Wood. In two other columns, I have inserted in the one the total number of Scandinavian species of each genus in the British list, irrespective of identity, founding the list on Löven's researches; and in the other, the total number in like manner of Mediterranean species, founding the list on the works of Phillippi, on my Ægean lists, and on the dredging papers of Mr. MacAndrew. These two columns, when compared with the others, will afford not a few indications of the respective influences of the northern and southern elements in the British marine fauna. The numbers of the Scandinavian Echinodermata are taken from the excellent memoir by Duben and Koren.

British genera.	Total of British species.	Species inhabiting the Littoral zone.	Inhabiting the Laminarian zone.	Obscure species within described area.	British, without the limits of area.	No. of species in English papers.	No. of species in Scotch papers.	British later tertiary fossils identical with living British species.	Scandinavian species of these genera.	Mediterranean species of these genera.
TEST. MOLLUSCA.										
LAMELLIBRANCHIATA.										
Teredo	6	6	...	...	...	*	*	1	2	3
Xylophaga	1	1	...	...	...	*	*	0	1	0
Pholas	4	4	4	...	...	3	0	1	3	2
Pholadidea................	1	1	1	...	...	1	0	1	0	0
Gastrochæna	1	...	...	...	...	1	0	1	0	1
Saxicava................	2	...	2	...	...	2	2	2	2	2
Petricola................	1	1	1	1	...	*	0	0	0	1
Venerupis	1	1	1	...	...	*	0	1	0	2
Mya	2	2	1	...	...	1	1	2	2	0
Panopæa................	1	0	0	...	...	0	1	1	1	1
Corbula	1	0	1	...	...	1	1	1	2	2
Sphænia................	2	0	1	...	...	1	1	2	0	?
Neæra................	3	0	1	...	...	1	1	1	5	4
Poromya................	1	0	0	...	...	0	1	1	1?	1
Pandora	2	0	1	1	...	1	1	2	0	3
Lyonsia	1	0	1	...	...	1	1	0	1	1
Thracia	5	0	5	...	...	5	4	2	3	5
Cochlodesma	1	0	1	...	...	1	1	1	1	?
Soleu	4	2	3	...	...	3	3	2	3	5
Ceratisolen................	1	1	?	...	...	*	0	0	0	1
Solecurtus	2	0	0	...	...	2	2	0	1	2
Psammobia................	4	1	4	...	...	4	2	3	3	3
Diodonta	1	0	1	...	...	1	1	0	0	1
Tellina	9	4	7	...	...	8	7	6	5	13
Syndosmya................	4	1	4	...	...	4	3	3	3	3
Scrobicularia	1	1	1	...	...	1	*	1	1	2
Donax	2	2	1	...	...	1	*	2	1	4
Ervilia	1	0	0	...	...	1	0	0	0	1
Mactra	6	5	6	1	...	4	4	6	3	5
Lutraria	2	2	2	...	...	2	1	1	0	1
Tapes	4	3	4	...	...	2	3	3	3	6
Cytherea................	1	0	1	...	...	1	0	1	0	3
Venus................	5	2	5	...	...	5	4	3	4	6
Artemis	2	0	2	...	...	2	2	2	2	2
Lucinopsis	1	0	1	...	...	1	1	0	1	1
Cyprina	1	1	1	...	...	1	1	1	1	0
Circe	1	0	1	...	...	1	1	1	0	1
Astarte	6	0	4	...	...	2	6	6	4	4
Isocardia	1	0	0	...	...	1	1	1	1	1
Cardium................	8	1	3	...	...	8	7	3	7	17
Lucina	6	0	3	...	...	5	4	4	4	12
Diplodonta................	1	0	1	...	...	1	0	1	0	2
Montacuta	3	1	3	...	...	3	3	3	2	1
Turtonia................	1	1	0	...	...	*	*	0	1	?
Kellia	3	1	2	1	...	2	1	2	1	3
Lepton	2	0	2?	...	1	1	1	2	0	1
Galeomma	1	1	1	...	...	*	0	0	0	1
Mytilus	1	1	1	...	...	1	*	1	1	2
Modiola	4	1	4	...	...	4	3	3	1	4
Crenella	6	3	6	...	...	3	4	4	5	4
Nucula	5	0	3	...	...	4	5	3	4	5
Leda	2	0	1	...	...	1	2	2	4	2
Arca	3	0	2	...	...	2	2	3	3	9
Pectunculus	1	0	1	...	...	1	1	1	0	2
Avicula	1	0	0	...	...	*	0	1	0	1

British genera.	Total of British species.	Species inhabiting the Littoral zone.	Inhabiting the Laminarian zone.	Obscure species within described area.	British, without the limits of area.	No. of species in English papers.	No. of species in Scotch papers.	British later tertiary fossils identical with living British species.	Scandinavian species of these genera.	Mediterranean species of these genera.
TEST. MOLLUSCA.										
LAMELLIBRANCHIATA.										
Pinna	1	1	1	...	...	1	1	1	0	2 or 3
Lima	3	0	2	...	...	3	3	3	5	7
Pecten	9	1	7	...	...	7	9	7	13	17
Ostrea	1	1	1	...	...	1	1	1	1	6
Anomia	4	3	3	1	...	3	4	4	4	4
PALLIOBRANCHIATA.										
Hypothyris	1	0	0	...	1	0	0	1	?	0
Terebratula	2	0	1	...	...	0	1	1	3	2
Megathyris	1	0	0	...	...	0	1	1	1	6
Crania	1	0	0	...	...	0	1	1	1	1
PTEROPODA.										
Hyalæa	1	0	0	...	1	0	0	0	0	4
Spirialis	3	0	0	...	1	*	*	0	1	2
GASTEROPODA.										
Chiton	10	5	8	...	...	5	7	1	11	8
Patella	3	2	1	...	...	1	2	2	2	3
Acmæa	2	2	2	...	...	1	2	1	2	1
Pilidium	1	0	0	...	...	0	1	1	2	0
Propilidium	1	0	0	...	...	0	1	0	1	0
Dentalium	2	0	2	...	...	2	1	2	1	8
Pileopsis	1	0	0	...	...	1	1	1	1	1
Calyptræa	1	0	1	...	...	1	0	1	0	1
Fissurella	1	0	1	...	...	1	1	1	0	3
Puncturella	1	0	0	...	...	0	1	1	1	0
Emarginula	3	2	2	...	...	2	2	2	2	5
Haliotis	1	1	0	...	1	0	0	0	0	1
Trochus	16	5	11	...	1	10	10	9	8	28
Phasianella	1	1	1	...	...	1	1	0	0	3
Adeorbis	1	1?	1	...	...	1	0	1	0	1
Scissurella	1	1?	1?	...	...	...	1	1	2	2
Ianthina	3	0	0	...	1	*	0	0	0	3
Littorina	4	4	0	...	...	*	*	3	4	1
Lacuna	4	0	4	...	...	*	3	2	6?	0
Rissoa	29	10	14	1	3	13	13	8	18	37
Jeffreysia	2	2	0	...	1	*	0	0	0	?
Skenea	1	1	0	...	...	*	*	0	1	0
Skenea?	4	0	4?	...	...	...	2	0	?	1
Turritella	1	0	1	...	...	1	1	1	1	3
Cœcum	2	0	2	...	...	2	2	2	?	1
Aporrhais	2	0	1	...	...	1	2	1	1	2
Cerithium	3	1	2	...	...	2	3	1	3	10
Scalaria	5	0	3	...	...	4	4	3	4	6
Aclis	4	0	3?	...	...	1	2	2	1	1
Stylifer	1	0	1?	...	...	*	0	0	1	?
Eulima	4	0	4?	...	...	3	4	2	3	5
Chemnitzia	8	0	6?	...	1	4	4	4	2	8
Odostomia	22	*	*	*	1	?	15	3	6	2
Eulimella	4	0	2	...	...	1	2	1?	3	3
Truncatella	1	1	0	...	...	*	0	0	0	1
Otina	1	1	0	...	...	*	0	0	0	0
Natica	7	1	4	...	1	3	6	5	7	9
Lamellaria	2	1?	2	...	...	1	1	1	4	1
Velutina	2	0	1	...	...	1	2	1	2	0
Cerithiopsis	2	0	2	...	...	1	1	1	0	1
Trichotropis	1	0	1	...	...	0	1	1	1	0

British genera.	Total of British species.	Species inhabiting the Littoral zone.	Inhabiting the Laminarian zone.	Obscure species within described area.	British, without the limits of area.	No. of species in English papers.	No. of species in Scotch papers.	British later tertiary fossils identical with living British species.	Scandinavian species of these genera.	Mediterranean species of these genera.
TEST. MOLLUSCA. GASTEROPODA.										
Purpura	1	1	(1)	...	...	1	1	1	1	1
Murex	3	2	2	...	1	2	1	1	1	8
Fusus	9	0	2	...	3	2	6	4	6	3
Buccinum	4	1	1	...	1	1	2	2	2	0
Nassa	3	2	3	...	...	3	2	1	2	11
Trophon	3	0	1	...	...	2	3	3	3	1
Mangelia	15	0	9	...	...	11	13	11	13	34
Marginella	1	?	1	...	...	1	1	1	0	5
Volva	2	0	0	...	...	2	(1)*	1	0	4
Cypræa	1	1	1	...	...	1	1	1	1	7
Tornatella	1	1	1	...	...	1	1	1	2	3
Bulla	11	0	7	...	...	3	8	4	13	13
Bullæa	6	0	2	...	...	1	4	3	4	3
Pleurobranchus	2	?	2?	...	...	*	*	0	1	6
Aplysia	1	0	1	...	...	*	1	0	1	6
Conovulus	2	2	0	...	...	*	*	1	?	3
ECHINODERMATA.										
Comatula	2	0	1	...	...	1	2	1?	2	1
Ophiura	2	0	2	...	...	2	2	0	1	3
Ophiocoma	11	2	5	...	1	5	6	0	10	11
Euryale	1	0	0	...	...	0	*	0	3	1
Uraster	4	3	4	...	...	2	3	1	3	3
Cribella	2	1	1	...	...	1	1	0	2	1
Solaster	2	0	2	...	...	1	2	0	3	?
Palmipes	1	0	0	...	...	1	1	0	0	1
Asterina	1	1	0	...	...	*	*	0	0	3
Goniaster	2	0	0	...	1	1	1	0	4	1
Asterias	1	0	1	...	...	1	1	0	4	4
Luidia	1	0	1	...	...	1	1	0	1	1
Echinus	7	2	3	...	1	2	4	1	6	7
Cidaris	1	0	0	...	...	0	*	0	1	1
Echinocyamus	1	0	1	...	...	1	1	1	1	1
Brissus	1	0	1	...	...	0	1	0	2	2
Amphidetus	2	1	2	...	...	1	1	?	2	2
Spatangus	1	0	1	...	...	1	1	?	1	1

Causes which seem to determine or to have determined the peculiarities of the horizontal distribution of Species on the western coast of Great Britain.

These seem to be mainly,—first, the influence and distribution of existing oceanic currents; and secondly, the geological changes which the region has undergone since the tertiary epoch, and during the last term of that epoch. The first is the climatal influence, acting by its regulation of the temperature of the sea; the second, a geological influence, the action of which, so far as the present epoch is concerned whilst under review, has passed away.

Along the southern coast of England, the upper portion of the Coralline zone (18–30 fathoms) has a wide extension from the shore towards the eastern extremity of the English channel, occupying its whole breadth and gradually narrowing along the coasts of Devon and Cornwall, where the deeper portion of the same region approaches the land more nearly than elsewhere on the western English coast*. To the extension and connection of lands

* The naturalist, besides consulting the usual hydrographical charts, cannot do better than study the interesting Map of the English Channel by Mr. Austen, published in the Geological Journal.

across the eastern channel, ancient but not anterior to the existing population of the British seas, we may ascribe some of the peculiarities of our southernmost marine fauna, especially the presence there of southern forms of mollusks, inhabitants of the Littoral or Laminarian zones, and undoubtedly colonists from a more southern assemblage, such as we now see in the Channel Islands. The inhabitants of greater depths taken off the Cornish coast at considerable distances from shore, we have seen to be species of a different climatal character, boreal instead of southern; and when the distribution of animals on the Nymph Bank and off the southernmost coast of Ireland shall have been more fully explored, we shall find—at least, so the facts already made known indicate—that there is a large tract of considerable depth in the southern part of St. George's Channel, of the great deep-sea fishing-grounds, characterized by this boreal fauna, bearing a close relationship with the extinct fauna of the northern drift of the south-eastern districts of Ireland and parts of the coast of Wales. A great part of the Irish sea is very shallow, rarely sufficiently deep to affect the character of its fauna; parts of its floor, as between the Isle of Man and Lancashire, barely emerging from the Coralline zone, and its deepest portions of any extent scarcely infringing on the region of deep-sea corals. Between the Isle of Man and the Mull of Galloway, it is true, there is the deep and narrow ravine, 150 fathoms in its deepest part, discovered by Captain Beechey and dredged by him. But the results of his valuable research, carefully investigated by a most able naturalist, Mr. W. Thompson of Belfast, have shown that we have no fauna in that limited gulf at all corresponding to its depth, and that its contents are normally inhabitants of shallower regions. For this reason, the absence of the assemblage of subarctic or boreal species met with in all the older British submarine areas of considerable depth, and the curious interruption in the distribution of the smaller terrestrial quadrupeds which occurs in this quarter, reaching, as many of them do, the extreme parts of the south of Scotland, yet not inhabiting the nearest portions of Ireland opposite or any part of that island, I am induced to hazard the conjecture, that the great ravine in question dates its origin from a period later than the close of the glacial epoch, yet before that of the general spread of the greater part of the Germanic fauna and flora over these islands—of that part which, from causes varying in different species of animals and plants, was the more tardy in its progress. In the regions of the Clyde and along the inner Hebrides we have a great variety of depths; but the phænomenon most striking is the great depth of many of the lochs, often of considerable dimensions, whilst the entrances to them are exceedingly shallow; and in some cases the seas without them for a considerable distance are very shallow also. The fauna of these isolated deeps is very different from that of the Gallovegian ravine, for in the former we find assembled and imprisoned creatures which are characteristic of very deep regions of the sea, and which are mainly of a marked Scandinavian character. Sometimes, as in the neighbourhood of the Croulin islands, between Skye and the Ross-shire coast, we find a deep area of the sea thronged with Scandinavian species, living on the remains of the ancient glacial sea-bed and mingled with the exuviæ of their extinct ancestors, and of other creatures, now wholly extinguished within our seas, of an equally boreal or even arctic complexion. We have to sail a long way from the islands before we come to the edge of the permanently 100-fathom line, which, as we go northwards, must be sought for considerably to the west of St. Kilda and north of the desolate rocks of Sulisker and Rona. Around the Zetland Isles is the region in which the British explorer has the best opportunity of inquiring into the features of the fauna of the greater abysses of our seas, though of these depths we can scarcely claim more than the 100-fathom region as coming within the compass of British natural history. The soundings for a degree and a half north of Unst do not reach 300 fathoms; and from the Naze of Norway to the coast of Scotland there is a line of soundings not reaching to 100 fathoms, quite sufficient, as may be seen from an examination of the tables here given, to keep up a considerable communication and interchange with the Scandinavian marine fauna.

That the diffusion of Lusitanian forms along our southern shores and for some distance up St. George's Channel is due to the action of southern currents and their climatal influence, must be evident to any person who will compare the range of those species with the course and extension of Rennell's current, which, striking towards our shores from the coast of Spain, impinges on our south-western English provinces and diffuses its influence over an area exactly corresponding with the extension of our marine creatures of southern types. The extension, more or less powerful in different years, of the Gulf-stream towards the Irish coast, and the combined influence of it and its branch-current already mentioned, affects an area extending from our south-western English province round the western coast of Ireland and impinging on the western shores of Scotland in its northern portion, sufficient to account for the curious curve of distribution taken by those animals which range in that line almost from Devon to Zetland, but are rare or absent in the central portions of the Irish sea. The setting-in of the arctic current from the centre will account for the transmission to our northern shores of numerous Scandinavian forms. But no action of currents, as at present maintained, can account for the isolated patches and imprisoned assemblages of glacial animals to which I have more than once alluded in this Report. To account for them we must trace the physical conformation of the British seas in an epoch anterior to the present, and by doing so, shall find that the causes similar to those now in action differently disposed, will give us a clear insight into the origin of these phænomena. I have elsewhere theorized fully on this subject*, and have only to add, that all subsequent researches, a great mass of which is embodied in this Report, go in the strongest manner to confirm the views I had ventured to advance.

Desiderata within this area.—A great deal may yet be done for the exploration of the part of the British seas which has furnished the subject of this Report. Although little that is new, if anything, can be expected from the coasts of Hants, Sussex and Kent, yet it would be satisfactory to have a well-filled series of dredging papers relating to those counties. The central portion of the English channel and its entrance have yet to be systematically explored, and the depths of the Cornish coast and around the Scilly Isles should be sedulously examined. Off the entrance of the Bristol channel are isolated, or nearly so, patches of 60 fathoms and thereabouts which require to be carefully explored. The deeper portions of the Irish sea should be looked to more minutely. A more difficult task, and one which can be hardly hoped for fulfilment without the help of a steam-vessel and continued calm weather, is the dredging of the deeps off the Hebrides in the open ocean. Much of the deep sea area around the Zetlands is sure to reward the explorer. The lochs of Sutherlandshire have not as yet been systematically examined. And lastly, though I fear the consummation, however devoutly wished for, is not likely soon to be effected, a series of dredgings between the Zetland and the Faroe Isles, where the greatest depth is under 700 fathoms, would throw more light on the natural history of the North Atlantic and on marine zoology generally, than any investigation that has yet been undertaken.

* Memoirs of Geological Survey, vol. i.

Notes on the Distribution and Range in depth of Mollusca and other Marine Animals observed on the coasts of Spain, Portugal, Barbary, Malta, and Southern Italy in 1849. *By* ROBERT MACANDREW, *Esq., F.L.S.*

List of Species of Mollusca obtained in Vigo Bay during the first week of April and the last week of August 1849.

	Depth.	Ground.	Living at	Frequency.	
Saxicava arctica	......	sand	8 fath.	rare	smooth variety in mud.
Corbula nucleus	......	mud	5 to 25 f.	abun.	
Neæra cuspidata	......	mud	20 fath.	rare.	
Pandora rostrata	4 fath.	mud	......	rare.	
—— obtusa	......	sand	10 fath.	rare.	
Thracia villosiuscula?	......	sand	8 fath.	rare.	
Lyonsia striata	4 fath.	mud	......	rare.	
Solen siliqua	......	sand	low water	freq.	sold in the market.
—— ensis	......	sand	low water	freq.	
—— vagina	......	sand	low water	freq.	
Psammobia vespertina	......	sand	low water	freq.	
—— tellinella	8 fath.	null.	......	rare	valves small.
Tellina tenuis	shore	sand	......	freq.	
—— donacina	shore	sand	......	rare.	
—— distorta?	8 fath.	sand	......	rare.	
—— crassa	shore	sand	......	rare	one valve.
—— serrata	10 fath.	sand	......	rare	one valve.
Diodonta fragilis	......	sand	shore	abun.	one living.
Syndosmya alba	......	mud	10 fath.	freq.	
—— prismatica	......	mud	10 fath.	rare.	
Scrobicularia piperata	shore	...	......	rare.	
Donax anatinus	......	...	......	not ab.	
Mesodesma donacilla	......	sand	shore	freq.	
Mactra subtruncata	......	sand	5 to 10 f.	freq.	
—— truncata?	......	sand	shore	rare	or solida.
Lutraria oblonga	shore	sand	......	rare	valves.
—— elliptica	......	sand	low water	rare	sold in the market.
—— rugosa	sh. to 4 f.	...	......	num.	valves, three pairs.
Tapes virginea	......	mud	8 fath.	abun.	very highly coloured.
—— decussata	......	sand	low water	freq.	
—— pullastra	......	sand	low water	freq.	large.
—— aurea	......	sand	low water	freq.	large.
Venus verrucosa	......	sand	5 fath.	freq.	
—— striata	......	mud	20 fath.	freq.	
—— fasciata	......	null.	8 fath.	lim.	
—— ovata	......	null.	8 fath.	freq.	
Lucinopsis undata	3 fath.	mud	......	rare.	
Circe minuta	......	null.	8 fath.	abun.	
Astarte triangularis	......	null.	8 fath.	rare.	
Artemis exoleta	......	sand	low water	abun.	finely coloured, sold in market.
—— lincta	......	sand	low water	...	more rare than preceding.
Cardium edule	......	sand	littoral	abun.	
—— echinatum	......	sand	littoral	rare.	
—— tuberculatum	......	mud	littoral	rare	one specimen more square than medium specimen.
—— ciliare	......	mud	10 fath.	freq.	
—— norvegicum					
—— papillosum, var.	......	sand	10 fath.	lim.	only a few specimens, rose-coloured.
—— exiguum	......	sand	shore	local	larger than British specimens.
Lucina lactea	......	mud	10 fath.	rare.	
—— digitalis	......	sand	10 to 15 f.	rare.	
—— flexuosa	......	mud	4 fath.	r. & sm.	
—— spinifera	......	mud	10 to 12 f.	local.	

	Depth.	Ground.	Living at	Frequency.	
Lucina spinifera var.	......	mud	10 to 12 f.	local	smooth, cream or buff-colour.
Montacuta bidentata	......	mud	4 fath.	rare.	
Kellia suborbicularis	......	mud	8 fath.	freq.	in dead shells of *Tapes virginea.*
Lepton squamosum.........	8 fath.	sand	......	rare	valves. [shells.
Galeomma Turtoni	......	mud	10 fath.	v. r.	one specimen in mud with dead
Kellia? (genus uncertain)	......	mud	5 fath.	rare	of same genus, perhaps species,
					as a shell, procured alive under-
Mytilus Galloprovincialis?	......	rocks	littoral	abun.	der stones in Faro Harbour.
—— edulis?	......	rocks	littoral	abun.	entrance of the bay.
Modiola tulipa...............	......	mud	12 fath.	rare.	
Crenella marmorata	......	gravel	12 fath.	rare	in Ascidiæ.
—— costulata..............	shore	...	......	v. r.	one valve.
Nucula nucleus	......	mud	5 to 25 f.	freq.	
—— radiata	......	mud	20 to 25 f.	rare.	
—— nitida	......	mud	20 to 25 f.	freq.	
Arca tetragona	8 fath.	nul.&gr.	......	rare	valves.
—— lactea	8 fath.	nul.&gr.	......	rare	valves.
Pectunculus glycimeris ...	......	nul.&gr.	8 to 12 f.	rare.	
Avicula tarentina	......	mud	8 fath.	rare	one living, several dead on the
					shore, where they were proba-
Pecten maximus	......	sand	8 fath.	freq.	bly brought by the Seine nets.
—— opercularis	......	sand	8 to 20 f.	not f.	small.
—— varius	......	sand	8 fath.	not f.	
—— obsoletus	8 fath.	sand	......	rare	valves.
—— distortus	......	rocky	6 fath.	local.	
—— similis..................	20 fath.	mud	......	rare	valves.
—— fuci	15 fath.	sand	......	rare	valves.
Ostrea edulis	......	...	low water	...	abundant in shallow water near
					the head of the bay, and ex-
					cellent quality.
—— —— var. parasitica .	......	...	low water	...	covering rocks near head of the
Anomia ephippium	......	s. & gr.	10 fath.	freq.	bay, small.
—— patelliformis	......	s. & gr.	10 fath.	rare.	[trance of bay.
Crania anomala	......	...	25 fath.	v. r.	dredged one specimen near en-
Chiton rufus	......	...	l. w. to 12 f.	abun.	creeping on the shore and at-
—— fascicularis	......	s. & m.	8 fath.	freq.	tached to dead shells, &c.;
—— marginatus.............	......	...	littoral	freq.	some came up with the chain
—— asellus	......	s. & m.	8 to 12 f.	freq.	every time we got under way.
—— lævis	......	s. & m.	8 to 12 f.	rare.	
—— cancellatus............	......	s. & m.	8 to 12 f.	rare.	
Patella vulgaris	......	...	littoral	abun.	
—— pellucida................	......	...	8 fath.	freq.	on fucus.
Acmæa virginea	......	sand	8 fath.	freq.	large.
Emarginula rosea	......	sand	8 to 12 f.	freq.	not large.
Fissurella reticulata	......	...	8 to 12 f.	rare	small.
—— gibba	......	...	8 to 12 f.	rare	small.
Calyptræa sinensis	......	shells	l. w. to 20 f.	v. f.	
Bullæa aperta	......	mud	4 fath.	freq.	
—— scabra..................	4 fath.	mud	......	rare.	
Bulla hydatis	......	mud	sh. to 4 f.	v. a.	
—— akera	......	mud	4 fath.	freq.	
—— cylindrica	......	sand	8 fath.	freq.	
—— lignaria	......	mud	10 fath.	v. r.	one specimen.
—— umbilicata	4 fath.	mud	......	local.	
—— truncata	4 fath.	mud	......	local.	
Aplysia depilans	......	sand	l. w. to 8 f.	...	extremely abundant on the
Rissoa ulvæ...................	4 fath.	mud	......	local.	shore.
—— vincta....................	4 fath.	...	low water	local.	
—— costata	4 fath.	...	......	rare.	
—— costulata..............	4 fath.	...	......	v. r.	
—— labiosa	4 fath.	...	......	freq.	
—— interrupta?	......	...	4 fath.	local.	

	Depth.	Ground.	Living at	Frequency.	
Rissoa striata	......	...	low water	freq.	
—— pellucida	4 fath.	...	......	rare.	
—— parva	......	...	4 fath.	rare.	
—— calathiscus	4 fath.	...	......	rare.	
—— cimex?	......	...	8 fath.	f. but l.	
—— lactea	4 fath.	...	......	rare.	
—— violacea?	shore	...	......	rare.	
Alvania albella	8 fath.	...	......	...	one specimen (lost).
Odostomia of 2 or 3 species	......	s. & m.	8 to 12 f.	local.	
Skenea?	4 fath.	...	......	rare.	
Chemnitzia elegantissima	4 to 12 f.	sand	......	freq.	
—— scalaris	8 fath.	sand	......	v. r.	
—— fulvocincta	......	sand	8 fath.	v. r.	only one specimen.
—— fenestrata	4 fath.	mud	......	v. r.	only two specimens.
—— indistincta?	8 fath.	mud	......	v. r.	only two specimens.
—— scalaris	8 fath.	sand	......	v. r.	only two specimens.
—— —— new?	8 fath.	sand	......	v. r.	a fragment, large.
Eulima polita	......	sand	10 fath.	rare.	
—— subulata	......	sand	10 to 15 f.	rare.	
Natica Alderi	......	sand	6 to 10 f.	freq.	
—— monilifera?	shore	...	......	...	one, dead and imperfect.
Velutina lævigata	......	sand	8 fath.	rare	small.
Tornatella fasciata	......	sand	8 fath.	...	one, young.
Lamellaria perspicua	......	sand	8 & 12 f	rare	animal a bright orange colour.
Haliotis tuberculatus	shore	...	......	...	fragment.
Scalaria communis	......	...	shore	few.	
—— Turtoni	shore	...	......	...	fragment.
—— clathratulus	4 fath.	mud	......	one.	
Vermetus semisurrectus (Serpula tubularia)	......	...	shore	...	extremely abundant, in large groups brought in by fishing nets.
—— triqueter	......	s. & m.	5 to 12 f.	freq.	
—— Mulleri	......	s. & m.	5 to 12 f.	freq.	
Solarium luteum	......	mud	20 fath.	....	one, living.
—— stramineum	......	mud	8 fath.	...	one, living.
—— ——	8 fath.	mud	......	...	minute, depressed, bicarinated (*qy.* young of preceding?).
Trochus umbilicatus	shore	...	......	freq.	
—— tumidus	......	sand	8 to 12 f.	freq.	
—— striatus	......	saud	8 to 12 f.	abun.	
—— exiguus	......	null.	8 fath.	v. a.	
—— Montagui	......	sand	15 fath.	rare.	
—— magus	......	sand	7 fath.	freq.	
—— Laugieri	12 fath.	sand	......	v. r.	
—— cinerarius	......	sand	10 fath.	freq.	on fucus.
—— ziziphinus	......	rocky	8 fath.	freq.	
—— crassus	......	...	shore.		
—— ——	......	sand	10 fath.	freq.	on fucus (*qy.* vars. of *T. cinerarius*).
Adeorbis subcarinatus	4 fath.	mud	......	rare.	
Phasianella pulla	......	...	8 f. & sh.	local.	
Lacuna puteolus?	shore	...	......	...	one dead specimen.
Littorina littoreus	......	...	littoral	freq.	
—— rudis	......	...	littoral	freq.	
—— littoralis	......	...	littoral	freq.	
—— saxatilis?	......	...	littoral	freq.	
Turritella tricostalis	......	sand	8 to 12 f.	abun.	
—— terebra	......	mud	12 to 25 f.	...	more rare than preceding; very produced.
Cerithium reticulatum	......	mud	4 fath.		
—— perversum	4 fath.	...	......	rare.	
Pleurotoma attenuatum	6 to 10 f.	mud	......	freq.	
—— costatum	......	mud	8 fath.	freq.	
—— lineare	......	sand	8 fath.	freq.	
—— elegans	8 fath.	sand	......	...	one specimen.
—— brachystomum	12 fath.	mud	......	freq.	

	Depth.	Ground.	Living at	Frequency.	
Pleurotoma purpureum ...	8 fath.	sand	......	rare.	
—— septangulare	......	sand	8 fath.	...	two, fine and large.
—— coarctatum or Smithii	......	sand	8 fath.	rare.	
Fusus contrarius	8 fath.	sand	shore	...	obtained seven living specimens on shore near the town, five dead in 8 fath. near the mouth of the bay.
—— muricatus	......	sand	8 fath.	v. r.	
—— corallinus	......	sand	8 fath.	freq.	
—— ——	15 fath.	sand	......	rare	carinated; some resemblance to *P. lapillus.*
Murex erinaceus	......	...	shore	freq.	
—— Edwardsii	......	...	shore	freq.	
—— cristatus? var.? ...	......	sand	8 fath.	...	three specimens together.
Triton variegatum	......	sand	8 fath.	...	one, living.
—— corrugatum	......	sand	8 fath.	...	one, living.
Chenopus pes-pelecani ...	......	sand	8 fath.	local.	
Purpura lapillus	......	...	littoral	freq.	near the town and low down the bay small and dark colour, at head of the bay large and white.
Nassa macula	......	sand	4 to 8 f.	freq.	
—— varicosa	......	mud	4 fath.	rare.	
—— reticulata	......	s. & m.	......	freq.	ordinary form, in sand, dark coloured undulated var. in mud.
Ringuicula auriculata	4 to 25 f.	mud	20 to 25 f.	v. a.	large, never striated.
Buccinum, new sp.	......	mud	6 to 25 f.	v. a.	smooth, purple, obscurely banded; animal very active.
Nesæa minima	8 fath.	sand	......	local.	
Erato lævis	......	sand	8 fath.	...	two specimens living.
Cypræa Europæa	......	sand	8 fath.	freq.	
Dentalium dentalis or quadrangulare	......	mud	5 to 20 f.	abun.	
—— tarentinum	......	mud	5 to 20 f.	rare.	
Cæcum trachea	8 fath.	sand	......	rare.	
—— —— new?	......	mud	20 fath.	local	pellucid, very narrow in proportion to length, ¾in.: greenish colour when living.
Spirorbis.					
Pollicipes cornucopia	......	...	......	...	gathered from rocks at entrance of the bay, sold abundantly for food, and much esteemed.
Balani.					
Clitia verruca.					
Acasta Montagui.					
Anatifa vulgaris.					
—— striata.					
4 species of Echinus.					
4 species of Star-fishes.					
4 species of Comatula.					
Holothuriæ.					
Cucumariæ.					
Alcyonium digitatum.					
—— ? ——.					
Pennatula (Med. species).					
Actiniæ &c. Zoanthus Couchii.					
Edwardsia.					
Veritillum.					

Vigo Bay extends 16 or 18 miles inland; in mid-channel the bottom is muddy, 25 fathoms, near the entrance, gradually shoaling as you proceed upwards; the littoral fauna, which is of a British or Celtic character, better developed towards the head of the bay, being more abundant, and the individuals attaining larger size.

Of the preceding list of 200 species of Mollusca (omitting *Balani* and *Lepades*), twenty-six are not inhabitants of the seas of the British Islands, viz.—

Tellina serrata.
Mesodesma donacilla.
Lutraria rugosa.
Cardium papillosum, var.
Lucina digitalis.
—— (genus unknown).
Mytilus galloprovincialis.
Chiton rufus*.
—— ——, new ?*.
Fissurella gibba.
Rissoa violacea ?.
Chemnitzia (new)*.
Solarium luteum.
Solarium stramineum.
Trochus Laugieri.
Turritella tricostalis.
Fusus contrarius*.
Pleurotoma maravigni.
Murex Edwardsii.
—— cristatus ?.
Triton variegatum.
—— corrugatum.
Ringuicula auriculata.
Buccinum —— (new ?)*.
Dentalium quadrangulare.
—— —— (new ?)*.

The shell which I have designated above under the name of *Fusus contrarius* I believe to be distinct from the reversed var. of *F. antiquus*.

Of the species not British, at least twenty have been found in the Mediterranean; the exceptions are marked * in the list, and of these two, viz. *Fusus contrarius* and *Buccinum*, new species (which may be a var. of *B. modestum*), I look upon as doubtful.

The subjoined list contains thirty species found at Vigo, and not known to inhabit the Mediterranean. Six of them may be considered doubtful, viz. *Fusus contrarius* and *Buccinum* (new ?), for the reasons already mentioned; *Natica monilifera* and *Lacuna puteolus*, because they are in the Vigo list upon the faith of single, old, dead and imperfect specimens; *Natica Alderi* and *Pecten obsoletus*, because possibly identical with *N. Marochiensis* of authors, and a Pecten procured at Gibraltar.

The twenty-nine species procured at Vigo, but not in the Mediterranean, all inhabit the British seas except six or seven (marked * in the list), *Fusus contrarius* being doubtful.

Donax anatinus.
Mactra truncata.
Tapes pullastra.
Kellia? (genus unknown)*.
Pecten obsoletus.
Chiton rufus*.
—— marginatus.
—— asellus.
—— ——, new ?*.
Patella pellucida.
Rissoa ulvæ.
—— pellucida.
—— vincta.
—— striata.
Chemnitzia, new ?*.
Natica monilifera ?.
—— Alderi.
Velutina lævigata.
Trochus tumidus.
—— cinerarius.
Lacuna puteolus ?.
Littorina littoreus.
—— rudis.
—— saxatilis.
Fusus contrarius*.
—— —— (carinated).
Purpura lapillus.
Buccinum —— (new ?)*.
Dentalium —— (new*).

From the foregoing lists, it appears that the marine fauna of Vigo, as regards Mollusca, is more nearly related to that of the British Isles than to that of the division in which it is situated, the Lusitanian.

The only land shells I met with in the neighbourhood of Vigo, are,—

Helix aspersa.
—— caperata.
—— cellaria.
Helix nemoralis.
—— barbula.
—— revoluta.

I attempted to dredge off the Berlings bearing E.S.E. 8 or 10 miles, but could obtain no bottom with 200 fathoms' line.

Species obtained by dredging off Cascaes Bay, south of the rock of Lisbon: bottom hard sand, depth 15 to 20 fathoms.

Corbula nucleus.
Solen ensis.
Solecurtus legumen.
Syndosmya alba.
Artemis lincta.
Venus striatula.
Cardium aculeatum (young).
Pinna —— (fragment).
Patella pellucida (*qy.* southern limit of range?).
Bulla cylindrica.
Odostomia conoidea.
Chemnitzia fulvocincta.
Eulima subulata—7 or 8 living.
Nassa varicosa.
Cymba olla—2 living (*qy.* most northern locality?).

Dredging Paper No. 1.

Date, 5th of April, 1849.
Locality, Cape St. Mary's, South Coast of Portugal.
Depth, 15 to 30 fathoms.
Distance from shore, about $1\frac{1}{2}$ mile.
Ground, coarse sand, mud.
Region,

Species obtained.	Number of living specms.	Number of dead specimens.
Serpula filograna	1 group	
Ditrupa subulata or coarctata	innum.	
Dentalium quadrangulare	8	
—— tarentinum	5	
Pholas dactylus	...	a fragment.
Corbula nucleus	4	
Pandora rostrata	...	valves.
Thracia phaseolina	...	1 valve.
Solen siliqua	...	a fragment.
—— pellucidus	1	
Solecurtus candidus	...	fragments.
—— antiquatus	...	a valve.
Lutraria?	...	frag. of 1 or 2 species.
Psammobia tellinella	...	valves.
—— ferroensis	...	valves.
Diodonta fragilis	...	1 valve.
Tellina distorta	2	1
—— crassa	...	4 valves.
—— planata	...	2 valves.
—— costæ	...	2 valves.
Donax trunculus.	...	valves.
—— politus	...	num. valves.
Syndosmya alba	1	num. valves.
Ervillia castanea	...	num. valves.
Mactra stultorum	...	fragment
—— subtruncata	...	2
Cytherea chione	...	1
—— venetiana	...	valve.

Species obtained.	Number of living specms.	Number of dead specimens.
Venus verrucosa	...	fragment.
—— striatula	abun.	
—— fasciata	1	
—— casina	...	fragment.
Circe minuta	3	
Cardium edule	...	valve.
—— lævigatum	1	
—— papillosum, var.	5	
—— fasciatum	1	valve.
Cardita trapezia	...	valve.
Lucina lactea	...	valve.
—— spinifera	...	1
—— digitalis	4	valves.
—— divaricata	...	valves.
Diplodonta rotundata	...	valves.
Mytilus afer?	...	valve.
Modiola	...	valve.
Nucula nitida	1	
—— radiata	2	
Leda emarginata	...	num. valves.
Arca tetragona	...	valves.
—— lactea	...	valves.
Pectunculus glycimeris	...	valves.
Pinna ingens ?	...	fragment.
Pecten maximus.		
—— opercularis	...	valves.
—— varius	...	valves.
—— polymorphus	...	valves.
Emarginula fissura	...	2
Fissurella gibba	...	2
Calyptræa sinensis	...	3

Species obtained.	Number of living specms.	Number of dead specimens.	Species obtained.	Number of living specms.	Number of dead specimens.
Bulla truncata	...	2	Pleurotoma elegans	6	4
Natica Guilleminii	4		—— purpureum	...	fragment.
—— sagra	...	1	—— striolatum	...	1
Tornatella fasciata	...	fragment.	—— attenuatum	...	several.
Eulima polita	...	1	—— Smithii	...	several.
Trochus ziziphinus	...	fragment.	—— ——	1	several.
—— Montagui	...	1	Murex erinaceus	...	fragment.
—— canaliculatus	...	1	Chenopus pes-pelecani	...	fragments.
Turritella terebra	18		Nassa reticulata	5	
—— sulcata	...	2	—— macula	...	1
Phasianella pulla	...	1	—— varicosa	4	
Cerithium vulgare	...	3	Buccinum modestum	6	
—— reticulatum	...	several.	Ringuicula auriculata	4	12
—— perversum	...	1			

The port of Faro in Algarve is situated behind the low islands, or rather salt marshes which form Cape St. Mary's (Cabo de Santa Maria). There are several channels leading to it, but only one (facing the east) navigable for vessels drawing 8 to 12 feet water. This is only accessible at high tide over a succession of sand-banks. At low water most of the channels are nearly dry: bottom mud, with abundance of Zostera. I remained in the port five days, but was able to do but very little in the way of research. The following is a list of the shells obtained in the harbour and on the neighbouring shore, the species marked * being procured alive:—

Pholas candidus.
—— dactylus.
Petricola lithophaga*.
Venerupis irus*.
Panopæa Aldrovandi — numerous valves, 2 or 3 united.
Solen siliqua*—in the market.
—— ensis.
—— vagina*—in the market.
Solecurtus legumen—valves.
—— strigillatus—valves.
Psammobia vespertina—valves.
—— costata (Hanley)—large, concentrically wrinkled, radiated.
Tellina tenuis.
Diodonta fragilis.
Syndosmya prismatica*.
Scrobicularia piperata.
Donax trunculus.
—— politus.
Ervillia castanea—several perfect shells, united valves, but none alive.
Mactra helvacea—numerous valves on the exposed shore.
—— stultorum.
—— subtruncata*.
Lutraria elliptica*.
—— oblonga*.
Lutraria rugosa.
Cytherea chione.
Tapes aurea.
—— decussata.
—— perforans.
Venus verrucosa.
—— fasciata*.
—— striatula.
Circe minuta.
Artemis exoleta.
—— lincta.
Cardium edule*.
—— —— var. rusticum of Mont.
—— —— var.—very wide in proportion to length.
—— norvegicum.
—— tuberculatum.
—— exiguum?*.
Lucina lactea.
Bornia corbuloides* — abundant under stones.
†—— genus unknown*—abundant under stones.
Kellia suborbicularis*.

† Somewhat resembling *Bornia corbuloides* in form, but larger, much wider, opake. An

Mytilus galloprovincialis*.
—— minutus.
Modiola barbata.
—— tulipa.
Crenella marmorata*.
Lithodomus caudigerus*—in stones found in Asturias, but not at Cadiz or in the Mediterranean.
Arca lactea*—abundant under stones.
—— tetragona*—one under stones.
Pectunculus glycimeris—abundant valves, used by fishermen instead of lead.
Lima scabrella?.
Pecten maximus.
—— varius.
Ostrea edulis.
Chiton marginatus??*
—— fascicularis*.
Patella vulgaris*.
Siphonaria concinna*.
Fissurella græca.
Bulla striata.
Natica intricata*.
—— Guilleminii.
Sigaretus haliotoideus (of Lam.).
Littorina neritoides.
Phasianella intermedia—on Zostera.
Rissoa labiosa—on Zostera.
—— lactea.
Chemnitzia elegantissima.
†Trochus crassus?*, var.—pale colour (Qy. is it met with further south?).
—— umbilicatus*—on Zostera.
—— striatus*—on Zostera.
Trochus Laugieri*—on Zostera.
—— canaliculatus*—on Zostera.
—— ——, var.?
—— ——, var.?
Turbo rugosa.
Turritella sulcata.
Cerithium vulgatum.
—— reticulatum.
—— perversum.
Murex corallinus*.
—— truncatus*.
—— Brandaris*.
—— erinaceus*.
—— Edwardsii*.
Triton variegatum*.
—— corrugatum.
—— cutaceum.
Chenopus pes-pelecani.
Purpura hæmastoma.
Cassis saburon?—two, dead.
Nassa reticulata.
—— macula.
Columbella rustica.
Mitra —— (yellow, large).
Cymba olla—picked up abundantly from bottom of a narrow channel at low water.
Cypræa Europæa*.
Conus mediterraneus—abundant on muddy banks.
Serpula triqueter, &c.
Balanus*—on stones.
——, two species*—upon fishermen's cork.

It will be noticed, that of the foregoing list, there are only *Trochus umbilicatus* and *crassus* (doubtful), and perhaps *Chiton marginatus* (a doubtful determination), British species not found in the Mediterranean.

Dredged at San Lucar de Barameda (mouth of the Guadalquivir), 12th, 21st, and 22nd of April, locality not favourable for dredging; bad enough for anchorage on account of the strong tide and freshwater coming down after the heavy rains—sandy shore. The most abundant species were *Mactra stultorum*, ordinary variety, and one pure white in about equal plenty; *Tellina costæ* not uncommon; valves of *Lutraria rugosa* small. Numerous common South European species.

Between the bar of San Lucar and Cadiz I made use of the dredge at various points, in 8 to above 20 fathoms, and found the bottom to be black

epidermis furnished with minute tufts of hair arranged in rows, diverging from the limbs, giving it the appearance of being striated.

N.B. I have formerly found dead and worn specimens on the shore of Asturias, when I supposed it to be *Bornia complanata*. I procured the same, or an allied species, smaller, dead, from mud in Vigo.

† *Possibly* a variety of *T. articulatus*, or intermediate between the two species.

mud, with hardly any shells except *Nucula nitida* and *Turritella terebra.* Between Cadiz and Cape Trafalgar, I met with better success (see dredging papers No. 2 and No. 8).

Dredging Paper No. 2.

Date, 23rd of April, 1849.
Locality, between Cadiz and Cape Trafalgar.
Depth, 30 fathoms.
Distance from shore, 8 to 10 miles.
Ground, sand and gravel.
Region,

Species obtained.	Number of living specmns.	Number of dead specimens.	Observations.
Gastrochæna cuneiformis ...	1 or 2	......	in the root of the coral (*qy.* Oculina?).
Saxicava arctica	......	1	minute.
Corbula nucleus	several.		
Pandora obtusa	1	1 & valves.	
Solecurtus antiquus	......	valves.	
Psammobia ferroensis.........	2 young.		
Tellina serrata..................	......	valves.	
Syndosmya alba	1		
—— intermedia?	1		
Ervillia castanea...............	......	2 valves.	
Mactra subtruncata	......	1 valve.	
Tapes virginea..................	......	several.	
Cytherea venetiana...........	......	valves.	
Venus verrucosa	......	1 valve.	
—— fasciata	3		
—— ovata	......	valves.	
Circe minuta	4		
Astarte incrassata?...........	......	1 valve.	
Cardium echinatum	......	1 valve.	
—— roseum?..................	6		
—— minimum	2		
Lucina radula	......	valve.	
—— digitalis	......	1 & valve.	
—— spinifera..................	......	valve.	
Diplodonta rotundata.........	......	valve.	
Modiola vestita	1		
Nucula nitida	2		
Leda emarginata...............	......	num. valves.	
Arca lactea	1		
—— obliqua	......	1 valve.	
—— antiquata?	5	num. valves.	
—— tetragona	......	1 valve.	
Lima fragilis	......	1 valve.	
Pecten maximus	......	fragments.	
—— opercularis...............	......	fragments.	
—— varius	......	fragments.	
—— polymorphus	......	fragments.	
Fissurella græca?	......	2	
Calyptræa sinensis	4		
Vermetus ——	1		
Bulla cylindrica	2		
—— truncata...................	......	several.	
Rissoa Montagui...............	......	3	
—— ——	......	1	allied to vitrea?
Odostomia conoidea	several	several.	
—— acuta	......	1	

Species obtained.	Number of living specmns.	Number of dead specimens.	Observations.
Eulima polita	2	2	
—— subulata	3		
Chemnitzia elegantissima	3		
—— rufa	1		
—— —— new?	1	11	very slender oblique undulated ribs.
—— —— new (rosea)	......	5	
—— fulvocincta?	1		
Scalaria communis	......	1 broken.	
Trochus ziziphinus	......	1	
—— millegranus	......	1	
Turbo rugosus	......	2 opercula.	
Turritella terebra	several.		
—— tricostalis	several.		
Cerithium reticulatum	......	several.	
—— perversum	......	1	
Fusus corneus (Lin.)	......	1	
Pleurotoma gracilis	......	1	
—— brachystomum	......	several.	
—— reticulatum var. spinosum	1		
——, new sp.	......	1	banded, black and yellow.
—— ——			
Buccinum modestum	1	several.	
—— minus	1	2	
Nassa reticulata	1	several.	
—— macula	several	several.	
Ringuicula auriculata	several	several.	
Dentalium quadrangulare	several	several.	
Ditrupa subulata	several	several.	
Balanus	1		
Adna anglica	1	......	on Caryophyllia.
Numerous Zoophytes, a large red coral, Occulina.			

Dredging Paper No. 8.

Date, 26th of July, 1849.
Locality, 8 miles north and west of Cape Trafalgar.
Depth, 15 fathoms.
Distance from shore, 5 miles.
Ground, coarse sand with broken shells.
Region,

Species obtained.	No. of living specimens.	No. of dead specimens.	Observations.
Dentalium entalis or tarentinum	......	4	
Ditrupa strangulata?	few.		
Serpula intorta	few.		
—— triqueter	few.		
Corbula nucleus	6		
Pandora obtusa	1		
—— rostrata	1		
Solen ensis	1	......}	small.
Psammobia ferroensis	1	valves.	
—— tellinella	......	valves.	
Mactra elliptica?	......	valve	small.

Species obtained.	No. of living specimens.	No. of dead specimens.	Observations.
Lutraria elliptica	......	1 valve.	
Tapes virginea	3	abundant.	
Cytherea chione	......	valves.	
—— venetiana	......	1 valve.	
Venus fasciata	6		
—— casina	......	1	
—— ovata	2		
—— striatula	1		
Circe minuta	5		
Astarte triangularis	......	valves.	
Cardium papillosum	......	1 & valves.	
Lucina digitalis	2		
Kellia suborbicularis	......	1 valve.	
Modiola tulipa	1		
Nucula nucleus	1		
—— radiata	8		
Leda striata	......	a valve.	
Arca tetragona	......	valves.	
—— lactea	2		
Pectunculus glycimeris	1	1	
Lima subauriculata	......	1 valve.	
Pecten maximus	3		
—— opercularis	10	......	small.
—— varius	4	......	much incrusted with sponges, &c.
—— polymorphus	8	......	much incrusted with sponges, &c.
Ostrea edulis	abundant.		
Anomia ephippium	abundant.		
Chiton lævis	2		
Fissurella græca	......	1	
Calyptræa vulgaris	numerous.		
Acmæa virginea	......	1	
Bulla truncata	......	1	
Natica Alderi	1	2	
Trochus magus	3	several.	
—— ziziphinus	5		
—— Montagui	2		
Turritella tricostalis	numerous.		
Pleurotoma	......	3	
Marginella miliacea	......	2	
Murex erinaceus	7		
—— cristatus	10		
Triton nodiferum?	......	2	
Nassa varicosa	1	1	
—— reticulata	2		
Buccinum minus	2		
Ringuicula auriculata	......	3	
Amphioxus lanceolatus	7		
Echinus, 2 species.			
Ophiuræ, &c.			

On the 24th of April, in the Strait of Gibraltar, the water was teeming with Salpæ, generally in the form of double chains; the individuals varying in size from a quarter of an inch or less to three inches in length. The opake part of the smaller was blue, of the larger brown. They were very phosphorescent when agitated in water. Various small and beautiful Medusæ. Near the entrance of the Bay of Gibraltar I put down the dredge in 130 fathoms of water, but had the greatest difficulty in recovering it from a rocky bottom, and obtained nothing.

I spent a full fortnight in Gibraltar (on my way out and home), and dredged more or less nearly every day: bottom sand and mud.

Species of Mollusca obtained at Gibraltar end of April and beginning of May 1849.

	Depth.	Living at	Frequency.	
Gastrochæna cuneiformis .	......	4 to 8 f.	local	in stone.
Saxicava arctica	......	8 to 40 f.	...	not common.
—— ——, var. ?............	......	40 fath.	1 spm.	
Venerupis irus...............	shore	......	freq.	
Panopæa Aldobrandi	......	......	local	fragments on Med. shore.
Corbula nucleus	......	8 to 20 f.	freq.	
Neæra cuspidata	45 fath.	......	rare.	
—— costulata...............	45 fath.	......	rare.	
Pandora obtusa	......	10 to 25 f.	rare.	
Thracia convexa	45 fath.	......	1 valve.	
—— pubescens	......	8 fath.	rare.	
Solen siliqua	shore	......	freq.	
—— pellucidus	......	40 fath.	v. r.	
Solecurtus antiquus	4 to 8 f.	......	rare	valves.
—— strigillatus	shore	......	local.	valves.
—— candidus...............	sh. & 6 f.	......	rare.	
Solemya mediterranea ...	shore	6 fath.	rare	only one living specimen.
Psammobia vespertina ...	shore	......	freq.	
—— costulata...............	8 fath.	......	rare.	
—— ferroensis	8 fath.	......	local.	
Tellina tenuis	shore	......	freq.	Med. shore.
—— pulchella...............	shore	......	local.	
—— distorta	......	8 fath.	local.	
—— donacina ?	......	8 fath.	rare	one specimen.
—— crassa	......	8 fath.	rare	one specimen.
—— serrata	15 to 45 f.	40 fath.	rare	frequent valves.
—— Balaustina	......	45 fath.	...	one specimen (large), size of the British specimens; it appears to become smaller, but more abundant further eastward.
—— depressa	shore	......	freq.	
Diodonta fragilis	shore	......	freq.	
Scrobicularia Cotardi	shore	......	local.	
Donax trunculus............	shore	......	freq.	
—— venustus	shore	......	local.	
—— politus	......	8 fath.	rare.	
Mesodesma donacella......	shore	......	freq.	
Mactra subtruncata	shore	......	freq.	
—— helvacea ?	shore	......	a frag.	
Corbula ——, new ?	......	8 fath.	rare	small, triangular, elongated.
Lutraria elliptica............	shore	......	valves.	
—— elongata	8 fath.	......	valves.	
—— rugosa	shore	......	1 valve.	
Tapes decussata	shore	......	freq.	
—— aurea?..................	shore	......	freq.	
—— Beudantii	shore	......	freq.	
—— geographica	shore	......	local.	
—— florida..................	shore	......	local.	
—— virginea	8 fath.	8 fath.	freq.	
Cytherea venetiana.........	sh. 40 f.	6 to 25 f.	freq.	
—— ——, var. ? or new ? .	20 to 45 f.	30 fath.	rare	valves not unfrequent, only one or two living, white, concentrically wrinkled.
—— chione...........	sh. 8 fath.	8 fath.	freq.	
Venus gallina	shore	......	freq.	
—— striatula	......	40 fath.	local.	
—— verrucosa	sh. to 6 f.	6 fath.	freq.	
—— fasciata	sh. to 20 f.	8 fath.	freq.	
—— casina	......	8 fath.	rare	finely coloured.
—— ovata	......	6 to 40 f.	freq.	
—— ——, new ?	......	8 fath.	rare	two small specimens allied to *V. casina*, smaller, more orbicular, convex, white.
Astarte Danmoniensis......	......	45 fath.	local	young and old, identical with British.

	Depth.	Living at	Frequency.	
Astarte incrassata	......	30 to 40 f.	local	very distinct from preceding, grooved only towards the umbo.
—— ——, var. ?............	......	30 to 40 f.	local	sulcæ more numerous, closer, and extending to the margin, smaller.
—— ——, var. ?............	......	30 fath.	rare	smaller than preceding, *radiated.*
—— triangularis............	......	7 to 8 f.	local	large and fine.
Artemis exoleta	......	shore	local	(Med.).
—— lincta	shore	6 fath.	local.	
Cardium erinaceum.........	8 fath.	......	local	large.
—— ——, var. (white) ...	......	......	local	from fisherman.
—— tuberculatum	shore	......	freq.	(Med.).
—— ——, var., white ...	shore	......	rare	(Med.).
—— aculeatum	shore	......	rare	(Med.).
—— lævigatum	......	8 to 12 f.	local.	
—— papillosum	......	20 to 40 f.	local.	
—— punctulatum ?	......	30 fath.	v. r.	
—— minimum	......	30 fath.	v. r.	
—— papillosum, var.......	......	20 to 40 f.	rare.	
Cardita sulcata	......	sh. to 10 f.	v. a.	
—— squamosa (aculeata, Ph.)	......	15 to 45 f.	freq.	
—— calyculata	shore	......	valve.	
Lucina lactea	......	8 fath.	local.	
—— spinifera	......	15 to 25 f.	rare.	
—— digitalis	......	4 to 30 f.	freq.	
Diplodonta rotundata......	......	4 to 8 f.	freq.	
Lepton squamosum.........	shore	......	valve.	
Bornia corbuloides	shore	......	freq.	
—— complanata............	shore	......	rare	two or three valves.
Mytilus galloprovincialis...	shore	......	freq.	
Modiola barbata	shore	......	local.	
—— tulipa	......	10 to 25 f.	rare.	
—— vestita..................	12 to 45 f.	20 to 40 f.	local.	
Crenella marmorata	......	10 fath.	rare.	
—— costulata...............	shore	......	rare	valves.
—— rhombea...............	40 fath.	......	rare	valves.
Nucula nucleus	......	6 to 20 f.	freq.	
—— nitida	......	12 to 40 f.	freq.	
—— polii	......	30 to 45 f.	local.	
—— radiata	......	30 to 45 f.	freq.	
Leda emarginata............	......	4 to 12 f.	local.	
—— striata..................	......	30 to 40 f.	freq.	
Arca ?	......	20 fath.	rare	small, living ; resembles *A. fusca.*
—— lactea	......	20 to 12 f.	local.	
—— antiquata	......	30 to 45 f.	local	numerous valves, few living.
—— raridentata............	......	45 fath.	v. r.	three specimens.
—— tetragona	......	30 fath.	v. r.	one specimen, small.
Pectunculus glycimeris ...	......	30 fath.	rare	small, one very large valve on shore.
—— pilosus	......	8 fath.	local	mud.
Avicula tarentina	shore	......	1	
Pinna squamosa	shore	......	local	fragments at various depths.
Lima fragilis	15 fath.	......	local	valves.
—— tenera..................	10 fath.	......	local	valves.
—— subauriculata	......	35 fath.	rare	one living, small, several fragments.
—— scabrella ?	shore	......	local	valves.
Pecten maximus	sh. to 40 f.	4 to 25 f.	freq.	
—— opercularis	......	20 to 40 f.	local	small.
—— varius	......	8 fath.	freq.	
—— distortus..............	......	8 fath.	local.	
—— polymorphus	......	6 fath.	...	common on shore.
—— gibbus..................	15 to 45 f.	25 fath.	...	one, living, numerous valves.
—— obsoletus ?	......	30 fath.	...	one, living.

	Depth.	Living at	Frequency.	
Pecten Fuci?	......	30 fath.	rare	destitute of spines.
—— similis..................	20 to 40 f.	......	local	valves.
Ostrea edulis	8 fath.	......	local.	
Anomia ephippium.........	......	various	freq.	varieties, aspera, electrina, &c.
—— patelliformis	......	8 fath.	rare.	
Hyalæa tricornis...........	45 fath.	......	...	one, pellucid, radiated with pink.
Cleodora	45 fath.	......	...	fragment.
Chiton siculus	......	sh. to 8 f.		
—— fascicularis	......	8 fath.		
—— Rissoi	......	sh. to 8 f.		
Patella athletica?	......	littoral	freq.	
—— ——	......	littoral	freq.	angulated.
Siphonaria concinna	......	littoral	freq.	
Acmæa virginea	......	8 fath.	freq.	
Haliotis tuberculata, var.?	......	shore	local.	
Emarginula elongata	various	......	freq.	
Fissurella rosea	......	littoral	freq.	
—— gibba	8 to 15 f.	8 fath.	freq.	
—— græca?	......	litt. to 8 f.	local.	
—— costaria?	......	8 fath.	local.	
Capulus ungaricus	12 fath.	......	rare.	
Calyptræa sinensis	......	0 to 30 f.	v. a.	
Bulla lignaria	8 fath.	......	rare.	
—— cylindrica	......	12 fath.	rare.	
—— truncata	10 to 40 f.	......	local	some large.
—— umbilicata	20 to 40 f.	......	local.	
—— acuminata	20 fath.	......	1	
Rissoa cimex	8 fath.	......	freq.	
—— calathiscus	8 fath.	......	freq.	
—— Montagui	8 fath.	......	freq.	
—— 2 others	8 fath.	......	freq.	
Eulima polita	0 to 30 f.	15 fath.	rare.	
—— nitida	0 to 30 f.	15 fath.	rare.	
—— unifasciata	15 fath.	......	1 spm.	
Eulimella acicula	......	15 fath.	local.	
—— —— (Scillæ?)	......	15 fath.	local	whorls flat, deeply grooved between.
Odostomia conoidea	......	8 to 30 f.	local.	
—— spiralis	......	8 to 30 f.	rare.	
Chemnitzia varricosa	shore	......	1	
—— elegantissima	0 to 30 f.	10 fath.	local.	
—— varicosa	15 to 30 f.	......	rare.	
—— scalaris	15 to 30 f.	......	rare.	
—— fulvocincta	15 to 30 f.	30 fath.	1 small.	
—— —— or cerithium? .	15 to 30 f.	......	rare.	
Natica Guilleminii	0 to 40 f.	12 fath.	freq.	
—— intricata	0 to 12 f.	8 to 10 f.	freq.	
—— bicallosa.				
—— sordida	12 fath.	......	v. r.	
—— Alderi.................	......	8 to 20 f.	local.	
—— sagra	......	8 fath.	local.	
—— macilenta?...........	......	30 to 40 f.	rare.	
Sigaretus perspicuus	shore	......	rare.	
Scalaria communis	......	shore	local.	
—— clathratulus	sh. to 10 f.	......	rare.	
—— Turtoni?	shore	......	local.	
Vermetus gigas	sh. to 10 f.	8 fath.	local.	
—— glomeratus	......	8 fath.	local.	
—— cancellatus?	......	8 fath.	local.	
—— semisurrectus (Serpula)	......	8 fath.	local.	
—— triqueter (Serpula)...	......	8 fath.	local.	
—— filogranus?............	8 fath.	......	local.	

	Depth.	Living at	Frequency.	
Pecten corneus?	8 fath.	......	local.	
Solarium stramineum?	40 fath.	40 fath.	rare	more compressed than specimens from Vigo, one living.
—— pseudo-perspectivum?	40 fath.	......	...	one, resembling in form *S. perspectivum*.
—— ——	40 fath.	......	...	one, small, flat, strongly reticulated.
Trochus Laugieri	......	8 fath.	freq.	with varieties.
—— striatus	......	littoral.	abun.	
—— Montagui	12 to 40 f.	15 fath.	local.	
—— magus	......	8 to 15 f.	freq.	smaller than in Britain.
—— granulatus	......	8 to 15 f.	local	smaller than in Britain.
—— dubius	12 fath.	......	rare.	
—— fanulum	......	6 to 10 f.	freq.	
—— divaricatus	......	littoral	freq.	
—— articulatus	......	littoral	freq.	
—— Richardii	......	littoral	freq.	
—— Vieillotti	......	littoral	local.	
—— conulus, var.	......	10 fath.	local.	
—— fragaroides	......	littoral	local.	
—— ziziphinus	......	6 to 8 f.	local.	
Turbo rugosus	0 to 30 f.	8 fath.	freq.	
Phasianella pulla	......	8 fath.	local.	
Littorina littoralis	......	littoral	local.	
—— neritoides	......	littoral	abun.	
Turritella tricostalis	......	0 to 30 f.	abun.	*large* only in shallow water.
—— terebra	......	8 to 40 f.	abun.	produced, narrow, in deep water, nearly all distorted.
Mesalia sulcata	......	8 to 15 f.	freq.	
—— ——	......	15 fath.	...	two, living, *qy.* (new?).
——? ——, new	......	15 to 30 f.	rare	four, living, smooth like terebra.
——? ——	......	15 to 30 f.	...	one, living (minute).
Cerithium vulgatum	......	littoral	abun.	
—— reticulatum	......	lit. to 12 f.	local.	
—— perversum	10 to 30 f.	......	local.	
—— ——	20 fath.	......	rare	white.
—— ——?	20 fath.	......	rare	white.
Cancellaria cancellata	......	8 fath.	rare.	
——, new sp.	......	8 to 15 f.	rare	white.
Fusus pulchellus	......	8 to 40 f.	local.	
—— rostratus?	......	8 to 12 f.	local.	
—— corallinus	......	4 to 30 f.	freq.	
—— corneus (Lin.)	......	8 fath.	local.	
Murex multilamellatus	15 fath.	......	...	one, known hitherto as a fossil only.
Fusus ——?	......	8 fath.	...	one, short.
—— ——?	......	10 to 30 f.	local	some resemblance to *T. corallinus*, but conical, more produced, varies in colour from white to dark brown, latter genera true.
Pleurotoma brachystomum	......	8 to 15 f.	local.	
—— ginnannianum	......	8 fath.	freq.	
—— reticulatum	......	4 to 8 f.	local.	
—— purpureum	......	0 to 8 f.	local.	
—— Boothii	10 fath.	......	...	one, fine, but dead (occupied by a hermit crab).
—— septangulare	8 fath.	......	...	one, imperfect.
—— attenuatum	......	4 to 8 f.	local	} probably some others not identified.
—— gracile (Mont.)	......	4 to 8 f.	rare	
—— crispatum	40 fath.	......	one	
—— elegans	......	6 to 25 f.	freq.	
—— vauquelinii?	8 to 15 f.	......	local	
—— lævigatum	8 fath.	......	one	
—— nanum	8 fath.	......	local	
—— ——	......	10 fath.	v. r.	banded yellow and black, one living, one dead.
Murex brandaris	......	5 to 30 f.	local.	
—— truncatus	......	5 to 10 f.	freq.	
—— erinaceus	......	0 to 10 f.	local.	
—— cristatus	......	8 fath.	local.	

	Depth.	Living at	Frequency.	
Ranella gigantea	shore	......	local	of Mediterranean.
Triton variegatum	shore	......	local	of Mediterranean and bay.
—— nodiferum	shore	......	local	of Mediterranean.
—— cutaceum	shore	......	local	bay.
—— corrugatum	......	8 fath.	local.	
Chenopus pes-pelecani ...	......	8 to 15 f.	local.	
Cassis sulcosa	shore	......	rare.	
Nassa mutabilis	......	8 fath.	freq.	
—— neritoides	......	8 fath.	freq.	small variety.
—— incrassata	......	8 fath.	freq.	
—— reticulata	......	4 to 12 f.	freq.	
—— varicosa	......	8 fath.	freq.	
Buccinum minus............	......	8 fath.	freq.	
—— minimum	0 to 10	......	freq.	
—— variabilis	......	4 to 10 f.	freq.	
—— corniculum	......	littoral	freq.	
—— granum	......	10 fath.	rare.	
—— scriptum...............	......	8 fath.	freq.	
Columbella rustica	......	littoral	freq.	
—— —— ?..................	8 fath.	......	two.	
Ringuicula auriculata	10 to 25 f.	......	local.	
Mitra ebenus	......	8 fath.	freq.	
—— columbellaria.........	......	8 to 30 f.	local.	
Cymba olla	shore	......	local	Mediterranean.
Erato lævis	8 to 20 f.	......	rare.	
Marginella clandestina ...	......	15 to 40 f.	freq.	
—— miliacea	......	8 fath.	freq.	
Ovula spelta	......	8 to 10 f.	rare	on Gorgonia.
Cypræa pyrum	shore	......	rare.	
—— europæa...............	......	8 fath.	local.	
Conus mediterraneus	......	littoral	freq.	
Spirula Peronii	shore	......	freq.	
Dentalium tarentinum ...	......	8 to 40 f.	rare	some of the smaller specimens finely striated longitudinally with a waved appearance.
—— quadrangulare	......	8 to 20 f.	freq.	
Ditrupa subulata............	30 to 45 f.	......	rare.	
—— ——, new?	......	15 to 40 f.	local	small, transparent, not much arcuated, narrow end grooved fore and aft.
Anatifa lævis	......	shore	local.	
—— striata..................	......	......	rare.	
—— fascicularis	......	......	rare.	
Balani.				
Echinus esculentus, abundant.				
—— ——.				
Lluydia fragilissima				
Asterias, &c.				

Few species of land-shells on the rock; the prevailing are—

Helix pisana.
—— virgata.
Helix lactea, var. Hispanica.
Bulimus acutus.

List of Shells procured at Malaga from 6th to 11th of May 1849, with the addition of some species obtained in same locality on a former occasion.

	Dead at	Living at	Frequency.	
Dentalium fissura, or rubescens.	shore	4 fath.	local	*all* the specimens have (upon close examination) a very narrow fissure.
—— tarentinum	......	8 to 30 f.	local.	
Pholas dactylus	shore	......	rare	valves.
—— candida	shore	......	rare	valves.
—— parva	shore	......	rare	valves.
Corbula nucleus	......	4 to 30 f.	freq.	
Pandora rostrata	shore	4 to 8 f.	freq.	
Thracia phaseolina	shore	......	local.	
Solen ensis	shore	4 to 8 f.	freq.	
—— vagina	shore	......	local.	
Solecurtus legumen	shore	4 fath.	freq.	
—— antiquus	......	4 fath.	local.	
Psammobia ferroensis	shore	......	local.	
Diodonta fragilis	shore	......	freq.	in the harbour.
Scrobicularia piperata	shore	......	local.	
Tellina costæ	shore	......	local.	
—— —— (new)	shore	......	local	some resemblance to *T. costæ*, but larger and with more colour.
—— pulchella	shore	......	freq.	
—— tenuis	shore	......	freq.	
—— depressa	shore	......	freq.	
—— distorta	shore	......	local.	
—— punicea	shore	......	local.	
—— planata	shore	......	local.	
Syndosmya alba	......	4 fath.	abun.	
Donax trunculus	shore	shore	freq.	} sold for the table and much esteemed; obtained by men wading with nets, as shrimps in England.
—— venustus	shore	shore	freq.	
Mesodesma donacilla	shore	shore	freq.	
Lutraria elliptica	shore	......	freq.	
—— oblonga	4 fath.	......	local.	
—— rugosa	shore	......	1 valve.	
Mactra subtruncata	......	4 fath.	freq.	
Tapes Beudantii	shore	......	local.	
—— geographica	shore	......	local.	
Cytherea venetiana	shore	4 to 12 f.	local.	
—— chione	shore	4 fath.	freq.	
Venus gallina	shore	4 fath.	abun.	procured extensively for food.
—— striatula	......	35 fath.	freq.	
—— fasciata	......	4 to 12 f.	freq.	
—— ovata	......	4 to 12 f.	freq.	
—— ——, new?	......	35 fath.	...	large, closely laminated.
Circe minima	......	4 to 12 f.		
Artemis lincta	shore	4 fath.		
Cardium aculeatum	shore	4 to 8 f.		
—— tuberculatum	shore	4 to 8 f.		
—— edule	shore			
—— fasciatum	......	4 to 8 f.		
Cardita calyculata	......	littoral	abun.	rocks.
Lucina lactea	......	littoral	abun.	harbour.
Pectunculus violascens	shore	4 to 8 f.	abun.	
Nucula polii	......	35 fath.	local	large and fine.
—— nucleus	......	4 to 30 f.	freq.	
Leda emarginata	......	4 to 8 f.	local.	
Avicula tarentina	......	35 fath.	rare	two fine groups.
Chama gryphoides	shore	......	rare.	
Mytilus afer	......	littoral	abun.	rocks, the common species.
Crenella costulata	shore	4 fath.	rare.	
Pecten varius	shore	4 to 8 f.	freq.	
Ostrea edulis	......	4 to 8 f.	freq.	

	Dead at	Living at	Frequency.	
Anomia ephippium and var. electrina	shore	4 to 8 f.	freq.	
Hyalæa tricornis	shore	......	rare.	
Chiton fascicularis	......	littoral	freq.	
Patella, species uncertain	......	littoral	freq.	
Siphonaria concinna	......	littoral	freq.	
Emarginula elongata	0 to 8 f.	......	local.	
Fissurella rosea	......	littoral	local.	
Calyptræa sinensis	......	0 to 8 f.	abun.	
Sigaretus haliotideus	shore	......	one.	
Bullæa aperta	shore	4 fath.	freq.	
Truncatella Montagui	shore	......	rare.	
Rissoa monodonta	......	4 fath.	abun.	on Zostera.
—— labiosa	......	4 fath.	freq.	on Zostera.
——, new sp. ?	......	35 fath.	rare	resembling *R. abyssicola*, but distinct.
Odostomia conoidea	......	35 fath.	local.	
Chemnitzia elegantissima	......	35 fath.	local.	
Neritina viridis	......	4 fath.	local	on Zostera.
Natica sordida	30 fath.	......	one.	
—— sagra	shore	4 to 8 f.	freq.	
—— Guilleminii	shore	......	freq.	
—— intricata	shore	......	local.	
Tornatella fasciata	shore	......	local.	
Ianthina nitens	shore	......	rare.	
Scalaria communis	shore	......	local.	
—— pseudoscalaris	shore	......	local.	
Vermetus gigas	shore	......	local.	
—— ——, *qy.* corneus?	shore	......	local.	
Solarium stramineum	shore	......	rare.	
—— ——	......	35 fath.	rare	on Avicula, minute, flat, bicarinated.
Trochus ziziphinus	shore	4 fath.	local.	
—— striatus	......	4 fath.	...	extremely abundant on Zostera.
—— magus	......	4 fath.	freq.	
—— Laugieri	shore	4 fath.	freq.	
—— conulus, var.	......	4 to 8 f.	local	small.
—— granulatus	......	4 fath.	rare.	
—— tessellatus	shore	......	local.	
—— Richardii	......	littoral	freq.	
—— divaricatus	......	littoral	freq.	
—— articulatus	......	littoral	freq.	
—— Vieillotti	......	littoral	local.	
—— fragaroides	......	littoral	freq.	
—— ——	......	littoral	freq.	
Phasianella pulla	......	4 fath.	local.	
Littorina neritoides	shore	......	rare.	
—— petræa	......	littoral	abun.	
—— tigrina (D'Orbigny)	......	littoral	local.	
Turritella tricostalis	shore	......	...	a fragment.
—— terebra	......	12 to 35 f.	freq.	
Cerithium vulgatum	shore	......	freq.	
—— reticulatum	shore	......	freq.	
—— perversum	shore	......	rare.	
Cancellaria cancellata	......	4 fath.	freq.	
Pleurotoma brachystomum	30 fath.	......	local.	
—— ginnannianum	......	4 fath.	local.	
—— attenuatum	......	2 to 4 f.	local.	
—— lævigatum	......	2 to 4 f.	local.	
Triton variegatum	......	4 fath.	local.	
Cassis sulcosa	shore	......	local.	
Murex trunculus	......	4 fath.	freq.	
—— brandaris	......	4 fath.	freq.	
—— erinaccus	......	4 to 8 f.	freq.	

	Dead at	Living at	Fre-quency.	
Nassa mutabilis	......	4 to 8 f.	freq.	
—— neritoides	shore	......	local.	
—— macula	......	4 to 8 f.	freq.	
—— reticulata	......	4 to 8 f.	freq.	
—— varicosa	......	4 to 8 f.	freq.	
Pollia maculosa	......	littoral	freq.	rocks.
Buccinum minus	......	4 fath.	v. a.	on Zostera.
—— variabilis	shore	......	freq.	
—— corniculum	shore	......	freq.	
—— granum	shore	4 fath.	freq.	
—— modestum?	......	4 to 8 f.	local	two varieties.
Columbella rustica	......	littoral	abun.	
Ringuicula auriculata	2 to 8 f.	......	freq.	
Mitra ebeneus	......	littoral	local.	
Cymba olla	shore	......	local.	
Cypræa pyrum	shore	......	local.	
—— europæa	shore	......	freq.	
Conus mediterraneus	......	littoral	freq.	
Spirula Peronii	shore	......	freq.	
Anatifa fascicularis	shore	......	...	numerous valves.
—— striatus	shore	......	local.	
Balani.				
Large Asterias, abundant.				
Comatula, abundant.				
ZoanthusCouchii uponAvicula.				

Sea-bottom mud, to a distance of 5 or 6 miles from land.

A small shrimp-formed crustacean, claws short and broad, emits a sharp snapping noise when taken in the fingers and even after it is in spirits. The species not uncommon in most of the ports I visited in the Mediterranean.

On the 12th of May, between Malaga and Carthagena, attempted twice to dredge, but obtained no bottom with 350 fathoms line.

Carthagena, 14th to 16th of May.

	Ground.	Dead at	Living at	Fre-quency.	
Saxicava arctica	mud	......	35 fath.	rare.	
Petricola lithophaga	...	shore	......	freq.	
Venerupis Irus, var.	...	shore	......	freq.	
Neæra cuspidata	s. & m.	30 fath.	......	rare	valves.
—— costulata	s. & m.	......	30 fath.	rare	one living.
Tellina balaustina	s. & m.	......	30 fath.	rare.	
—— serrata	s. & m.	30 fath.	......	rare	valves.
—— planata	...	shore	......	local.	
—— punicea	sand	6 fath.	......	rare	valves.
—— distorta	sand	7 fath.	......	local.	
—— donacina	sand	7 fath.	......	local.	
—— fabula	sand	7 fath.	......	local.	
Diodonta fragilis	...	shore	......	local.	
Syndosmya	mud	......	40 fath.	rare	small, pellucid.
Donax trunculus	...	shore	......	freq.	
—— venustus	...	shore	......	local.	

	Ground.	Dead at	Living at	Frequency.	
Tapes florida	...	shore	......	local	(small).
Cytherea venetiana	s. & m.	......	30 fath.	rare.	
—— chione	sand	......	7 fath.	local	small.
Venus gallina	...	shore	......	freq.	
—— ovata	s. & m.	......	30 fath.	freq.	
—— fasciata	s. & m.	......	30 fath.	local.	
Circe minima	s. & m.	......	30 fath.	local.	
Lucinopsis undata	sand	7 fath.	......	rare	one specimen.
Cardium lævigatum	s. & m.	......	30 fath.	rare	young.
—— exiguum	weed	......	5 fath.	local.	
—— papillosum	s. & m.	......	30 fath.	local.	
—— echinatum	weed	......	5 fath.	one.	
Cardita trapezia	...	shore	......	freq.	
—— sulcata	...	......	7 fath.	one	large.
Lucina lactea	...	shore	......	freq.	
—— spinifera	mud	......	30 to 40 f.	local.	
—— pecten	...	shore	......	local.	
—— divaricata	weed	......	5 to 40 f.	local	small.
Diplodonta rotundata	weed	5 fath.	......	local.	
—— ?	weed	......	5 to 8 f.	local	very convex, yellow or buff.
Kellia corbuloides	...	shore	......	local.	
Modiola tulipa	weed	......	7 fath.	local.	
—— petagnæ	...	shore	......	local.	
Mytilus minimus	...	shore	......	freq.	
Nucula nucleus	s. & m.	......	10 to 40 f.	freq.	
—— nitida	sand	......	10 fath.	local.	
—— polii	mud	......	30 to 40 f.	local.	
Leda emarginata	mud	......	7 fath.	local.	
—— striata	s. & m.	......	30 to 40 f.	local.	[a fusca.
Arca	s. & m.	40 fath.	......	valve	same as at Gibraltar, resembling
Pecten gibbus	s. & m.	40 fath.	......	local	valves.
—— hyalinus	weed	......	5 fath.	one.	
—— striatus ?	sand	......	8 fath.	one.	
—— polymorphus	sand	6 to 8 f.	......	local	valves.
—— pes-felis?	s. & m.	40 fath.	......	...	fragment.
Spondylus gæderopus	s. & m.	6 to 10 f.	......	local	valves.
Anomia ephippium	s. & m.	6 to 10 f.	5 to 10 f.	freq.	
Chiton marmoreus	s. & m.	......	5 to 10 f.	rare.	
—— ——	s. & m.	......	5 to 10 f.	one	same as at Gibraltar, elongated.
—— siculus	s. & m.	......	5 to 10 f.	one	small.
Patella	...	shore	......	local	small.
Fissurella rosea	...	shore	......	local.	
—— gibba	...	shore	......	local.	
Calyptræa sinensis	s. & m.	......	5 to 10 f.	abun.	
Crepidula unguiformis	s. & m.	shore	......	one.	
Bulla striata	s. & m.	30 fath.	......	one.	
—— Cranchii	s. & m.	......	30 to 40 f.	rare.	
—— truncata	...	......	30 to 40 f.	local.	
—— acuminata	...	30 fath.	......	one.	
—— umbilicata	s. & m.	30 to 40 f.	......	rare.	
—— ——, new spec. ?	...	30 to 40 f.	30 to 40 f.	local	subcylindrical, thin, pellucid,
—— striatula ? Forbes	...	30 to 40 f.	......	local.	broad, extremity contracted,
Auricula bidentata ?	...	shore	......	one.	giving the appearance of Cu-
Rissoa monodonta?	...	shore	5 fath.	local.	vieria.
—— parva	...	shore	5 fath.	local.	
—— acuta	...	sh. & 5 f.	......	local.	
—— purpurea	...	shore	......	local.	
—— Bruguieri	...	10 fath.	......	v. r.	
—— granulata	...	shore	......	freq.	
—— calathiscus	...	shore	......	freq.	
—— Montagui	...	shore	......	freq.	
—— new ?	...	30 fath.	......	one.	
and some others.					

	Ground.	Dead at	Living at	Frequency.	
Odostomia	s. & m.	......	30 to 40 f.	rare.	
Eulima polita	s. & m.	......	30 to 40 f.	rare.	
—— distorta	s. & m.	......	30 fath.	v. r.	
—— subulata	s. & m.	......	30 fath.	rare.	
Natica macilenta	s. & m.	......	30 to 40 f.	rare.	
—— intricata	s. & m.	......	40 fath.	rare	small.
—— Alderi	s. & m.	......	30 to 40 f.	rare.	
Scalaria crenata	...	shore	......	one.	
—— pseudoscalaris	...	shore	......	rare.	
Neritina viridis	weed	shore	5 fath.	abun.	
Vermetus semisurrectus (Serpula)	sand	......	30 fath.	local.	
Vermetus gigas	sand	......	30 fath.	local.	
—— cancellatus ?	sand	......	30 fath.	local.	
Trochus striatus	sand	......	4 fath.	freq.	
—— ——	...	......	4 fath.	rare.	
Phasianella pulla	weed	......	4 fath.	local.	
—— intermedia ?	weed	......	4 fath.	local.	
Littorina petræa	...	shore	......	freq.	
Turritella tricostalis	s. & m.	......	30 fath.	local.	
—— terebra	s. & m.	......	30 fath.	local.	
Cerithium reticulatum	weed	......	4 fath.	freq.	
—— perversum	weed	4 fath.	......	local.	
Fusus muricatus	s. & m.	......	30 fath.	rare	two specimens.
—— corallinus	sand	......	8 fath.	local.	
—— corneus, Lin.	sand	......	8 fath.	local.	
Pleurotoma gracile	sand	30 to 40 f.	......	rare.	
—— lævigatum	sand	8 fath.	......	rare.	
—— purpureum	sand	8 fath.	......	local.	
—— ginnannianum	mud	......	10 to 40 f.	local.	
—— brachystomum, and about 3 others	mud	......	30 to 40 f.	local.	
Nassa neritoides	sand	......	8 fath.	freq.	
Buccinum minimum	sand	......	8 fath.	local.	
Ringuicula auriculata	mud	......	40 fath.	local.	
Erato lævis	sand	......	8 fath.	local.	
Marginella clandestina	s. & m.	......	30 to 40 f.	freq.	
—— miliacea	sand	......	8 fath.	local.	
Dentalium tarentinum	sand	......	8 fath.	local.	
—— fissura or rubescens	mud	......	5 fath.	local.	(fissured).
Ditrupa	s. & m.	......	30 to 40 f.	local	species obtained at Gibraltar
Brissus lyrifer	mud	......	40 fath.	...	one.
Starfish	sand	......	10 fath.		
A fragment of Pavonaria	...	......	40 fath.	...	mud.

Bay of Algiers, 18th to 21st of May; bottom sand and mud.

	Dead at	Living at	Frequency.	
Dentalium tarentinum	......	10 to 35 f.	local.	
—— dentalis	......	6 to 10 f.	local.	
—— fissura	......	6 to 10 f.	local.	
—— ——	35 fath.	......	local	striated, waved appearance, *qy.* var. of *D. tarentinum.*?
Ditrupa subulata ?	35 fath.	......	local.	
Saxicava arctica	......	35 fath.	rare.	
Anatifa striata	......	surface	abun.	on floating reeds, &c.
—— fascicularis	......	surface	abun.	on blades of Zostera and other floating substances.
Corbula nucleus	......	8 fath.	freq.	
Thracia phaseolina	35 fath.	......	rare.	

	Dead at	Living at	Frequency.	
Solecurtus antiquus	35 fath.	......	rare	valves.
Psammobia ferroensis	......	10 fath.	local	small.
—— costulata	10 fath.	......	local.	
Tellina pulchella	......	8 fath.	local.	
—— donacina	......	10 fath.	freq.	
—— distorta	......	10 fath.	freq.	
—— balaustina	......	10 fath.	rare.	
—— punicea	shore	......	local.	
—— depressa	shore	......	local.	
Syndosmya, sp.	......	20 to 30 f.	rare	very narrow and pointed.
Donax trunculus	shore	......	freq.	
—— venustus	shore	......	local.	
—— politus	......	8 fath.	local.	
Mactra stultorum	......	shore	freq.	
—— subtruncata	......	6 fath.	freq.	
Tapes virginea	......	10 fath.	local.	
—— —— nitens?	10 fath.	......	one.	
—— Budantii	6 fath.	......	local.	
—— florida	6 fath.	......	local.	
Cytherea chione	6 to 8 f.	......	freq.	
—— venetiana	......	35 fath.	local.	
—— ——, var.? or new?	......	35 fath.	rare	white, striated.
Venus gallina	......	shore	freq.	
—— striatula	......	30 fath.	freq.	mud.
—— verrucosa	......	6 fath.	...	sold in market.
—— fasciata	......	6 to 35 f.	freq.	
—— ovata	......	6 to 35 f.	freq.	
Artemis exoleta	......	6 to 8 f.	freq.	
—— lincta	......	6 to 8 f.	freq.	
Astarte incrassata	35 fath.	......	rare	valves.
Cardium tuberculatum	shore	......	local.	
—— ciliare	......	25 fath.	local	mud.
—— echinatum	8 fath.	......	local	valves.
—— exiguum	......	6 to 10 f.	local.	
—— papillosum	......	35 fath.	local.	
—— lævigatum (sulcatum?)	......	35 fath.	rare.	
Lucina digitalis	......	35 fath.	rare.	
—— pecten	6 to 8 f.	......	local.	
—— radula?	6 to 8 f.	......	rare	valve.
—— lactea	......	6 to 8 f.	local.	
—— divaricata	......	6 to 8 f.	local	one large.
—— bipartita	35 fath.	......	rare	valves.
Cardita trapezia	8 to 6 f.	......	local	valves.
—— calyculata	shore	......	freq.	
—— squamosa (aculeata, Phil.)	......	35 fath.	local.	
Chama gryphoides	6 to 8 f.	......	rare.	
Mytilus galloprovincialis	......	shore	freq.	very large and fine.
Modiola barbata	......	6 to 8 f.	v. r.	
—— vestita	......	35 fath.	v. r.	
Nucula nucleus	......	6 to 8 f.	freq.	
—— nitida	......	6 to 8 f.	freq.	
—— radiata	......	6 to 8 f.	local.	
—— polii	......	35 fath.	local.	
Leda emarginata	......	6 to 10 f.	freq.	
—— striata	......	35 fath.	freq.	
Arca noë	shore	......	freq.	valves.
—— barbata	6 to 10 f.	......	local	valves.
—— lactea	......	6 to 10 f.	local.	
—— tetragona	......	35 fath.	local.	
—— obliqua	......	35 fath.	v. r.	one or two valves.

	Dead at	Living at	Frequency.	
Pectunculus glycimeris	......	35 fath.	rare	small.
—— violascens	shore	......	v. a.	
Pinna	6 to 8 f.	......	...	fragments.
Lima squamosa	shore	......	local	valves.
—— scabrella	shore	......	local	valves.
—— tenera	6 to 10 f.	......	local	valves.
—— fragilis	35 fath.	......	local	valves.
—— subauriculata	35 fath.	......	rare	valves.
Pecten maximus	......	6 to 8 f.	local.	
—— polymorphus	35 fath.	......	local	valves.
—— similis	35 fath.	......	local	valves.
—— pes-felis	35 fath.	......	v. r.	valves.
—— varius	35 fath.	......	freq.	valves.
—— gibbus	35 fath.	......	freq.	valves.
—— distortus	35 fath.	......	local	valves.
—— opercularis	35 fath.	35 fath.	local.	
—— hyalinus	......	6 to 8 f.	rare.	
—— sulcatus	......	6 to 8 f.	rare.	
Spondylus gæderopus	6 to 8 f.	......	local	valves.
Ostrea edulis	......	......	...	in the market.
Anomia ephippium	......	6 to 10 f.	local.	
Chiton	35 fath.	......	rare	valves, white.
——	35 fath.	......	rare.	
Patella	shore	......	freq.	
Umbrella mediterranea	8 fath.	......	v. r.	a fragment.
Emarginula elongata	35 fath.	......	local.	
Fissurella gibba	35 fath.	......	local.	
—— rosea?	6 fath.	......	local.	
Haliotis tuberculatus	6 fath.	......	rare.	
Capulus Ungaricus	35 fath.	......	rare.	
Calyptræa sinensis	6 to 10 f.	......	abun.	
Crepidula unguiformis	......	shore	...	in a dead Cassis.
Bullæa aperta	......	6 fath.	freq.	
—— punctata	......	35 fath.	rare.	
—— ——, new	......	6 fath.	one	animal resembling *B. aperta*; shell and gizzard small and totally different.
Bulla striata	6 fath.	6 fath.	rare.	
—— Cranchii	......	35 fath.	rare.	
—— truncata	......	35 fath.	local.	
—— acuminata	35 fath.	......	v. r.	
Rissoa acuta	6 to 10 f.	......	local.	
—— cimex	6 to 10 f.	......	local.	
—— Montagui	6 to 10 f.	......	local.	
—— labiosa	6 to 10 f.	......	local.	
—— Macandreæ, Hanley, new	35 fath.	......	v. r.	a fragment.
Odostomia conoidea?	10 fath.	......	rare	large.
Chemnitzia elegantissima	35 & 10 f.	......	local.	
—— scalaris	35 fath.	......	rare.	
—— indistincta?	35 fath.	......	rare.	
Eulimella acicula	35 fath.	......	rare.	
Natica millepunctata var. maculosa	......	......	freq.	in the market.
—— sagra	8 fath.	......	rare.	
—— Alderi	......	8 fath.	local.	
Neritina viridis	8 fath.	......	local.	
Tornatella fasciata	8 fath.	......	rare.	
Scalaria communis	8 fath.	......	rare.	
—— lamellosa?	35 fath.	......	rare.	
Trochus crenulatus	8 to 10 f.	......	local.	
—— ziziphinus	35 fath.	35 fath.	local.	
—— dubius	35 fath.	......	rare.	
—— tessellatus	......	littoral	freq.	large.

	Dead at	Living at	Frequency.	
Trochus articulatus	......	littoral	local.	
—— crenulatus, var. ?	8 to 10 f.	......	local.	
—— Vieillotti	8 to 10 f.	......	local.	
Phasianella pulla	......	8 to 10 f.	local.	
—— intermedia	......	8 to 10 f.	local.	
Turbo rugosus	35 fath.	......	local	young.
Littorina petræa	......	littoral	freq.	
Turritella tricostalis	......	35 fath.	local	small.
—— terebra	......	20 fath.	local	mud.
Cerithium vulgatum	......	6 fath.	freq.	
—— ——, var.	......	35 fath.	local.	
—— adversum	......	8 to 10 f.	local.	
—— reticulatum	8 to 10 f.	......	local.	
Cancellaria cancellata	......	8 to 25 f.	freq.	
Pleurotoma balteata	35 fath.	......	...	a fragment, banded, black and yellow.
Pleurotoma	......	10 fath.	rare.	
Fusus corneus	......	8 fath.	local.	
—— corallinus	......	10 fath.	local.	
—— elegans	......	10 fath.	rare.	
Murex cristatus	......	6 fath.	rare.	
Triton variegatum	shore	......	local	market.
—— nodiferum	shore	......	local	market.
Chenopus pes-pelecani	......	8 to 10 f.	local.	
Purpura hæmastoma	......	littoral	local	market.
Columbella rustica	......	littoral	freq.	
Mitra ebeneus	......	8 to 10 f.	local.	
—— Savignii	8 to 10 f.	......	local.	
—— columbellaria	......	35 fath.	rare.	
Cassis sulcosa	......	shore	freq.	market.
Nassa reticulata	......	6 fath.	freq.	
—— neritea	......	6 fath.	freq.	
—— macula	......	6 fath.	freq.	
—— varicosa	......	6 to 10 f.	freq.	
—— ——	......	35 fath.	one	large, reticulated, serrated operculum.
Buccinum mutabile	......	6 to 10 f.	local.	
—— variabile	......	6 to 10 f.	freq.	
—— minus	......	6 to 10 f.	local.	
Marginella clandestina	......	35 fath.	freq.	
—— miliacea	......	8 fath.	freq.	
Ovula spelta	8 fath.	......	rare.	
—— carnea	35 fath.	......	local.	
Ringuicula auriculata	......	35 fath.	local.	
Cypræa erosa ?	8 fath.	......	...	fragment.
—— europæa	8 fath.	......	local.	
—— pulex	8 fath.	......	local.	
Conus mediterraneus	......	shore	dead.	

Of the foregoing, those from 10 fathoms and under were obtained in the harbour, sand and mud; from 35 fathoms off Cape Matafus, east point of the bay, sand; and from between 10 and 35 fathoms in the bay, mud.

Spondylus gæderopus, *Lithodomus lithophagus*, *Arca noe*, &c., sold alive in the market, but brought from Mahon.

I was disappointed in not being able to dredge on the ground of the great coral fishery between Algiers and Tunis, but the wind was too strong when I passed over it.

Goletta, near Tunis, 23rd to 27th of May.

Dentalium fissura or rubescens, *white*.
Solemya mediterranea.
Tellina costæ.
Lutraria rugosa—a valve.

Mactra stultorum.
Tapes florida ?
Donax trunculus.
Scrobicularia tenuis—shore of the lake.
Cardium edule, var.—shore of the lake, small, wide, thin.
—— —— —— ?—shore of the bay, strong, triangular, fewer ribs (22), and other common littoral species.

In Tunis Bay 25 fathoms, mud.

Corbula rosea ?—small, thin, pellucid, numerous.
Cytherea venetiana—small.
Arca noe—valves.
Arca antiquata ?—valves large.
Bulla striata.
Natica olla.
—— millepunctata—banded var.
Nassa neritea.
Erato lævis.
Cerithium fuscatum (living).
Trochus articulatus (living).
—— tessellatus (living).
Helix pisana†. } alive.
Glandina follicula—large†. } alive.
Bulimus decollatus—large†. } alive.
Clausilia papyracea†. } alive.
Helix melanostoma†. } dead.
—— naticoides†. } dead.

Dredging Paper No. 3.

Date, 29th of May, 1849.
Locality, north-east of the Island of Zembretta, mouth of Gulf of Tunis.
Depth, 35 fathoms.
Distance, $1\frac{1}{2}$ to 2 miles from the island.
Ground, sand and gravel with occasional rocks.

Species obtained.	No. of living specimens.	No. of dead specimens.	Observations.
Dentalium tarentinum	3		
—— ——, var. ?	......	2	striated with waved appearance.
Cæcum trachea	......	3	
Ditrupa subulata, var..........	several	numerous.	
—— subulata	1	few	small.
—— ——	......	1	pellucid, notched aperture, species at [Gibraltar.
Saxicava arctica	......	2	
Sphænia Binghami	1		
Corbula nucleus	several.		
—— rosea ?.....................	2		
Neæra cuspidata	......	1	
—— costulata..................	......	1	
Pandora obtusa	......	1	
Thracia phaseolina ?	1	......	young.
Solen pellucidus	2	......	young.
Syndosyma	1	......	young, pellucid.
—— tenuis	2		
Psammobia costulata	1 young	3 valves.	
Tellina donacina	......	valves.	
—— crassa	2 young	......	very minute.
—— balaustina	......	valves.	
—— punicea ?	1 young.		
—— pulchella	......	valves.	
—— distorta	......	valves.	
—— fabula.......................	......	3	small.
Lucina spinifera	5	......	small.
—— bipartita....................	1	2 & valves.	
—— divaricata	......	1 valve.	
—— digitalis	4	valves.	
—— ——, *qy.* astarte ?	2	6 valves.	
Cytherea chione	......	1	young.
Artemis exoleta ?...............	several	......	minute.
Circe minuta	3	......	minute.

† The most abundant land shells among the ruins of Carthage.

Species obtained.	No. of living specimens.	No. of dead specimens.	Observations.
Venus fasciata	several	......	minute.
—— striatula	2 young.		
—— ovata	several.		
Cardium papillosum	4	several.	
—— fasciatum	1		
—— lævigatum	2	......	young.
—— minimum	2		
—— ——	......	1	small, white.
Cardita trapezia?	1	valves.	
—— corbis	numerous	numerous.	the most abundant species, most dead.
Nucula nucleus	numerous	numerous.	
—— radiata	5	numerous.	
Leda emarginata	......	valves.	
—— striata	few.		
Arca tetragona	1 young.		
—— lactea	4		[wide.
—— ——	......	1 valve	resembling antiquata, but short and
—— ——	......	1 valve	reticulated.
Pectunculus glycimeris	2	......	young.
—— lineatus?	1		
Diplodonta apicalis?	2	valves.	
Modiola tulipa	1	several val.	
Crenella rhombea	20	valves.	
—— ——	......	1 valve.	
—— marmorata	2	......	minute.
Avicula tarentina	1 small	......	attached to a yellow Gorgonia.
Lima fragilis	1	valves.	
—— subauriculata	2	valves.	
Pecten Jacobæus	......	valves.	
—— varius	2	......	small.
—— opercularis	6 small.		
—— distortus (pusio)	1	valves.	
—— similis	1	valves.	
—— obsoletus or striatus?	......	1 valve.	
—— polymorphus	......	several	valves.
—— gibbus	......	several	valves.
Chama gryphoides	1		
Anomia ephippium	2	......	small.
Terebratula detruncata	......	several.	
Chiton lævis	2		
Haliotis tuberculatus?	......	1	
Emarginula elongata	......	2	
—— capuliformis	......	1	
Fissurella græca	......	2	one large, one small.
Calyptræa sinensis	......	1	
Crepidula unguiformis	......	2	[*daris.*
—— fornicata	1	......	small, on operculum of *Murex bran-*
Bullæa aperta	......	1	
—— scabra?	1		
Bulla hydatis	4	several	small.
—— truncata	few.		
—— Cranchii	......	2	
—— cylindrica	......	4	
Rissoa calathiscus	......	few.	
—— cimex	......	few.	
—— Montagui	......	few.	
—— acuta	......	few.	
—— Desmarestii	......	1	
—— Bruguieri	......	1	
—— labiosa	......	few.	
—— purpurea	......	1	
—— ——	......	3 or 4	
Odostomia conoidea	3		

Species obtained.	No. of living specimens.	No. of dead specimens.	Observations.
Odostomia conoidea	1	......	polished like Eulima.
Chemnitzia elegantissima	1	several.	
—— pallida	......	1	
—— scalaris	......	2	
—— gracilis ?	......	2	
—— indistincta ?	......	1	
Eulima nitida	2		
—— subulata	3		
Eulimella acicula ?	......	2	
Tornatella pusilla ?	......	1	small, white.
Natica millepunctata	......	2	young.
—— macilenta	several	several.	
—— Alderi	several	several.	
—— Guilleminii	......	1	
Scalaria clathratulus	......	1 & frag.	
—— lamellosa	......	2	
—— ——, new ?	......	1	coronated.
Vermetus triqueter	......	few.	
—— semisurrectus	......	few.	
—— glomeratus ?	......	few.	
—— corneus ?	......	1	
—— ——	......	1	very pellucid.
Mitra columbellaria	1	1	
—— ——, var.	......	2	
Trochus Montagui	2	8	
—— crenulatus and exiguus	......	several.	
—— sanguineus	......	2	
—— ——	......	6	species obtained larger at Malta.
—— canaliculatus	......	1	small.
—— granulatus	......	1	small.
Turbo rugosus	......	numerous	numerous young.
Turritella terebra	several.		
—— tricostalis	6	......	small.
Cerithium vulgatum, var.	3		
—— perversum	......	3	
—— reticulatum	......	several.	
—— —— ?	......	several	*qy.* whether var. of preceding ?
Fusus corallinus	......	several.	
—— ——	1	2	species at Gibraltar.
Pleurotoma maravignæ	1	3	
—— rude ?	......	2	small.
—— lineare	1	2	
—— reticulatum, var. spinosum	......	2	
—— crispatum	......	2	
—— teres	......	2	fragments.
—— brachystomum	......	several.	
—— septangulare	......	3	
—— purpureum	......	1	
—— attenuatum	......	several.	
and some not identified.	......		
Buccinum minus	......	1	
—— minimum	......	1	
Marginella secalina	1	1	
—— miliacea	......	several.	
—— clandestina	......	several.	
Ringuicula auriculata	......	1	
Erato lævis	1		
Cypræa pulex	......	several.	
Some minute shells not identified.			
Adna anglica	......	1	
Various Zoophytes, Sponges, &c.			

30th of May. Becalmed between Cape Bon and the island of Pantellaria, captured fifteen turtles; obtained from them two specimens of Coronula and several groups of *Anatifa lævis*; also several specimens of a species of crab.

A fish (Remora?) attached to bottom of the vessel near the bow, 18 inches under water. In form something like a dog fish, about 12 inches long: attempted to catch it from the boat, but it immediately let go its hold and dived, leaving a black mark upon the copper where it had adhered.

Obtained in the tow-net a specimen of a small Hyalæa, several of Atlanta, of *Creseis spinigera*, and two other species. N.B. I found after sunset to be the most favourable time for catching Pteropoda, &c.

Several Velellæ; a turtle was seen to eat one.

31st of May. Calm, 6 to 8 miles from Pantellaria, attempted to dredge, but got no bottom with 360 fathoms.

1st of June. Calm, near Pantellaria; not being able to get bottom from the vessel, went off in the boat, about 200 yards from shore; obtained bottom in 50 fathoms, shoaling rapidly to 35 fathoms. For species obtained see Dredging Paper No. 4.

Dredging Paper No. 4.

Date, 1st of June, 1849.
Locality, south side of the Island of Pantellaria.
Depth, 35 to 50 fathoms (steep).
Distance from shore, a furlong.
Ground, gravel, sand and nullipore.
Region,

Species obtained.	No. of living specimens.	No. of dead specimens.	Observations.
Dentalium entalis or tarentinum	......	1	
—— dentalis of Phillippi	......	1	
Cæcum trachea	......	3	
Saxicava arctica	1		
Corbula nucleus	......	1 valve.	
Neæra cuspidata	......	1 valve.	
Psammobia costulata	......	1 valve.	
Tellina donacina	......	valves.	
—— distorta	......	valves.	
—— balaustina	1	1	
Syndosmya	......	1 valve.	
Cytherea venetiana, var.?	......	valves.	white, striated.
Venus verrucosa	......	valves.	
—— fasciata	1	valves.	
—— ovata	......	valves.	
Cardium papillosum	......	valves.	
Cardita Corbis	......	2 & valves.	
Lucina spinifera	......	valve.	
—— bipartita	......	2 valves.	
—— divaricata	......	2 valves.	
—— digitalis	1	2 valves.	
—— ——	......	2 valves.	very convex.
Kellia suborbicularis	5	......	small.
Modiola barbata	......	2 valves.	young.
Crenella marmorata	......	2 valves.	
Nucula nucleus	......	2 valves.	
Leda emarginata	......	2 valves.	

Species obtained.	No. of living specimens.	No. of dead specimens.	Observations.
Arca barbata	1	2 valves.	
—— tetragona	1	2 valves.	
—— lactea	......	2 valves.	
Pectunculus glycimeris	......	2 valves.	
Pinna muricata ?	......	fragments	transparent, beautiful spoon-shaped processes.
Lima subauriculata	......	valves.	
Pecten maximus	1	valves.	
—— distortus (pusio)	4	valves.	
—— polymorphus	1	valves.	
—— striatus ?	3	valves.	
—— testæ	......	valve.	
—— gibbus	......	valves.	
—— similis	......	valves.	
Anomia ephippium	3		
—— patelliformis	1		
Terebratula cuneata	1		
—— detruncata	2		
Chiton lævis	3		
—— siculus	1		
—— ——	1	......	species at Gibraltar.
Lottia virginea	......	several.	
Emarginula capuliformis	......	several	minute.
—— elongata	......	2	
Fissurella costaria or græca	3		
—— gibba	......	1	
Crepidula fornicata	1		
—— ungulina	......	1	
Pileopsis ungaricus	......	2	
Bulla hydatis	......	1	
—— truncata	......	few.	
Rissoa granulata	......	few.	
—— Bruguieri	......	2	
—— calathiscus	......	few.	
—— lactea ?	......	few.	
—— ——	......	few	} not identified.
—— ——	......	few	
Odostomia conoidea	......	few.	
Eulima distorta	......	1	
Chemnitzia elegantissima	......	several.	
—— or Cerithium	......	3	
——, new ?	1	......	short, banded.
Natica, new ?	......	several	minute.
Trochus Montagui	......	several	minute.
—— conulus	1	......	small.
—— crenulatus	......	1	
—— exiguus	......	4	
—— ——	......	} few.	
—— ——	......		
Turbo rugosus	......	1 & several	minute.
Aclis ascaris ?	1	......	minute.
Turritella terebra	several	......	young.
—— tricostalis	2	......	
Cerithium vulgatum, var.	1		
—— reticulatum	several	several.	
Murex Edwardsii	......	2	young.
—— cristatus	......	1	
Fusus muricatus	1	......	young.
Pleurotoma brachystomum	1	2	
—— lineare	......	1	
—— striolatum	......	1	
—— ——	......	2	
Buccinum variabile	......	2	

Species obtained.	No. of living specimens.	No. of dead specimens.	Observations.
Buccinum corniculum	......	2	
Mitra ebeneus	1		
—— Savigni	1		
—— columbellaria	......	1	
Erato lævis	......	1	
Marginella secalina	5	several.	
—— clandestina	......	several.	
Hyalæa tridentata	......	4	
A few minute shells not identified.			
Numerous Sponges, Zoophytes, &c.			

DREDGING PAPER No. 5.

Date, 7th of June, 1849.
Locality, off Malta.
Depth, 40 fathoms.
Distance from shore, 1 to 2 miles.
Ground, sand and stones.
Region,

Species obtained.	No. of living specimens.	No. of dead specimens.	Observations.
Dentalium dentalis	numerous.		
—— rubescens or fissura ...	......	1	
—— tarentinum, var.?	......	1	striated with an undulated appearance.
Cæcum trachea	......	2	
Ditrupa coarctata or strangulata	several.		
—— ——	......	2	with notched apex.
Corbula nucleus	several.		
Neæra cuspidata	......	1 & valves.	
—— costulata	1	2 & valves.	
Pandora obtusa	2		
Psammobia ferroensis	......	valves.	
Tellina distorta	......	1 & valves.	
—— balaustina	3		
—— serrata	.. ...	1 & valves.	
—— depressa	......	1 valve.	
Syndosmya tenuis? (prismatica?)	......	valves.	
Venus ovata	1	valves.	
Astarte incrassata?	8	......	sulcated to the margin, some of them radiated.
Cardium papillosum	1		
—— minimum	1		
—— lævigatum	......	valve.	
Cardita squamosa	5		
Lucina spinifera	5		
Diplodonta rotundata	......	1 valve.	
Modiola barbata?	1		
Nucula nucleus	several.		
Leda emarginata	3		
—— striata	4		
Arca tetragona	8		
—— antiquata	......	1 valve.	
Pectunculus glycimeris	......	1 & valve.	
Lima subauriculata	......	valves.	
Pecten Jacobæus	......	valves.	

Species obtained.	No. of living specimens.	No. of dead specimens.	Observations.
Pecten gibbus ...	......	valves.	
—— polymorphus	......	valves.	
—— testæ	1		
—— similis	......	valves.	
—— sulcatus	......	1 & 1 valve.	
Anomia patelliformis	1		
Pileopsis hungaricus	......	1	
Bulla lignaria	......	1	
—— Cranchii	......	2	
—— hydatis	......	4	
—— striatula ?	......	1	
Rissoa Bruguieri	......	3	
—— carinata (costata)	......	2	
—— acuta, var.	......	5	longer, destitute of ribs, one very large.
—— Desmarestii	......	3	
—— ——	......	4	like cimex, but minute.
Natica macileuta	2		
Eulima polita	......	1	
—— distorta	......	1	
Chemnitzia varicosa	......	4	imperfect.
—— elegantissima	......	4	
—— indistincta ?	......	2	
—— ——	......	3	
Eulimella acicula ?	1		
Trochus tenuis or dubius ...	......	1	
—— magus	several.		
—— Montagui	......	1	
—— ——	......	several.	
—— ——	......	several.	
Turritella terebra	few	......	small.
—— tricostalis	1		
Cerithium vulgatum, var. ...	......	1	
—— reticulatum	......	several.	
—— ——	......	2 white.	
Fusus muricatus	1		
—— ——	1	......	species at Gibraltar.
Pleurotoma nanum	1		
—— secalinum	1		
Murex tetrapterus	......	2	
Chenopus pes-pelecani	1		
Buccinum	1		
Mitra ebeneus	......	1	
—— ——	1	......	bright orange colour, banded, small.
Ringuicula auriculata	......	2	striated.
Marginella secalina	3	4	
—— clandestina	several	several.	
Cypræa pulex	......	2	
Cidaris histrix	3		
Zoophytes.			
Algæ.			

In the harbour of Malta, where I was from the 3rd to the 7th of June, I procured from a sandy bottom, depth 6 to 12 and 15 fathoms, the following species :—

Dentalium tarentinum.
—— dentalis of Phillippi.
—— fissura or rubescens.
Gastrochæna cuneiformis.
Petricola lithophaga.
Venerupis irus.
Corbula nucleus.
Thracia phaseolina ?
Psammobia vespertina ?—small.
Tellina distorta—frequent.

Tellina serrata.
—— balaustina.
—— crassa—one small valve.
Syndosmya alba.
Artemis lincta.
Venus verrucosa.
—— fasciata.
—— ovata.
Cytherea chione.
—— venetiana.
Circe minuta.
Cardium ciliare—mud.
Cardita sulcata.
—— calyculata.
—— trapezia.
—— corbis (dead).
Lucina pecten.
—— divaricata.
—— lactea.
—— spinifera.
Diplodonta apicalis?
—— rotundata.
Mytilus minimns.
Modiola barbata.
Pinna squamosa.
Nucula nucleus.
—— nitida.
Chama gryphoides (frequent).
Lima squamosa.
—— scabrella?
—— tenera.
Pecten Jacobæus—alive.
—— polymorphus—valves.
—— hyalinus—valves.
—— sulcatus—valves.
—— glaber—valves.
—— distortus, var. pusio.
—— varius.
Chiton polii—above water mark.
Fissurella rosea?—above water mark.
—— gibbus.
Lottia?—small white: *qy.* cup of Acasta?
Vermetus gigas, and others.
Neritina viridis.
Natica millepunctata.
—— intricata.
Rissoa labiosa.
—— Montagui.
—— cimex.
—— acuta.
—— purpurea.
Rissoa monodonta?
—— ——.
—— ——.
Trochus crenulatus.
—— granulatus.
—— canaliculatus.
—— fragaroides.
—— divaricatus.
—— Jussieui.
—— Vieillotti.
—— magus.
—— ——.
—— ——.
—— ——.
Littorina petræa.
Turbo rugosus.
Phasianella pulla.
—— vieuxii.
—— intermedia.
Cerithium vulgare—large.
—— reticulatum.
Fusus Syracusanus.
—— muricatus.
—— corneus.
—— elegans.
Pleurotoma attenuatum.
—— ginnannianum.
—— secalinum.
—— rude?
—— lineare?
—— Gervillii.
—— purpureum.
—— lævigatum.
——, &c. &c.
Murex Edwardsii.
—— costatus.
Cassidaria Tyrrhena.
Dolium galea.
Pollia maculosa.
Nassa neritea.
—— macula.
Buccinum variabile.
—— minimum.
—— minus.
—— prismaticum.
Columbella rustica.
Mitra ebeneus.
—— Savignii.
Marginella miliacea.
Ringuicula auriculata.
Cypræa pulex.
Conus mediterraneus.

Observed several species alive on the shore (rocks) above water mark, such as *Chiton polii*, *Fissurella rosea*, *Murex Edwardsii*, &c.

Syracuse and Catania, 8th to 14th of June, sand.

	Dead at	Living at	Frequency.	
Solen pellucidus	......	40 fath.	rare	two very small specimens.
Neæra cuspidata	40 to 50 f.	......	rare	valves.
Pandora rostrata	......	8 fath.	local.	
Lyonsia striata	8 fath.	......	...	one specimen.
Tellina punicea	......	8 fath.	freq.	
—— serrata	30 fath.	......	rare.	
—— distorta	......	12 fath.	local.	
—— tenuis	shore	......	freq.	
Donax venustus	......	shore	local.	
Venus fasciata	......	8 fath.	freq.	
—— ovata	......	8 to 40 f.	freq.	
Circe minuta	......	12 fath.	freq.	
Cardium echinatum	8 fath.	......	local.	
—— papillosum	......	40 fath.	local.	
Cardita trapezium	sh. to 10 f.	......	freq.	
—— corbis	12 fath.	......	rare.	
Diplodonta apicalis	12 fath.	......	rare.	
Montacuta bidentata	......	8 fath.	rare.	
Galeomma Turtoni	......	shore	...	one specimen, young, in a stone.
Modiola barbata	8 fath.	......	rare.	
Lithodomus dactylus or lithophagus	......	shore	freq.	in stones, &c.
Mytilus minimus	......	shore	freq.	
—— galloprovincialis	......	shore	freq.	
Nucula nucleus	......	8 to 12 f.	freq.	
—— radiata	......	20 to 30 f.	local.	
—— polii	......	40 fath.	rare.	
Leda emarginata	......	8 fath.	freq.	
—— striata	......	30 to 45 f.	freq.	
Arca tetragona	......	30 to 45 f.	local.	
—— ——	40 fath.	......	...	one specimen, strongly reticulated.
Lima suborbicularis	20 to 40 f.	......	rare	valves.
—— scabrella ?	......	shore	two	in a stone.
Pecten opercularis	20 to 40 f.	30 fath.	rare.	
Anomia aculeata	......	10 fath.	rare.	
Terebratula cuneata	......	40 fath.	...	one specimen *in situ*.
—— detruncata	30 to 45 f.	......	local.	
Chiton siculus	......	shore	freq.	
—— cajetanus	......	shore	freq.	
—— fascicularis	......	shore	freq.	
—— ——	......	8 fath.	freq.	
Patella athletica ?	......	shore	local.	
Calyptræa sinensis	......	80 to 30 f.	freq.	
Emarginula elongata	12 fath.	......	local.	
Bulla umbilicata	8 to 30 f.	......	rare.	
—— acuminata	30 fath.	......	v. r.	
Rissoa Desmarestii	8 fath.	......	local.	
—— cimex	8 fath.	......	freq.	
—— Montagui	8 fath.	......	freq.	
—— ——	8 fath.	......	rare.	
Odostomia conoidea	......	12 fath.	rare.	
Eulima polita	......	30 fath.	rare.	
Chemnitzia elegantissima	8 to 30 f.	......	local.	
—— indistincta ?	30 fath.	......	rare.	
—— ——	30 fath.	......	...	a fragment.
Neritina viridis	8 fath.	......	local.	

	Dead at	Living at	Frequency.	
Natica millepunctata	8 fath.	......	local.	
—— olla	......	6 to 12 f.	local.	
—— intricata	......	12 fath.	local.	
—— marochiensis (Alderi)	......	12 fath.	local.	
—— Guilleminii	8 fath.	......	local.	
Scalaria	40 fath.	......	v. r.	small, coronated.
Vermetus cancellatus	......	8 fath.	local.	
Trochus fanulum	......	8 fath.	local.	
—— crenulatus	8 fath.	......	local.	
—— canaliculatus	6 fath.	......	freq.	
—— divaricatus	......	shore	freq.	
—— fragaroides	......	shore	freq.	
—— articulatus	......	shore	freq.	
—— granulatus	......	8 to 10 f.	local.	
—— Vieillotti	8 to 10 f.	......	local.	
—— Jussieui	8 to 10 f.	......	local.	
—— conulus, var.	......	10 fath.	local.	
—— ——	......	10 fath.	local	small.
—— —— (var. of T. canaliculatus ?)	8 fath.	......	one	large, smooth.
Phasianella vieuxii	......	8 to 10 f.	local.	
Cerithium vulgatum	......	shore	freq.	
—— reticulatum	8 fath.	......	freq.	
—— perversum	8 fath.	......	local.	
Fusus corneus	......	8 fath.	one	young.
—— rostratus ?	......	30 fath.	rare.	
—— corallinus	......	30 fath.	freq.	
Pleurotoma reticulatum	6 fath.	......	local.	
—— purpureum	6 fath.	......	rare.	
—— rude	......	20 fath.	rare.	
—— Smithii or striolatum, &c. &c. &c.	8 fath.	......	rare.	
Murex Edwardsii	......	shore	freq.	
—— cristatus	......	shore	freq.	
Triton reticulatum	8 fath.	......	local.	
Chenopus pes-pelecani	8 fath.	10 fath.	local.	
Pollia maculosa	......	shore	abun.	
Nassa macula	......	8 to 10 f.	freq.	
—— mutabilis	......	8 to 10 f.	local.	
—— ——	10 fath.	......	rare.	
Buccinum corniculum	......	shore	freq.	
—— variabile	shore	......	freq.	
—— D'Orbignii	......	shore	freq.	
—— scriptum	......	6 to 10 f.	local.	
Columbella rustica	......	shore	abun.	
Mitra lutescens	10 fath.	......	local.	
—— ebeneus	......	8 to 10 f.	local.	
Ringuicula auriculata	......	30 fath.	local.	
Erato lævis	......	12 fath.	local.	
Marginella secalina	......	20 fath.	local.	
—— clandestina	......	30 fath.	freq.	
Conus mediterraneus	8 fath.	......	local.	

A remarkable large annelid, 15 to 18 inches in length and about an inch across the back.

No land shells worthy of note.

Ditrupa subulata? alive in great abundance off Catania in 25 fathoms, sand.

Port of Messina, 16th of June, 40 fathoms, sand and gravel.

Tellina serrata—living, one small.
Montacuta bidentata.
Astarte incrassata.
Nassa reticulata.
—— macula.
—— prismatica.

18th of June attempted to dredge in the Faro of Messina, but could get no bottom in consequence of the strong current.

20th of June caught a shark 9 feet in length, after it had afforded us a fine opportunity of watching and admiring its movements in the water. The stomach contained a sea fowl, heads, legs, &c. of fowls thrown overboard some hours previously, a small canvas rag, several cuttle-fish beaks, a quantity of feathers, &c.

Bay of Naples, 26th and 29th of June.

	Dead at	Living at	Frequency.	
Corbula nucleus	......	8 to 10 f.	freq.	
Thracia phaseolina ?	......	8 to 10 f.	rare.	
Solecurtus antiquus	8 to 10 f.	......	local	valves.
—— strigilatus	......	......	freq.	in the market.
Solemya mediterranea	......	8 to 12 f.	local	very young.
Tellina distorta	......	8 to 12 f.	abun.	
—— serrata	......	8 to 12 f.	local	valves.
Syndosmya	......	8 to 12 f.	local	minute, transparent.
Donax trunculus	......	2 to 4 f.	abun.	sold in the market.
Tapes aurea ?	8 to 10 f.	......	local	small.
Cytherea chione	......	8 to 10 f.	freq.	small.
—— venetiana	......	8 to 10 f.	local.	
Venus verrucosa	......	8 to 10 f.	local.	
—— gallina	......	2 to 4 f.	abun.	
Circe minuta	......	8 to 12 f.	local.	
Cardium papillosum	......	30 to 40 f.	local.	
Cardita sulcata	......	8 fath.	local.	
Lucina sinuosa	......	30 fath.	v. r.	small.
—— spinifera	......	30 fath.	local.	
—— divaricata	......	8 fath.	local.	
—— ? ——	......	8 fath.	local	very convex, yellow.
Montacuta substriata	......	30 fath.	freq.	on a Spatangus.
—— bidentata	......	30 fath.	rare.	
—— ferruginea	30 fath.	......	v. r.	one, imperfect.
Kellia corbuloides	8 fath.	......	local	valves.
Mytilus minimus	......	littoral	freq.	
Modiola barbata	......	2 fath.	local	upon *Arca noe.*
Chama gryphoides	......	2 fath.	local	upon *Arca noe.*
Nucula nitida	......	8 fath.	local.	
Leda emarginata	......	8 fath.	local.	
—— striata	......	30 to 40 f.	local.	
Arca noe	......	2 fath.	freq.	in the market.
—— barbata	......	2 fath.	freq.	in the market.
Pectunculus glycimeris	......	30 fath.	rare.	
Lottia ?	10 fath.	......	...	one specimen, minute, white, striated.
Fissurella rosea	......	shore	local.	
—— gibba	10 fath.	......	local.	
——	8 fath.	......	local.	
Haliotis tuberculata ?	......	shore	freq.	market.
Bullæa scabra ?	......	30 fath.	local.	
—— aperta	......	8 fath.	local.	
Bulla Cranchii	......	30 fath.	local.	
—— truncata	......	30 fath.	local.	
Rissoa cimex	8 fath.	......	local.	

	Dead at	Living at	Frequency.	
Rissoa Desmarestii	8 fath.	......	local.	
Eulimella acicula............	......	10 fath.	local.	
—— ——	......	10 fath.	local.	
Odostomia conoidea	......	10 fath.	local.	
—— ——	......	10 fath.	rare.	
—— ——	......	30 fath.	rare.	
Chemnitzia elegantissima ?	......	10 fath.	local.	
—— ?	30 fath.	......	local.	
Natica olla	......	8 fath.	local.	
—— macilenta	......	10 fath.	local.	
—— Alderi....................	......	10 fath.	local.	
Scalaria	......	30 fath.	rare	coronated, same as at Syracuse.
Vermetus........................	......	10 fath.	local.	
Tornatella pusilla ?	......	30 fath.	one.	
Turritella ?	......	30 fath.	one	minute.
Fusus..............................	......	12 fath.	local	minute, species at Gibraltar.
Pleurotoma elegans.........	......	10 fath.	local.	
—— attenuatum............	......	8 fath.	local.	
—— ginnannianum	......	8 fath.	local.	
—— brachystomum	......	10 to 30 f.	local.	
—— nanum	10 fath.	......	local.	
—— purpureum	10 fath.	......	local.	
—— sp. ?	10 fath.	......	local.	
Nassa varicosa...............	......	8 to 10 f.	freq.	
Ringuicula auriculata......	......	10 to 30 f.	local.	
Dentalium dentalis ?	......	10 fath.	local	ten ribs.
—— tarentinum............	......	10 fath.	local.	
Ditrupa subulata.				

Dredging Paper No. 6.

Date, 4th of July, 1849.
Locality, Gulf of Cagliari, south-east of Colombo Point.
Depth, 20 to 25 fathoms.
Distance from shore, 3 to 4 miles.
Ground, sand and gravel.
Region,

Species obtained.	No. of living specimens.	No. of dead specimens.	Observations.
Dentalium dentalis	......	several.	
—— rubescens or fissura ...	1		
Cæcum trachea	......	1	
Ditrupa subulata or strangulata	several.		
—— ——	2	......	with notched apex.
Gastrochæna cuneiformis ...	......	1	in a fragmeut of *Triton variegatum*.
Corbula nucleus...............	3	1	
Neæra cuspidata	1		
Psammobia ferroensis	......	1 & valves.	
—— costulata	......	2	
Tellina donacina...............	......	valves.	
—— distorta	1	valves.	
—— balaustina	1	valves.	
Syndosmya	1	valves	small.
—— tenuis ? (prismatica ?).	......	valves.	

Species obtained.	No. of living specimens.	No. of dead specimens.	Observations.
Cytherea chione	1 young	valve.	
—— venetiana	......	1 minute.	
Venus fasciata	1		
—— ovata	numerous.		
Artemis exoleta	......	valves.	
Astarte incrassata	3		
Cardium lævigatum	......	1	
—— exiguum, var.?	1		
—— minimum	......	1	
—— papillosum	......	valves.	
Cardita sulcata	1	......	large.
—— trapezia	2		
Lucina spinifera	......	valves.	
—— lactea?	......	valves.	
Chama gryphoides	1	1	
Modiola barbata	2		
—— tulipa	1	......	young.
Nucula nucleus	......	valves.	
—— radiata	......	valves.	
Leda emarginata	2	valves.	
—— striata	2	1	
Arca tetragona	2		
—— ——	......	1 valve.	
Pectunculus glycimeris?	1	......	small.
Pinna	......	fragment.	
Lima subauriculata	......	fragment.	
Pecten Jacobæus	......	fragment.	
—— polymorphus	......	valves.	
—— similis	......	valves.	
—— opercularis	......	valves.	
—— hyalinus	1	valves.	
—— sulcatus	......	valves.	
Terebratula detruncata	......	1	
Crepidula fornicata	1		
—— unguiformis	......	2	
Calyptræa sinensis	......	1	
Bullæa aperta	1	1	
Bulla umbilicata?	......	1	
—— striatula?	......	1	
—— acuminata	......	1	
—— truncata	......	2	
—— hydatis	......	1	
—— obtusa or mamillata	......	1	
Rissoa violacea	......	1	
—— calathiscus	......	few.	
—— scabra?	......	1	
Odostomia conoidea	3		
—— interstincta (Flem.)	1		
Chemnitzia fulvocincta	1		
—— pallida? or varicosa	......	1	
—— gracilis?	......	1	
—— elegantissima?	......	1	
Natica Alderi or marochiensis	......	1	
—— macilenta	......	1	
—— millepunctata	......	2	small.
Scalaria communis	......	1	
Vermetus gigas	1		
—— triqueter	few.		
—— glomeratus	few.		
Trochus conulus	......	1	
—— crenulatus	......	1	
—— magus	......	fragment.	

Species obtained.	No. of living specimens.	No. of dead specimens.	Observations.
Trochus exiguus...............	......	3	
—— ——	1		
Phasianella Vieuxii	1	1	
Turbo rugosus	......	......	an operculum.
Turritella terebra	2		
—— tricostalis	1		
Cerithium vulgatum, var.?...	......	4	
—— reticulatum	......	several.	
Pleurotoma gracile...........	......	1	
—— brachystomum	1	1	
—— ginnannianum	......	1	
—— ——	......	1	
—— ——	......	1	
Fusus corallinus...............	1		
Triton variegatum	......	fragment.	
Chenopus pes-pelecani	......	2 young.	
Mitra Savignii	......	1	
Marginella miliacea	......	1	
—— clandestina	......	several.	
2 Holothuriæ, &c.			

Mahon, 9th and 10th of July, sand.

	Dead at	Living at	Frequency.	
Dentalium tarentinum ...	......	30 fath.	local.	
—— fissura or politum ? .	......	8 fath.	local	white.
—— dentalis of Phillippi	......	8 fath.	freq.	
Corbula rosea..............	......	8 fath.	freq.	
—— nucleus	......	8 fath.	freq.	
Thracia villosiuscula	......	8 fath.	rare.	
Psammobia costulata......	8 fath.	......	rare.	
Tellina distorta	......	8 fath.	local.	
Syndosmya..................	......	10 to 30 f.	local.	
Donax venusta	shore	......	local.	
Mactra stultorum	......	shore	freq.	
Tapes virginea	......	10 fath.	local.	
—— —— nitens ?.........	10 fath.	......	...	one, imperfect.
Venus verrucosa............	......	8 fath.	freq.	
Cytherea.....................	10 fath.	......	local	species obtained at Malta.
Circe minuta	......	10 to 30 f.	local.	
Cardium exiguum	......	10 fath.	local.	
—— ciliare..................	......	4 fath.	freq.	mud.
Cardita trapezia............	shore	shore	freq.	
Lucina divaricata	......	10 fath.	local.	
—— spinifera	......	30 to 35 f.	local.	
—— or Diplodonta	......	10 fath.	local	yellow.
Montacuta substriata......	......	30 to 35 f.	freq.	on *Spatangus purpureus*, small.
Lepton squamosum	10 fath.	......	rare	valve.
Lithodomus lithophagus ..	......	shore	freq.	
Modiola tulipa	......	10 fath.	local.	
Mytilus galloprovincialis ..	......	shore	freq.	
—— minimus	......	shore	freq.	
Chama gryphoides.........	......	8 fath.	local.	
Leda emarginata	......	8 fath.	local.	
Arca noë.....................	......	shore	freq.	
Pecten glaber...............	10 fath.	......	local	valves.
—— sulcatus	10 fath.	......	local	valves.
Ostrea edulis	......	......	freq.	market.
Spondylus gæderopus	......	shore	freq.	market.

	Dead at	Living at	Frequency.	
Plicatula	......	shore	rare	upon Spondylus.
Chiton siculus	......	shore	local.	
Patella	shore	......	local	small.
Fissurella reticulata	30 fath.	......	local.	
—— rosea	8 fath.	......	local.	
Calyptræa vulgaris	......	8 to 20 f.	freq.	
Haliotis tuberculata ?	8 sh.	......	rare	of small size, much used in shell work.
Bullæa aperta	......	8 fath.	local.	
Rissoa calathiscus	8 to 10 f.	......	local.	
—— Montagui	8 to 10 f.	......	local.	
—— coronata (costata ?)	8 to 10 f.	......	rare.	
Neritina viridis	8 to 10 f.	......	local.	
Natica millepunctata	8 to 10 f.	......	local.	
Scalaria communis	8 fath.	......	local.	
Trochus crenulatus	8 to 10 f.	......	freq.	
—— exiguus	8 to 10 f.	......	freq.	
—— canaliculatus, var. ?	8 to 10 f.	......	local.	
—— Jussieui	8 to 10 f.	......	local.	
—— Richardii	8 fath.	......	freq.	
—— ——	8 to 10 f.	......	rare	carinated, obtained similar in Malta.
—— ——	8 fath.	......	rare.	
—— fanulum	......	8 fath.	freq.	fine and large.
Phasianella pulla	......	8 fath.	local.	
—— Vieuxii	8 fath.	......	local.	
Cerithium perversum	8 fath.	......	local.	
Fusus corallinus	......	8 to 20 f.	local.	
—— corneus	......	8 fath.	local.	
—— ——	......	20 fath.	local	species at Gibraltar.
Pleurotoma attenuatum	8 fath.	......	rare.	
—— lineare	......	8 fath.	local.	
—— multilineatum ?	8 fath.	......	local.	
—— ——	8 fath.	......	local.	
Murex Edwardsii	......	shore	freq.	
—— erinaceus	......	shore, &c.	freq.	
Triton reticulatum	8 fath.	......	rare.	
Nassa neritea	8 fath.	......	freq.	
—— macula	......	8 to 10 f.	freq.	
—— reticulata	......	8 fath.	freq.	
—— ——	8 fath.	......	rare	small.
Buccinum corniculum	......	shore	freq.	
—— scriptum	......	8 fath.	local.	
—— d'Orbignii	......	shore	local.	
—— variabile	8 fath.	......	local.	
Columbella rustica	......	shore	freq.	
Ringuicula auriculata	30 fath.	.. ...	local.	
Marginella miliacea	10 fath.	......	local.	
Cypræa pulex	shore	......	local.	
Conus mediterraneus	shore	......	freq.	

Most of the preceding were obtained in the harbour, but a few outside, where the bottom was a very white sand, covered with Zostera to the depth of above 20 fathoms; beyond which, in 25 to 35 fathoms, I obtained several specimens of *Spatangus purpureus* (with *Montacuta substriata*), also numerous examples of *Turbinolia milletiana*, dead, of smaller size than the Cornish specimens.

A small schooner is constantly employed in taking shell-fish for sale at Algiers, where they are retailed in the market, the vessel returning when all is sold for a fresh supply. The assortment appeared to consist of oysters, *Spondylus gæderopus*, *Arca noë*, *Lithodomus lithophagus*, *Venus verrucosa*, &c.

Dredging Paper No. 7.

Date, 12th of July, 1849.
Locality, off Conijera (one of the smaller Balearic Islands), near Cabrera.
Depth, 40 fathoms.
Distance from shore, 2 miles.
Ground, very white sand and nullipore with abundance of sea-weed and coral.
Region, coralline.

Species obtained.	No. of living specimens.	No. of dead specimens.	Observations.
Pandora rostrata	......	valves.	
Solen ensis	......	a fragment.	
Solemya mediterranea	......	fragments.	
Psammobia costulata	......	2 & valves.	
Tellina distorta ?	1	2 & valves.	
Syndosmya tenuis ?	1		
Mactra subtruncata	......	......	a small valve.
Cytherea chione	4	......	young.
—— venetiana	1	valves.	
Venus casina ?	......	fragments.	
—— fasciata	3		
—— ovata	......	1 & valves.	
Circe minuta	3	1 & valves.	
Cardium lævigatum	......	2	
—— papillosum	......	1	
—— erinaceum	......	fragments.	
—— roseum ?	3	......	rose colour, convex.
—— minimum	......	1	
Lucina or Diplodonta	......	1 & valves.	
Kellia suborbicularis	1		
Crenella marmorata	2		
Arca tetragona	5	......	attached to nullipore.
—— barbata	1	......	attached to nullipore.
Pectunculus glycimeris	......	valve.	
—— violascens	......	fragment.	
Lima squamosa	......	valve.	
—— subauriculata	......	valve	half an inch long.
—— fragilis	......	valve.	
Pecten Jacobæus	......	valves.	
—— polymorphus	2	valves.	
—— opercularis	1	valves.	
—— varius	6		
—— similis	......	1 valve.	
—— striatus	2		
Anomia ephippium	4		
Chiton marmoreus ?	1		
—— fascicularis ?	5	......	pale reddish colour, very different from ordinary.
Umbrella mediterranea	......	1	
Emarginula elongata	......	1	small.
Calyptræa vulgaris	4		
Bulla hydatis	......	3	
—— striatula ?	......	1	
Chemnitzia	1	......	resembles *C. fulvocincta*, pink colour.
Odostomia conoidea	1		
Natica macilenta	2		
—— Guilleminii	......	2	
—— Alderi or marochiensis	1		
—— millepunctata	......	1	small.
Sigaretus perspicuus	......	1	
Tornatella fasciata	1	......	young.
Vermetus gigas ?	3		
—— glomeratus	5		
Trochus magus	1		

Species obtained.	No. of living specimens.	No. of dead specimens.	Observations.
Trochus exiguus	......	4	
—— conulus, var.............	6	......	small.
—— ——	......	5	small, ribbed.
Turritella tricostalis	3		
Cerithium vulgatum, var. ...	6		
—— reticulatum	......	1	
—— perversum..............	2		
Pleurotoma lineare	2		
Fusus pulchellus	3		
Murex crispata	......	1	
Cassis sulcosa...................	......	1	with hermit crab.
Mitra columbellaria	1		
Marginella miliacea	1	several.	
—— secalina	2	1	
Ringuicula auriculata.........	......	few.	
Cypræa europæa...............	......	1	
Ditrupa subulata	......	fragments.	
—— ——	......	2	notched aperture.
A small species of Echinus..	several.		
Ophiuræ	several.		
Spatangus purpureus	......	1	
Various corals.			
Actiniæ.			

In sailing from the Balearic Islands to Gibraltar I observed *Ianthina nitens*, not unfrequent, and occasionally with spawn attached; also Velella and Porpita.

Pteropoda become more rare proceeding eastward.

Lisbon, 10th of August, sand and mud, 7 to 12 fathoms, strong tide.

Corbula nucleus.
Syndosmya alba.
Lutraria oblonga (dead).
Mactra subtruncata.
Cardium ciliare.
Nucula nitida.
—— nucleus.
Pecten polymorphus—dark colour, *qy.* northern limit?
—— varius.
—— opercularis.
Ostrea edulis.
Anomia ephippium.
Chiton rufus.
Bulla akera, var.?
—— fragilis?—shore, living.
Chemnitzia elegantissima.
—— gracilis?.
Odostomia conoidea?.
—— new (brown).
Rissoa monodonta.
Scalaria clathratulus.
Trochus millegranus (young).
—— ziziphinus.
—— umbilicaris (dead).
Littorina rudis—dead, *one.*
Cerithium reticulatum.
Pleurotoma coarctatum.
Nassa macula.
—— varicosa.
Murex erinaceus.

At Cintra I found the following few land shells, 6th to 8th of August:—

Helix lactea.
—— aspersa.
—— hortensis—most southern locality I have observed it in.
—— pisana.
—— caperata.
—— spurca.
—— barbula.
—— polentina.
—— cellaria.
—— crystallina.
Helix umbilicata.
Bulimus acutus.
—— obtusus.
—— decollatus.
Pupa muscorum? I believe a distinct species, more elongated, having an extra whorl and an extra tooth.
—— ——, minute.
Clausilia rugosa? (slender).
Balea perversa, *qy.* southern limit?

On the Present State of our Knowledge of the Freshwater Polyzoa. *By* Professor Allman, *M.D., F.R.C.S.I., M.R.I.A.*

The discovery by Trembley* of a compound polypoid animal, which he found in the year 1741 in the freshwaters near La Haye, and to which he gave the name of "Polype à Panache," followed almost immediately by the detection of the same animal in England by Baker†, who described it under the name of "Bellflower animal," constitutes an interesting epoch in the history of zoology.

The "Polype à Panache" was nearly a century afterwards rediscovered by M. Dumortier, and described by this naturalist under the name of *Lophopus crystallinus* in an elaborate and important memoir published in the Bulletins de l'Acad. de Bruxelles‡. The *Lophopus crystallinus* presents a fine typical example of those polypoid molluscous animals, which, long confounded with the genuine polypes, were at last distinguished by the nearly simultaneous labours of Grant, Edwards and Thompson, and elevated into a distinct class under the names of *Polyzoa*, Thompson§, and *Bryozoa*, Ehrenberg‖. Thompson's name has the priority over that of Ehrenberg, and is perhaps even more expressive than that proposed by the celebrated zoologist of Berlin; justice to its author therefore requires its adoption, and in the present Report I shall employ it instead of the more generally used though more recent name of *Bryozoa*.

The Polyzoa constitute a class whose marine representatives are very numerous, and which has also examples of great elegance and interest in the still and running waters of the land. It is with these freshwater forms that the present Report is to be occupied.

The discovery of the "Polype à Panache" (*Lophopus crystallinus*) is the first recorded instance of the detection of a freshwater Polyzoon. This little animal had been carefully examined by Trembley and Baker, and both these naturalists, in the account they have left us of its structure, have shown themselves acute and faithful observers. It is singular that though Trembley and Baker had pointed out all the essential characters of polyzoal structure in *Lophopus*, the significance of their discovery should have remained unrecognized for nearly a century, and that it was not till a similar type in certain marine polypoid animals arrested the attention of naturalists, that the importance of this type and its true bearing on systematic zoology began to be appreciated.

The discovery of *Lophopus* was followed within a few years by that of *Plumatella*, *Cristatella* and *Alcyonella*; but these genera were imperfectly distinguished from one another, and our knowledge of their anatomy remained for many years exactly as it had been left by Trembley and Baker. At length Raspail¶, in 1828, published a very elaborate paper on *Alcyonella*. Elaborate, however, as is this memoir, copiously furnished as it is with well-executed figures, it tells us very little of value; in correctness of anatomical detail it falls far behind the accounts left us by Trembley and Baker; and though Raspail's attempt to unite *Plumatella repens* with *Alcyonella fungosa***

* Trembley, Mém. pour l'Hist. des Polypes d'eau douce, Mém. III.

† Baker, Employment for the Microscope, part 2. chap. x.

‡ Dumortier, Recherches sur l'Anat. et Physiol. des Polypes comp. d'eau douce, Bul. de l'Acad. Roy. de Bruxelles, 1835.

§ Zoological Researches, No. 1, 1830.

‖ Symbolæ Physicæ, 1831.

¶ Raspail, Hist. Nat. de l'Alcyonelle fluviatile, Mém. de la Soc. d'Hist. Nat. de Paris, tom. iv.

** The *Alcyonella stagnorum* of Lamarck was originally described by Pallas under the name of *Alcyonella fungosa*, in a memoir published in the *Novi Commentarii Academiæ Petropo-*

may admit of some defence, the union of all the other known species with this same form must be considered a retrograde step, which, were it not so obviously false, might have materially retarded further progress in this department of zoology. As it was, however, Raspail's memoir gave a stimulus to inquiry, and a number of investigators now applied themselves to the subject with zeal and with a success which might have been expected from the advanced state of general zoology, and from the increased means of research which improved microscopes had placed in the hands of naturalists.

Among those who now most materially advanced our knowledge of the freshwater Polyzoa, must be especially mentioned MM. Gervais, Dumortier and Van Beneden. To Gervais we are indebted for the first complete zoographic view of the subject, the determination and diagnosis of the genera and their systematic distribution*, while Dumortier and Van Beneden have both contributed most important information on the anatomical structure of certain species. Van Beneden moreover has given us a complete memoir on the whole of the species inhabiting the freshwaters of Belgium †, a memoir, which, both in a zoographical and zootomical point of view, is certainly the most valuable we possess; while within the present year an excellent paper on the anatomy of certain genera, with descriptions of new species, has been published by Mr. Hancock ‡ in the 'Annals of Natural History.' My own researches have been from time to time communicated chiefly to the meetings of this Association and of the Royal Irish Academy; and though they have not been hitherto brought together into a connected memoir, they are to be found in a detached form in the proceedings of both these bodies.

All the known forms of freshwater Polyzoa may be included under six genera, whose relations and leading diagnostic characters are represented in the following Table. These genera embrace seventeen species, sixteen of which have already been found in Britain.

		Family.			Genus.
Lophophore bilateral, mouth with a valve.	Cœnœcium free, locomotive	CRISTATELLIDÆ			Cristatella.
	Cœnœcium rooted	PLUMATELLIDÆ	Lophophore with two long arms	Cœnœcium sacciform, ectocyst gelatinous	Lophopus.
				Cœnœcium tubular, tubes united, ectocyst pergamentaceous	Alcyonella.
				Cœnœcium tubular, tubes distinct, ectocyst pergamentaceous	Plumatella.
			Arms of Lophophore obsolete		Fredericella.
Lophophore orbicular, mouth destitute of valve		PALUDICELLIDÆ			Paludicella.

litanæ, tom. xii. Van Beneden has been the first to point out the priority of Pallas's name, and in his *Recherches sur les Bryozoaires fluviatiles de Belgique*, has restored it after a lapse of many years; a revision, which justice to the original describer of the species, as well as the laws of Natural History nomenclature, demand, and which I shall gladly follow in the present Report.

* Annales Françaises et Étrangères d'Anatomie, 1839.

† Van Beneden, Recherches sur les Bryozoaires fluviatiles de Belgique, Mém. de l'Acad. Roy. de Belgique, 1848.

‡ On the Anatomy of the Freshwater Bryozoa, Ann. Nat. Hist., 2nd Ser. vol. v. p. 173.

Anatomy.

Definition of terms.—The old notion, which, by mistaking the zoological rank of the Polyzoa, erroneously referred them to the class of the Polypes, caused the same terms to be applied to them which were also used to designate the various parts of the true polypes. The recognition, however, of a type of structure in the Polyzoa totally distinct from that of the Polypes proper, necessitates a change in the terminology employed in their description. On these grounds I have ventured to substitute some new terms for those previously used; while our increased knowledge of polyzoal structure necessitates the use of certain additional terms of which we have no representatives in the descriptive terminology of previous authors. For the term Polype, therefore, originally applied not only to the Anthozoal radiata, to which its use ought to be confined, but also to the retractile portion of the Polyzoa, I have substituted in the following Report that of ***Polypide****. To the common dermal system of a colony, which, as well as the solid basis of the true Polypes, was formerly known under the names of Polypary and Polypidome, I have applied the term *Cœnœcium*†. The cœnœcium is composed of two perfectly distinct tunics; to the external I have given the name of ***Ectocyst***‡, and to the internal that of ***Endocyst***§. The sort of disc or stage which surrounds the mouth and bears the tentacula, I have called ***Lophophore***‖. The ***Perigastric***¶ ***space*** is the space included between the walls of the endocyst and the alimentary canal.

The terms now enumerated are such as I believe the nature of the subject strictly requires. I am fully aware that the changing of an established terminology is highly objectionable where it can possibly be avoided, but in the present case, where the very same terms are in two different classes of animals applied to organs in no respect homologous, the purposes of a rigidly scientific description can, I believe, only be served by some such change as that which I have here ventured to introduce.

I. *Organs for the Preservation of the Individual.*

A. *Dermal system.*—The Polyzoa are all compound animals, and by the expression, Dermal system, I intend to be understood, the *Cœnœcium* or common connecting medium of the colony. It is formed of a number of little chambers or cells organically united, in each of which is contained a polypide, and consists of two portions, which must be carefully distinguished, an internal tunic, soft, transparent and contractile (the *endocyst*), and an external investment (the *ectocyst*), which varies greatly in texture and form in the different genera. The endocyst lines the interior of the cells, and when it arrives at their orifice would protrude beyond the ectocyst, were it not that it here becomes invaginated or inverted into itself, and then terminates by being attached round the base of the tentacular crown; during the exsertion of the polypide it undergoes eversion, which, however, in all the freshwater species is but partial; a portion of the endocyst, as we shall afterwards more particularly see, remaining in a permanently inverted condition, in this respect differing remarkably from the marine species in which the eversion of the endocyst is perhaps in all cases complete. The endocyst thus constitutes a series of cells or sacs in organic continuity with each other, and in which the polypides surrounded by the perigastric fluid are suspended. These sacs are all closed above, where they are attached to the polypide, and below have in some cases their cavities in communication with those

* Πολυπούς, εἶδος. † Κοινὸς, οἰκίον. ‡ Ἐκτὸς, κύστις.
§ Ἔνδον, κύστις. ‖ Λόφος, φορέω. ¶ Περὶ, γαστήρ.

of neighbouring sacs, while in others this communication is interrupted by the existence of *septa*, to be presently described.

The structure of the endocyst in all the six genera is cellular, and in all cases admitting of favourable observation; transverse muscular fibres, to be afterwards described, may be detected in it. Shortly after its inversion it becomes altered in texture, losing its contractility and assuming a thinner and more membranous appearance; in this condition it continues till it terminates by being attached to the base of the tentacular crown; this thin non-contractile portion of the endocyst constitutes the tentacular sheath which encloses and protects the tentacula during the retracted state of the polypide. A portion, perhaps the whole, of the inner surface of the endocyst is clothed with vibratile cilia.

The *ectocyst*, or external investment, is in most of the species composed of a tough pergamentaceous brown membrane, strengthened by the deposition of irregularly-formed siliceous particles, which, except towards the apertures, where these particles are deficient, give to the ectocyst an opacity which renders an observation of the contained parts a matter of considerable difficulty. In some species of *Plumatella* and in *Alcyonella flabellum*, and *A. Benedeni*, the earthy particles are entirely absent from a longitudinal line which commences wide near the aperture of the cell, and gradually narrows as it passes downwards, when it soon assumes the appearance of a prominent keel, and then loses its transparency by the deposition of earthy matter, as in the rest of the tunic. The perfectly transparent wide origin of this line gives to the orifice of the cell the appearance of a deep notch at one side. In *Fredericella* a slightly prominent keel is also apparent, but the notch-like transparent space does not exist.

In *Cristatella* the ectocyst would at first sight seem to be entirely absent, and the cœnœcium to be composed exclusively of the endocyst. A careful examination, however, proves that both are present, and that the ectocyst consists of a highly-organized flexible and transparent tunic, of very evident cellular structure, and quite free from every kind of earthy deposit. The whole of this tunic is contractile, and presents below a flattened disc destitute of apertures. Upon the disc, which closely resembles the foot of a gasteropodous mollusc, this singular colony creeps about upon the stems and leaves of aquatic plants, exposing its beautiful plumes to the light and warmth of the sun.

Lophopus also at first sight conveys the impression of being destitute of an ectocyst, and having the place of this tunic supplied by a peculiar unorganized gelatinous secretion, in which the colony is enveloped. This apparently gelatinous investment is however in reality a distinctly organized tunic, which seems formed of a cellular or areolar tissue, enclosing in its meshes a transparent and colourless fluid. That such is its structure becomes apparent when the animal has undergone partial desiccation after removal from the water, for then the ectocyst loses a portion of the fluid which had been imprisoned in its tissue, and its membranous nature becomes revealed. Neither Trembley nor Baker takes any notice of this gelatinous envelope. M. Dumortier mentions it, and represents it in his figure*, while M. Van Beneden believes it to be an accidental investment acquired by the animal during confinement†.

The ectocyst in *Paludicella* is formed of a smooth pergamentaceous semi-transparent membrane, free from earthy deposit, and of a deep brown colour. Towards the orifice of the cell it becomes thin and delicate, and is here strengthened by four longitudinal horny ribs. The part of the ectocyst to which the ribs are attached is carried inwards during extreme retraction of

* Dumortier, *loc. cit.* † Van Beneden, *loc. cit.*

the polypide. These ribs I look upon as the true homologue of the *setæ* which crown the cell in *Bowerbankia* and other marine Polyzoa; if these setæ were reduced in number to four, and instead of being free were attached to the sides of the cell, they would at once be converted into the ribs of *Paludicella*; the fact of their being connected to one another by a delicate membrane does not in the least invalidate the view here taken, and the circumstance of their being detached from the sides of the cell will account for the different mode in which they are withdrawn during retraction.

The septa already alluded to as existing between the cells of certain freshwater Polyzoa, are formed both by the ectocyst and endocyst. In *Paludicella* they acquire their maximum in development and constancy; they exist here between every cell, and consist of an annular process which projects transversely from the ectocyst into the interior of the cell, with a covering of endocyst on its upper and under surface. The septum thus formed is rendered complete by the aperture in its centre being closed by a peculiar body, which projects into the cavity of the cell at each side. The structure of this body is remarkable; it consists of a central mass or nucleus, surrounded by a distinct layer of somewhat elongated cellules placed perpendicularly to the surface of the nucleus. The body which thus closes up the centre of the annular septum has, without doubt, some office to perform besides that of simply completing the septum; but upon the nature of this office I can form no satisfactory opinion. In the other genera the septa are by no means so constant or complete as in *Paludicella*. In several species of *Plumatella*, especially *P. coralloides*, septa exist, but these generally occur only at intervals, leaving several cells between them, which communicate freely with one another; not unfrequently the septum itself is imperfect, admitting of a communication through its centre between two neighbouring cells. In *Alcyonella fungosa*, and in *Fredericella sultana*, imperfect septa may here and there be observed, while *Cristatella* and *Lophopus* would seem to be quite deprived of them, the cells in these genera all opening into one another..

B. *Organs of Digestion.*—The digestive system is very similar in all those species in which the lophophore is bilateral; these we shall therefore consider together; *Paludicella*, the only representative of the division with orbicular lophophore, presents some peculiarities, and should be examined by itself.

1. *Species with bilateral Lophophore.*—The *mouth* is a simple edentulous orifice of a circular or slightly crescentic form, placed in the centre of the body of the lophophore, and consequently occupying the bottom of the tentacular crater. Its margin is slightly elevated, and is continuous posteriorly, with a hollow valve-like organ of very peculiar formation. This organ arches over the mouth, and may be aptly enough compared in shape to the epiglottis of certain mammifers. The cavity in its interior communicates through an opening in the lophophore with the perivisceral space; its anterior walls are thick, and densely clothed on their external surface with vibratile cilia, while the posterior walls are thin, membranous, and transparent, and destitute of cilia. It may be observed, when the polypide is exserted from its cell, to be in a constant motion, which consists in an alternate elevation and depression of the organ. The elevation is effected by distinct muscular fibres, which are visible through the transparent posterior walls, and will be afterwards more particularly described, while the depression is probably the result simply of an antagonistic elasticity. On the true function and import of this curious organ I am unable to throw any light; though it is here described in connection with the organs of digestion, its relation to the digestive system is perhaps very remote. It may possibly be more correctly viewed as connected with sensation.

From the mouth an *œsophagus* of considerable length leads downwards to the stomach; it becomes gradually narrower as it approaches the latter, into which it opens by a very distinct conical projection.

To the œsophagus immediately succeeds the *stomach*, without the intervention of any distinct gizzard, such as we find in *Bowerbankia* and certain other marine Polyzoa; and I cannot explain the statement of so excellent an authority as Siebold, who asserts that he has seen in *Alcyonella* a gizzard with an organization precisely similar to that of *Bowerbankia**. The stomach is a large thick-walled sac, and may be divided into two portions, first a nearly cylindrical prolongation, which by one extremity immediately receives the œsophagus, while by the other it is continuous with the remaining portion of the stomach: it may be called the *cardiac* cavity of the stomach. The second division forms the greater portion of the stomach; it is also of a nearly cylindrical form; its direction is almost continuous with that of the former, but it is longer and wider; it terminates below in a rounded *cul-de-sac*; to distinguish it from the other, I shall call it the *pyloric* cavity of the stomach. Between the cardiac and pyloric cavities there is no marked line of demarcation, the structure of both being quite similar; notwithstanding, however, the similarity of structure, I believe there are physiological grounds for the distinction, for I consider the cardiac cavity as the true homologue of the gizzard in *Bowerbankia*.

On a level with the continuation of the cardiac into the pyloric cavity arises the *intestine*; it springs from the pyloric cavity, with which it communicates by a very defined orifice. The pylorus is distinctly valvular, and is furnished with prominent lips, which project into the intestine, and admit of the orifice being dilated or contracted, or even completely closed. The intestine is very wide at its origin, and passes up along the side of the cardiac cavity and œsophagus, rapidly diminishing in diameter till it terminates in a distinct anus just below the mouth.

Histology of Alimentary Canal.—The histological structure of the alimentary tube is somewhat complex. In the walls of the stomach I have succeeded in detecting three distinct layers. Internally we have a thick layer of a yellowish-brown colour; this is thrown into strong longitudinal rugæ, which, however, become less prominent in the *cul-de-sac* of the pyloric cavity: it is composed of transparent spherical cells filled with a clear fluid containing brown corpuscles. When the animal has been long left without food the brown corpuscles disappear from the cellules, and the stomach becomes colourless. Externally to this coloured layer, which we may perhaps view as the representative of the liver, is a layer of elongated colourless cellules, whose long axes are placed perpendicularly to the surface of the stomach. The third and most external layer consists of delicate circular fibres which surround the stomach, and are without doubt muscular; these fibres are particularly evident towards the fundus of the pyloric cavity, and are much less distinct as we ascend towards the œsophagus. The fundus of the pyloric cavity seems indeed to differ from the rest of the stomach in structure and function; the strong longitudinal rugæ and deep brown colour of the internal layer nearly disappear in it, and during the process of digestion we may perceive that the peculiar peristaltic action of the walls is more marked in it than in the remainder of the cavity, from which it is every now and then separated by a momentary hour-glass constriction.

In the œsophagus the internal layer of brown-coloured cellules is wanting, and there are no longitudinal rugæ. The layer of elongated cellules, however, is well-developed, and gives to this part of the alimentary canal a sort of tesselated

* Lehrbuch der Vergleichenden Anatomie der Wirbellosen Thiere, § 38. note 1.

appearance, when viewed under a high power of the microscope; external to this, another layer, possibly muscular, seems also to be present. The mouth and upper part of the œsophagus are clothed with a ciliated epithelium; but I could detect no appearance of cilia further than a short distance down the tube.

The structure of the intestine closely resembles that of the œsophagus; vibratile cilia, however, are altogether absent. In *Cristatella* the cellules of the internal layer are large, and filled in the well-fed animal with a clear greenish-blue fluid.

With the exception of the mouth and upper portion of the œsophagus, no part of the alimentary canal is ciliated in the species with bilateral lophophores. The whole tract is highly irritable, the presence of alimentary matter stimulating it to rapid and vigorous contraction.

2. *Species with orbicular Lophophore.*—In *Paludicella articulata*, the only freshwater representative of the species with the lophophore orbicular, the mouth is a perfectly circular orifice, with slightly projectile margin, and is totally destitute of the valve-like appendage which is found in all the other freshwater species. The upper part of the œsophagus is wide, and may perhaps here, more decidedly than in the other species, be distinguished as *pharynx*. It soon contracts into a long narrow tube, which leads to an oval sac corresponding to the cardiac cavity of the stomach in the other freshwater Polyzoa, and to the gizzard in certain marine species. This sac is much more distinct from the great cavity of the stomach than in the other Polyzoa of fresh water. It enters this cavity near its upper extremity, and presents here a well-marked constriction; in extreme retraction of the polypide it is bent back upon the rest of the stomach. The great cavity of the stomach is of a nearly cylindrical figure; from its upper extremity arises the intestine. This tube presents, just after its origin, a wide dilation, and then suddenly contracting, continues as a narrow cylindrical tube to its termination just below the mouth. The stomach is furnished with an internal layer of coloured cells, as in the other species, but is destitute of longitudinal rugæ. The pylorus is clothed with long vibratile cilia, which extend for a short distance into the cavity of the stomach. The mouth and upper part of the pharynx are also clothed with a ciliated epithelium.

The whole course of the alimentary matter, from the moment of its prehension to its final ejection, may be easily witnessed in many of the freshwater Polyzoa. If a polypide of *Plumatella repens* be watched while in an exserted state, different kinds of infusoria and other minute organic bodies may be observed to be whirled along in the vortices caused by the action of the tentacular cilia, and conveyed to the mouth, where many of them are at once seized and swallowed, and others rejected. The food having once entered the œsophagus, experiences in this tube no delay, but is rapidly conveyed downwards by a kind of peristaltic action, and delivered to the stomach; and at the moment of the passage of the alimentary matter from the œsophagus into the stomach the cardia may be observed to become more prominent. In the stomach the food is destined to experience considerable delay; it is here rapidly moved up and down by a strong peristaltic action, which first takes place from above downwards, and then inverting itself, propels the contents in an opposite direction. Every now and then the fundus of the stomach, which, as has already been said, seems to perform some function distinct from that of the rest of the organ, seizes a portion of the alimentary mass, and retains it for a moment by an hour-glass restriction separate from the remainder, and then powerfully contracting on it, forces it back among the other contents of the stomach. All this time the food is becoming imbued with the peculiar secretion of the gastric walls, and soon assumes a rich brown colour. After having thus undergone for some time the action of the stomach, the alimentary matter is delivered by degrees into the intestine, where it accumulates in the wide pyloric extremity of this tube. After continuing here for a while in a state of rest, and probably yielding to the absorbent tissues its remaining nutritious elements, portions in the form of roundish pellets become separated at intervals from the mass, and are slowly propelled along the tube towards the anus, where, having arrived, they are suddenly ejected into the surrounding water and rapidly whirled away by the tentacular currents. It was these excrementitious pellets that Turpin mistook for unarmed ova in *Cristatella*.

C. *Organs of Respiration and Circulation.*—Upon the tentacular crown and the walls of the perigastric space would seem, among the Polyzoa, chiefly to devolve the function of bringing under the influence of the aërating medium the nutritious fluid of their tissues.

The tentacular crown of a Polyzoon consists of two portions, namely, first, a sort of stage or disc (the *lophophore*) which surrounds the mouth; and secondly, of a series of *tentacula* which are borne in an uninterrupted series round the margin of the lophophore. The lophophore is throughout almost the entire class of an orbicular figure; but in the freshwater genera *Cristatella*, *Lophopus*, *Plumatella* and *Alcyonella*, its posterior margin, or that which corresponds to the side of the rectum, is prolonged into two long triangular lobes or arms, so as to cause the lophophore in these genera to present the form of a deep crescent, round whose entire margin the tentacula are borne in one continuous series. This condition of the lophophore is found in no marine species. In *Fredericella* the arms of the crescent are obsolete, and the lophophore here may, on a superficial view, appear orbicular; but a careful examination will render manifest its departure from the orbicular form, the side corresponding to the arms of the crescent being slightly prolonged obliquely upwards; a similar tendency to assume a bilateral form may also be observed, as Van Beneden* has already pointed out in certain marine genera. *Paludicella* is the only freshwater genus in whose lophophore not the slightest trace of bilaterality can be detected. The lophophore in all the genera forms the roof of the perigastric space; in the species with crescentic lophophores, the arms of the crescent are tubular and open into this space; the interior of the arms is clothed with vibratile cilia.

The tentacula are tubular, closed at their free extremity, and opening by the opposite through the lophophore into the perigastric space; in all the Polyzoa they are armed upon their opposed sides with vibratile cilia, arranged in a single series, and vibrating towards the remote extremity of the tentacle upon one side, and towards the base on the other. In *Fredericella* I have succeeded in detecting two very distinct layers entering into the structure of the tentacula, a condition which I have also made out, though not so evidently in other genera, and which is in all probability common to the whole class. The external layer consists of rounded cells filled with a colourless fluid, and often presenting a bright nucleus. Some of those cells which lie upon the back of the tentacle become in certain genera enlarged, giving a vesicular appearance to the organ; this is particularly evident in *Cristatella*. The internal layer is a delicate transparent membrane, in which I could detect no trace of structure; it resists putrefaction longer than the external cellular layer, and forms the immediate walls of the tubular cavity. A nervous filament and muscular fibres, to be presently described, may also be traced into

* Recherches sur l'Organisation des Laguncula, Nouveaux Mémoires de l'Acad. Roy. de Bruxelles, vol. xviii.

the tentacle. In *Cristatella*, a minute closed cavity, distinct from the rest of the lobe, may be very distinctly seen in the extremity of each tentacle ; it would also seem to exist in other genera, but is less easily demonstrated in these.

In all the freshwater genera, with the exception of *Paludicella*, the entire plume of tentacula is surrounded at its base by an exceedingly delicate transparent membrane in the form of a cup or calyx. This cup is adherent to the back of the tentacula, and its margin is in most instances prolonged more or less upon each tentacle, as a narrow triangular process, so as to present a sort of scalloped or festooned appearance; the festooning of the margin is most marked in *Fredericella*; in some species of *Plumatella* it is scarcely perceptible. A high power of the microscope, and carefully adjusted illumination, will enable us to detect in the calyciform membrane certain delicate anastomosing lines, which I at first suspected to indicate the presence of a vascular net-work; further examination, however has caused me to prefer viewing them as the lines of contact of delicate cellules of which the membrane is composed. The appearance in *Cristatella* especially confirms the latter supposition. The calyciform membrane has not yet been detected in any marine Polyzoon. In the curious marine genus *Pedicellina* the tentacula are indeed surrounded at their base by a kind of membranous calyx, but this is of an entirely different import from the membrane connecting the bases of the tentacula in the freshwater Polyzoa.

The perigastric space and interior of the tentacula and lophophore all freely communicate with one another, and are filled with a clear fluid, in which float numerous particles of very irregular form and size. In this fluid may be observed a constant rotatory motion, rendered apparent by the floating corpuscles as they are whirled away under the influence of the currents. That the fluid thus contained in the perigastric space, and thence admitted into the tentacula, consists really of water which had obtained entrance from without, there can, I think, be little doubt, and yet I have in vain sought for any opening through which the external fluid can obtain admittance to the interior. I have allowed the transparent genera *Cristatella* and *Lophopus* to remain many hours in carmine without being able to detect a single particle of this pigment in the perigastric space, though I have seen this space rapidly empty itself on the removal of the animal from the water, and again fill on restoring it to its natural element. Van Beneden* believed that he had detected in Alcyonella apertures, which he names "bouches aquifères," at the base of the tentacula; but this distinguished naturalist is certainly here in error: I shall presently point out the source of his mistake. Meyen asserts the existence of an aperture in the vicinity of the anus, through which, he tells us, he has witnessed the escape of an egg in *Alcyonella*†; and Siebold admits the correctness of this statement, and considers the aperture described by Meyen to be that through which the external water gains admittance to the interior‡. I have, however, fully convinced myself that no such aperture exists, and the phænomenon described by Meyen must certainly be due to an accidental rupture of the tissues, though the high authority of Van Beneden describes the passage of the eggs through an aperture similarly placed in the marine genus *Laguncula*§. It is possible that certain apertures may exist in some of the tissues of the animal so minute as to defy our attempts at detection, and yet capable

* Quelques Observations sur les Polypes d'eau douce, Bull. de l'Acad. Roy. de Bruxelles, 1839.

† Meyen, Naturgeschichte der Polypen, Iris, 1828.

‡ *Loc. cit.* § 41.

§ Recherches sur l'Org. des Laguncula, *loc. cit.*

of permitting a transudation of fluid. Rapp detected numerous minute apertures in the external walls of *Actinia*, keeping up a communication between the interior of the animal and the surrounding water; the discovery of Rapp I have fully confirmed, and yet the apertures are so small as to render it certain that they would have remained undiscovered were it not that their presence is betrayed by a minute stream which escapes from them during the contraction of the animal, which occurs immediately on its being removed from the water. May not similar apertures exist in the Polyzoa? and if so, I should feel inclined to seek them in the walls of the alimentary canal, perhaps of the rectum. The fluid which circulates in the perigastric space is not perfectly homogeneous, and numerous corpuscles of very various and irregular shape may be observed to float through it and be carried about by its current. Some of these corpuscles are perhaps spermatozoa; others are of no definite shape, and look like minute portions of the tissues separated by laceration. May they not be some of the products of digestion which have transuded through the walls of the alimentary canal, being thus conveyed into the only representative of a true circulation with which these animals present us?

The true signification of the perigastric fluid is a point whose determination must be of great importance in the physiology of the Polyzoa. If it be admitted, as I think it must be, that it consists mainly of water which has obtained entrance from without, it then corresponds to a true aquiferous system subservient to a respiratory function. But, as we have already seen, it is probable that it receives certain products of digestion which had transuded through the walls of the alimentary canal; it thus connects itself with the digestive system. It is moreover the only representative in these animals of a sanguiferous circulation, for in the Polyzoa there is certainly no trace of a heart, nor can anything referable to a true vascular system be detected. The perigastric circulation therefore unites in itself the triple function of a chyliferous, sanguiferous and respiratory system.

The next point of interest to determine, with regard to the perigastric fluid, is the cause of the peculiar currents observed in it. These currents, which extend into the tentacular crown, were long ago observed by Trembley* in *Lophopus crystallinus*; but this author contented himself with simply recording their existence, and made no attempt to explain them. Nordmann†, who observed them in both freshwater and marine genera, not being able to detect any trace of cilia or other moving power, compared them to the currents in the cells of *Chara*. That they are produced by the action of vibratile cilia, there can, however, now be no doubt. Van Beneden‡, tells us that he has seen these cilia, not only on the walls of the perigastric space, but on the external surface of the alimentary canal. I cannot, however, confirm their existence in the latter situation; indeed, my own observations are entirely opposed to their presence on the alimentary canal; and I cannot help thinking that this statement of Van Beneden is connected with some error of observation. I have, however, most distinctly seen them on the upper part of the tentacular sheath in *Plumatella* during the exserted state of the polypide; on other parts of the endocyst I have not succeeded in detecting them by direct observation; but the peculiar acceleration which the motion of the circulating corpuscles experiences when these approach the walls of the perigastric space, plainly indicate the presence of vibratile cilia in this situation.

D. *Muscular System.*—The muscular system is highly developed; we

* *Loc. cit.* † Micrographische Beiträge, Bd. ii. p. 75.

‡ Quelques Observations sur les Polypes d'eau douce, *loc. cit.*

shall first consider it in those species with bilateral lophophores, and afterwards attend to its disposition in *Paludicella*.

1. *Species with bilateral Lophophore.*—In all these the disposition of the muscles is exceedingly similar; seven distinct sets may be considered as demonstrated.

(1.) *Retractor Muscles of the Polypide.*—These, which are the largest and most powerful muscles of the animal, consist of two fasciculi which arise far down from the inner surface of the endocyst, and thence pass upwards, one along each side of the alimentary tract, to be inserted into the upper part and sides of the œsophagus. A few accessory fasciculi may also be generally seen arising near the origin of the former, and inserted into the sides of the stomach. The *use* of the retractor muscles is very obvious; acting towards the bottom of the comparatively fixed tube, they retract the whole alimentary canal with the tentacular crown, so as to place them in a state of security in the interior of the cœnœcium.

(2.) *The Rotatory Muscles of the Crown.*—These also consist of two fasciculi, which arise along with the set just described, and passing up in company with these, separate from them at some distance below the crown, and thence pass outwards to the right and left to be inserted each into its own side of the lophophore. *Use*: to rotate the tentacular crown and depress the lobes.

(3.) *The Tentacular Muscles.*—The muscular apparatus of the tentacula consists of a set of delicate parallel bands, which may be observed running from below upwards upon the margin of the lophophore; these bands are continuous with one another below, and when they arrive at the intervals between the roots of the tentacula, each divides into two others, which run along the opposite sides of two neighbouring tentacula. The margin of the lophophore in the interval of the bands presents an oval transparent space, which looks almost exactly like an aperture, and it would seem to be these spaces which M. Van Beneden has taken for aquiferous mouths; after very careful examination, however, I have convinced myself that no aperture exists here, the apparent mouths being merely transparent spaces in the lophophore.

(4.) *The Elevator Muscle of the Valve.*—This is a small, but very evident fasciculus, occupying the interior of the oral appendage, and visible through its transparent posterior walls; it arises from the lophophore near the base of the valve, and passing forwards and upwards, is inserted into the posterior surface of the anterior wall of the valve. *Use*: to elevate the valve and draw it backwards from the mouth.

(5.) *Superior Parieto-vaginal Muscles.*—These consist of numerous short bands, which arise all round from the inner surface of the endocyst, commencing close to the line of invagination, and extending for some distance downwards. From this origin they pass transversely inwards, and are inserted into the opposed surface of the invaginated endocyst and tentacular sheath. *Use*: to dilate the invaginated endocyst and sheath, and assist in keeping the invaginated endocyst and upper portion of the sheath permanently inverted.

(6.) *Inferior Parieto-vaginal Muscles.*—These consist of several radiating bands longer and stronger than the last, below which they arise from the inner surface of the endocyst in a single plane perpendicular to the axis of the cell, and thence passing upwards and inwards, are inserted into the sheath in a plane parallel to that of their origin, and just below the termination of the superior parieto-vaginal muscles. *Use*: to steady the sheath and regulate its position during the protrusion of the polypide, and to form a fixed plane on which it may roll outwards with the polypide in the act of protrusion.

(7.) *Vaginal Sphincter.*—The vaginal sphincter is a circular band surrounding the termination of the invaginated endocyst at the point where the latter passes into the tentacular sheath. Though a contraction of the endocyst at this spot, as if occasioned by the action of a powerful sphincter, may be always observed when the polypide is completely retracted, yet the demonstration of an actual muscle is by no means easy. I have however convinced myself of the existence of a distinct structure at the place where the contraction occurs, and, though I have not observed any evident fibres, I have no hesitation in viewing this structure as a sphincter muscle on which the contraction in question is dependent. The *use* of the sphincter is to close the sheath after the recession of the viscera, and thus protect the latter from all annoyance from without.

Besides the seven sets of muscles now described, a high magnifying power and properly adjusted illumination will enable us to detect in the walls of the endocyst, towards its anterior extremity, numerous delicate fibres which run transversely round the cell. They are doubtlessly muscular, and by their action constrict the endocyst in a transverse direction, and thus aid in the protrusion of the viscera. I have not succeeded in determining how far down the cell they extend, as the structure soon becomes concealed under the increasing opacity of the superjacent tissues. Circular muscular fibres are also very evident in the walls of the stomach; these have already been described in connection with the histology of the digestive system.

2. *Muscles of Paludicella.*—The muscular system of *Paludicella* differs in some important points from that of the species with bilateral lophophores. The muscles may here be divided into five sets:—

(1.) *The Retractor Muscle of the Polypide.*—This resembles in attachments and use the corresponding muscle in the other species, but is not divided like the latter into two distinct fasciculi.

(2.) *The Superior Parieto-vaginal Muscles.*—These constitute four strong fasciculi, which, arising from the sides of the cell near the top, are inserted into the opposed surface of the invaginated endocyst. The fibres of each fasciculus are inserted one after another in a straight line, commencing near the line of invagination, and extending for some distance down the invaginated tunic. These four lines of insertion are placed at nearly equal distances from one another, and thus cause the orifice and invaginated tube to assume a regular quadrilateral figure. The corneous ribs already described correspond to the centre of the intervals between the insertion of the muscles.

Mr. Hancock* enumerates, under the name of Superior Tube Retractors, two small additional fasciculi, which he describes as originating below those just mentioned, and as inserted also below them into the invaginated tube, their insertion becoming of course superior to them when the tube is evaginated during the exserted state of the polypide. The marine Polyzoa certainly afford an analogy for the existence of these muscles; but, though I have carefully sought for them in *Paludicella*, I have not succeeded in detecting them here as distinct fasciculi, and I prefer viewing them as some of the inferior fibres of the superior parieto-vaginal muscles. The *use* of the superior parieto-vaginal muscles is to assist in the invagination of the tube, and dilate it when completely retracted, thus acting as antagonistic to the vaginal sphincter, while the inferior fibres will check the complete evagination during exsertion.

(3.) *The Inferior Parieto-vaginal Muscles.*—These are about four strong fibres, first pointed out by Mr. Hancock; they arise from the inner surface

* *Loc. cit.*

of the endocyst near the top of the cell, two in front and two behind the polypide, and are inserted into the opposed surface of the tentacular sheath. Their *use* is to check the complete evagination of the sheath in the way we shall presently see.

(4.) *Vaginal Sphincter.*—This was also pointed out for the first time by Mr. Hancock. It consists of a set of fibres which run transversely round the invaginated tunic. I have not succeeded in dividing it into an inferior and superior set, as described by Mr. Hancock. Its *use* is to close the invaginated endocyst after the retraction of the polypide.

(5.) *The Parietal Muscles.*—These are numerous, short but strong, and very evident fibres, which run transversely in the endocyst in small groups of two or three fibres each, embracing about a third or fourth of the circumference of the cell. Their *use* is to compress the endocyst, and by thus diminishing the cavity of the cell, effect the exsertion of the polypide.

The description now given of the muscular system in the freshwater Polyzoa, will enable us to understand the mechanism by which the protrusion and retraction of the polypide are effected.

The grand agency to which we must assign the protrusive act, is without doubt the contraction of the endocyst effected in *Paludicella* by the well-developed parietal muscles, and in the other freshwater genera by the action of the corresponding delicate fibres already alluded to, or by the general contractility of the tunic itself; and indeed it does not seem possible to refer the act of protrusion to any other cause than the consequent pressure of the perigastric fluid against the body of the polypide, and the necessary compulsion of the latter to move in the direction of least resistance, or through the orifice of the cell; for the mere straightening of the œsophagus, to which Dr. A. Farre* attributes so large a share in the production of this act among the marine Polyzoa, can at most raise the lophophore and tentacula a very short distance, and can exercise no exsertile influence on the inferior portion of the polypide, which, indeed, it must rather tend to repel into the bottom of the cell; while in all the freshwater genera, with the exception of *Paludicella*, the œsophagus, in the retracted state of the polypide, is scarcely at all bent, so that here its agency in exsertion is at once out of the question.

Let us now suppose the polypide withdrawn into the recesses of the cell, and that hunger or some other stimulus impresses on it a desire of protrusion. The endocyst now contracts on the perigastric fluid, which, pressing on the polypide, forces it onwards towards the aperture; at the same time the vaginal sphincter relaxing, affords to the cone of tentacula a free passage through the tube of the inverted endocyst.

The succeeding steps in the process take place somewhat differently in the two great groups. In *Plumatella* and the other species with bilateral lophophores, as the polypide continues to advance from the cell, the invaginated endocyst is gradually carried out with it by a process of evagination, which proceeds up to a certain point, where it is stopped by the action of the inferior parieto-vaginal muscles, which, by straining upon the invaginated membrane, had already afforded a fixed line, on which it rolled outwards during eversion. This line constitutes the extreme limit of eversion, and that portion of the invaginated endocyst which lies between it and the mouth of the cell remains permanently invaginated. In *Paludicella* the process is somewhat more complicated; here the relaxation of the upper fibres of the superior parieto-vaginal muscles permits the eversion of the endocyst, but only

* Observations on the Minute Structure of some of the higher forms of Polypi. Philosophical Transactions, 1837.

to a certain extent, for the inferior fibres of these muscles soon check its further progress. The remainder of the invaginated membrane, which in the retracted state constitutes the tentacular sheath, continues to be carried outwards by the advancing polypide, the inferior parieto-vaginal muscles slowly relaxing to admit of it. These muscles, however, after a certain time refuse to suffer further relaxation, and thus afford a second check to the evagination of the membrane. Thus we have two small permanent invaginations existing after the completion of the protrusive act. One of these is placed within the other, and gives rise to the membranous cup which projects from the lips of the orifice in the exserted state of the polypide. This cup, therefore, which may plainly be seen under a proper illumination to consist of a membrane doubled into itself, is nothing else than the imperfectly evaginated tentacular sheath. It may be seen during the act of protrusion in *Plumatella* and other genera; but in these it is a mere temporary condition, being obliterated on the completion of the act. Mr. Hancock therefore appears to me to mistake the true import of this cup, when he maintains its homology with the crown of setæ in *Bowerbankia**. The true homologue of these setæ is to be found, as has been already stated, in the corneous ribs of the endocyst. When the protrusion of the polypide is complete, the last act in all the species is the display of the tentacula, which had previously been all drawn together into a close cone or cylinder; and scarcely any more pleasing sight can be presented to the microscopic observer than the spreading out of the beautiful crown and the excitement of the vortices in the surrounding fluid, by the countless cilia which instantly commence their untiring vibration on the sides of the tentacula.

The mechanism of retraction is easily understood. Here the perigastric fluid being no longer pressed upon by the contraction of the endocyst, the great retractor muscles act directly on the polypide and withdraw it into the cell, the superior and inferior parieto-vaginal muscles in *Paludicella* drawing after it as it descends that portion of the endocyst which had been carried out during protrusion; in the other genera, however, the superior muscles would seem to take no part in this act. When the retraction is complete the sphincter closes the tentacular sheath, and the polypide rests secure in the recesses of the cell.

The muscles of these animals are especially interesting in a physiological point of view, for they seem to present us with an example of true muscular tissue reduced to its simplest and essential form. A muscle may indeed here be viewed as a beautiful dissection far surpassing the most refined preparation of the dissecting knife, for it is composed of a bundle of elementary fibres totally separate from one another through their entire course. These fibres are distinctly marked with transverse striæ, a condition, however, which is not at all times equally perceptible; and some of our best observers have denied to the Polyzoa the existence of striated fibre. I have however, by repeated observations, satisfied myself of the striated condition of the fibre in the great retractor muscle in all the freshwater genera. In *Paludicella*, I have seen this state beautifully marked through the pellucid cell in the whole extent of the retractor muscle while the fibres were on the stretch in the exserted condition of the polypide; and in all the other genera it has, under favourable circumstances of observation, been more or less visible. In order to witness it in perfection the fibre must be on the stretch, for when this is torn from its attachments or lies relaxed on the bottom of the cell, the striæ become very obscure. When the broken extremity of a fibre is

* *Loc. cit.*

examined, the fracture will be found to have occurred in a plane perpendicular to the axis of the fibre, never presenting an uneven or lacerated appearance; and a marked tendency to separate into discs may be recognised in the detached and broken fibre. When the fibre is in an uncontracted state, it would seem to be perfectly cylindrical, and the normal act of contraction is so momentary that its condition during this act cannot be witnessed. When, however, the living polypide is torn from its cell, the ruptured fibres which continue attached to its body are thrown into a state of spasmodic contraction, and then it will be seen that they lose their cylindricity and become irregularly swollen at intervals, while the whole fibre has much increased in thickness: in this state we may also observe it obscurely striated. The swellings here visible in the contracted fibre are quite different from the peculiar knots described by Dr. A. Farre in the muscles of the marine Polyzoa. Such knots do not exist in the freshwater species, at least I have never seen them, with the exception perhaps of certain little swellings, which may be occasionally witnessed in the parietal muscles of *Paludicella* and in the superior parieto-vaginal muscles of *Plumatella*. In *Paludicella* I have witnessed a curious phænomenon presented by the muscular fibre. In this polyzoon the fibres of the great retractor muscle, while lying relaxed in the bottom of the cell after the retraction of the polypide, may frequently be seen to present a singular motion, impressing you with the idea of a cluster of writhing worms.

The existence of striated fibre in the Polyzoa was first noticed by Dr. M. Edwards, who detected it in *Eschara* *; and Mr. George Busk has since described and figured the same form of tissue in *Anguinaria spatulata* and *Notamia bursaria* †.

E. *Organs of the Life of Relation.*—I have succeeded in making out a distinct nervous system in all the genera with the exception of *Paludicella*, in which I have not as yet been able to effect any satisfactory demonstration of its existence. In all the species with bilateral lophophores, there may be seen attached to the external surface of the œsophagus, on its rectal aspect just below the mouth, an oval body of a yellowish colour. Careful examination shows that this body is furnished with a cavity or ventricle in its interior; that it is a nervous subœsophagean ganglion there cannot be any doubt, and I have succeeded in distinctly tracing nervous filaments in connection with it. In *Cristatella*, *Lophopus*, and other genera with crescentic lophophores, the ganglion may be seen giving off from each side a rather thick chord, which takes a course backwards, and immediately enters the tubular arms of the lophophore, and then running along the roof of this cavity, gives off at regular intervals a filament to each tentacle upon the outer margin of the arm. When it arrives at the extremity of the arm it turns on itself, and in its retrograde course gives off similar filaments to the tentacula placed upon the inner margin. I have thus traced it back to the base of the arms, but have here failed in my attempts to follow it further; it is however highly probable that it passes across the lophophore to unite with the corresponding filament of the opposite side. The ganglion also sends off filaments upwards towards the mouth; and a filament may be observed passing downwards along the œsophagus, and soon losing itself on the walls of this tube. I have made out this last filament very distinctly in *Cristatella*. From each side a delicate filament would seem to pass forwards on the œsophagus, but I have not suc-

* Milne-Edwards, Recherches Anatomiques, Physiologiques et Zoologiques sur les Eschares, Ann. des Sci. Nat., 2de Serie, t. vi.

† Busk in Transactions of the Microscopical Society of London, vol. ii.

ceeded in detecting anything like a complete collar surrounding the tube at this place. There is no other ganglion than the one just described, and nothing which can with any real probability be referred to an organ of special sense has as yet presented itself.

To M. Dumortier is due the credit of having first demonstrated the existence of a nervous system in the Polyzoa. He saw in *Lophopus crystallinus** the subœsophagean ganglion, though he speaks doubtingly of it as referable to the nervous system, while he assures us of a distinct ganglion placed at the base of each arm of the lophophore. This last is certainly an erroneous observation, and it is probable that the learned Belgian naturalist mistook for a ganglion the optical expression of the cavity of the arm when seen in transverse section.

II. *Organs for the Preservation of the Species.—Embryology.*

In the Polyzoa, both marine and freshwater, three distinct modes of reproduction may be witnessed, namely, by *buds* or *gemmæ*, by true *ova*, and by *free, locomotive embryos.*

1. *Reproduction by Gemmæ.*—The gemmæ always originate in the endocyst. In *Lophopus*, *Alcyonella*, *Plumatella* and *Fredericella*, they occur without any very regular order near the mouth of the cell. They at first appear as a small tubercle projecting into the perigastric space, but may soon be seen to take a development in an outward direction. The bud now presents the appearance of a vesicle projecting from the exterior of the parent cell, closed at its external or free extremity, but having its cavity in communication with the perigastric space. The polypide is gradually developed in the interior of the gemma, which soon opens at its free extremity so as to admit of the exsertion and retraction of the young polypide. The gemma is now a complete cell with its contained polypide, and in the branched species soon grows into a new branch springing from the side of the old one. In *Cristatella* the gemmæ are produced very regularly from the external side of the last-formed series of cells, and constitute a marginal series extending round the entire colony. Finally, in *Paludicella* the gemmæ are also exceedingly regular, always originating at a fixed point a little below and at each side of the orifice. From this position of the gemmæ, two opposite branches spring from the thick end of each cell; and though these branches are by no means necessarily developed on every cell, yet the fixed points on which they originate, and the constant angle at which they are given off from the parent cell, give to the whole colony a very regular and elegant appearance.

It is difficult, on account of the nature of the intervening structures, to follow the process of development of the polypide in the gemmæ of any of the species with the exception of *Paludicella*; in this, however, I have been able to trace its gradual formation from a very early stage to its complete development.

The gemma in the earliest condition in which I have been able to observe it, appears here as a minute tubercle projecting from the external walls of the cell, and filled with a granular parenchyma. We next find it hollowed out into a cavity which communicates with the interior of the parent cell. The tubercle with its cavity increase in size, and the gemma is now found to consist of an external envelope continuous with the ectocyst of the parent cell, and of a thick fleshy lining continuous with the endocyst; this internal tunic has numerous large round nucleated cells distributed through its sub-

* Dumortier, *loc. cit.*

stance, and internally it presents a rough uneven surface. The two tunics of the gemma are to become the ectocyst and endocyst of the future cell.

By this time the gemma has become considerably elongated and has acquired a clavate form, and its cavity begins to be cut off from that of the parent cell by the formation of a septum. We next perceive that a rounded mass has formed in the substance of the lining tunic, near the wide extremity of the gemma, and projects into the interior of the latter. In this mass we soon perceive a cavity, which, when viewed in front, appears surrounded by a slightly waved oval ring which is afterwards to become the tentacular crown of the polypide. The ring is at first quite simple, resembling a mere fold of thickish membrane, but in a short time it presents all round a series of minute tubercles, the rudiments of the future tentacula. Delicate fibres may now be distinctly seen passing from the little mass in which these appearances have been presenting themselves to the walls of the cavity of the gemma; these fibres are the rudimental retractors of the polypide. Circular fibres may also be now seen in the lining membrane of the gemma; these are chiefly collected near its proximal end, and are to become the parietal muscles of the adult. The tentacular sheath may about the same time be distinctly seen extending from the base of the rudimental tentacula to the walls of the cavity in which the young polypide is suspended, and fibres which are to become the superior parieto-vaginal muscles may be observed in connection with it. The rudimental polypide has now become somewhat enlarged below the tentacular ring, and here presents in its interior a cavity. This cavity is at first simple and continuous, but as the inferior extremity of the polypide continues to elongate, we soon find it divided into three distinct regions, which are the first indication of œsophagus, stomach and intestine. By the elongation of the tentacles, the tentacular crown has now acquired nearly its full development.

Up to this period the young polypide has been entirely shut off from all communication with the external water, and its nutrition must have been effected through the general nutrition of the colony; now, however, an opening occurs in the gemma just over the tentacular crown, and the last stage of development is entered on. The tentacular crown rapidly acquires its complete form, the inferior extremity of the alimentary canal becomes elongated into the great cul-de-sac of the stomach, the muscles are by this time all formed, and the polypide is capable of exsertion and retraction. It is now no longer dependent for its growth on the general nutrition of the colony, but has become an independent being, obtaining its food from without, and submitting it to the action of its own digestive system.

From the description here given of the development of the gemma in *Paludicella*, we must be at once struck with its remarkable similarity to that of the gemma in *Laguncula*, as elaborately described and figured by Van Beneden*; a glance indeed at the figures in Van Beneden's memoir is sufficient to convince us how closely the freshwater genus resembles that of the sea in the interesting process whose details we have been just following.

2. *Reproduction by Ova.*—All the freshwater Polyzoa produce true ova, which are formed in a definite organ or ovary. From the existence of a true ovary and ova, we are at once led to expect the co-existence of a male organ. That a testis is present in all the species of freshwater Polyzoa, there can I think now be little doubt. In most of the genera I have met with an organ which I have little hesitation in viewing as a testis, though, with the exception of *Paludicella*, the demonstration of such an organ is somewhat obscure. In this genus, however, I have had the most satisfactory demonstration of both

* *Loc. cit.*

testicle and ovary, the one loaded with spermatozoa, the other with ova in various stages of development.

The ovary and testis in *Paludicella* are both found in the same cell. The former is an irregularly-shaped body, adherent to the inner surface of the endocyst towards the upper part of the cell. About the end of June, when I discovered this organ, it was loaded with ova of various sizes, some so small as to require for their detection a high power of the microscope, while others were almost visible to the naked eye, and seemed ready to burst the restraining membrane of the ovary and escape into the cavity of the endocyst. Attached by one extremity to the external surface of the stomach near the commencement of the intestine, and by the other, apparently in connection with the ovary, is a cylindrical, flexible chord, which obeys all the motions of the stomach. Of the nature of this appendage which thus brings the ovary into connection with the stomach, I have been unable to arrive at any satisfactory conclusion. It can scarcely be an oviduct communicating with the cavity of the stomach, and thus affording, through the latter organ, a way of egress to the ova; for even though it be tubular,—a condition not by any means apparent,—it is evidently too narrow to receive the mature ova, even though it undergo as much dilation as would seem possible with such an organ.

The testicle is an irregularly-lobed mass attached like the ovary to the inner surface of the endocyst. It occupies a position near the bottom of the cell, and is thus separated by a wide interval from the ovary; like the latter organ it is connected with the stomach by a cylindrical chord, precisely similar to that already described as belonging to the ovary: this chord, which is connected with the testicle by one extremity, is attached by the other to the fundus of the stomach, and its office is just as obscure as that of the corresponding chord connected with the ovary. The testicle was observed at the same time as the ovary, and was then loaded with spermatozoa, multitudes of which projected from its surface in the form of a dense villosity, each minute filament of which exhibited a perpetually undulating motion. Many of the spermatozoa had escaped from the testicle and were carried about by the currents of the perigastric fluid, and thus brought in contact with the ovary, round which several were observed clustering. The spermatozoa in *Paludicella* are simple vibrioid bodies without any terminal enlargement, and exhibit a constant sinuous or undulatory motion.

The ova, on arriving at a certain stage of development and while still in the ovary, present distinctly the germinal vesicle and germinal spot; these, however, soon disappear. When the ovum escapes from the ovary it is a lenticular body surrounded by an annulus, in which a somewhat obscurely cellular structure is apparent. A coloured and very eccentric spot may be observed at this stage in the contents of the ovum. I have not been fortunate enough to observe the ova of *Paludicella* more than once, and have thus had no opportunity of making further observations on these bodies.

In those freshwater Polyzoa whose lophophore is bilateral, we find the ovary occupying a very different position from that which it holds in Paludicella. In these, attached by one extremity to the fundus of the stomach, and by the other to the inner surface of the endocyst near the bottom of the cell, may be observed a chord-like organ quite similar to what has already been described as passing from the stomach to the testicle in Paludicella. This chord is surrounded by the ovary, in which the ova may be observed in various stages of progress, becoming gradually more developed as they approach the gastric extremity of the ovary. The ova are for the most part few in number, and lie along the chord which connects them in a sort of moniliform manner. As they increase in size the membrane of the ovary becomes strained over them, and they finally rupture it and escape into the perigastric space, where they lie loose in the surrounding fluid.

Just before the chord-like organ becomes attached to the walls of the cell, it presents in many cases an enlargement which seems due to a peculiar investment acquired at this spot, and which is quite distinct from the ovary: this structure I believe myself justified in viewing as a testicle. M. Van Beneden believes in the existence of a testicle occupying in certain polypides of *Alcyonella fungosa*, the position of the ovary in others, and is thus led to maintain the existence of distinct male and female individuals in the same colony*. I confess however that my own observations do not tend to confirm the view of the distinguished professor of Louvain. The ova, on escaping from the ovary, are in most species, perhaps in all, still enclosed in a delicate transparent membranous investment, which however is soon lost. The general formation of all these ova, when they have arrived at maturity, is that which results from the apposition by the concave surfaces, of two concavo-convex horny discs united in all cases, except in *Fredericella*, by an annulus of a different structure which runs round the entire margin overlapping each disc. The ova in the different species vary from a lenticular shape to an elongated oval, and in *Fredericella* the marginal ring is obsolete. In all, one surface would seem to be a little more convex than the other.

In *Cristatella* the mature ovum is furnished with hooked spines, which spring alternately from the two sides just within the annulus, and thence passing outwards over the latter project in short rays beyond the margin. The disc in all the species is of a deep brown colour, and would seem to be composed of a single layer of hexagonal cellules, whose external walls in most cases slightly project beyond the surface of the disc, and thus give to the latter an elegantly mammillated condition. In some cases however the cellular condition of one or both discs is very obscure. The annulus is also composed of cellules, which here, however, occur in several layers; these cellules are also for the most part larger than those of the disc and of a different colour; they are filled with air, and give to the annulus a light spongy texture.

In *Cristatella* I have succeeded in tracing certain stages in the progress of the ovum towards the mature condition, in which it is ready to escape from the body of the parent. In an early stage it may be observed as a whitish semitransparent compressible vesicle enclosing a fluid loaded with granules or minute cellules. In this state its surface is perfectly smooth, but we find it before long acquiring two additional investments, which however possess but a temporary existence and are destined to disappear as the ovum advances to maturity. The internal of these is a thick layer of a gelatinous consistence, which immediately invests the ovum; the external is a delicate transparent membrane which retains the internal gelatinous investment in its place, and is thickly covered on its outer surface with minute vibratile cilia. The action of these cilia seems to be confined to the production of currents in the surrounding fluid, and is thus probably subservient to the function of aëration, for they are evidently too weak to act as organs of locomotion, at least I never witnessed the ovum carried about by their aid through the surrounding water. This interesting condition of the ovum must be carefully distinguished from a ciliate locomotive embryo, examples of which will be presently adduced. Within the gelatinous envelope the ovum acquires its horny shell and annulus, and has now attained to its full size, still invested by the gelatinous and ciliated envelopes, but as yet no

* Quelques Observations sur les Polypes d'eau douce, *loc. cit.*

trace of the spines is visible. These however shortly after show themselves growing out from the two faces of the ovum; they penetrate the gelatinous envelope, and soon impinge on the external membrane, which by this time has lost its cilia, and which now gives way, torn by the grapple-like extremities of the spines. The two temporary investments of the ovum now rapidly disappear, and the latter presents itself as the elegant little spiny lenticular body so characteristic of the genus *Cristatella*.

I have observed in the freshwater Polyzoa the curious fact of the very same individual producing two different kinds of ova. This occurs in *Plumatella emarginata* and in *Alcyonella Benedeni*. In both these, the cells may be observed towards the end of summer loaded with ova which lie loose within them. These are of an elongated oval figure, with a largely developed annulus which overlaps a considerable portion of the disc. But besides these bodies, others may also be observed invariably attached to the internal surface of the walls of the cell, to which they adhere by means of a peculiar cement, in which no trace of structure can be detected. These differ also from the unattached ova in shape, being much shorter in proportion to their width, while the annulus is exceedingly narrow, and presents but slight traces of that highly developed cellular structure so remarkable in the others. After the decay of the cœnœcium, many of these attached ova may be seen adherent to the stone or other body on which the specimen had developed itself, and to which they are now connected in lines through the medium of a portion of the old cell in which they had been produced. I am unable to state whether the development in these last-described bodies is similar to what occurs in the others, as I have not succeeded in witnessing the escape from them of the young.

In *Alcyonella fungosa* and *Lophopus crystallinus*, I have also witnessed bodies which differed from the ordinary ova of these Polyzoa in the possession of a regular elliptical aperture in the centre of their more convex face. They were always empty, and of their nature I have not been able to form any conclusion of value.

The nearly opake horny investment of the ova of all these species renders it impossible to trace those stages of the development of the embryo which occur previously to the hatching of the egg; and on rupturing the latter under the microscope, nothing can be witnessed but the escape of a fluid holding in suspension innumerable corpuscles which spread themselves over the field and exhibit but obscure traces of definite aggregation. When however the development has gone on to a certain extent within the ovum, the latter opens by the separation from one another of the two faces, and the young polyzoon gradually emerges and floats away freely through the water, but the surface of its investing tunic is altogether destitute of cilia or other active organs of locomotion; and its motions through the surrounding fluid seem to be quite passive, except so far as they may be possibly influenced by the ciliary action of the tentacula. It now possesses all the essential organs of the adult, the retractor muscles are well-developed, and the polypide is capable of regular exsertion and retraction; but the ectocyst is colourless and transparent, and free from the earthy particles which in the greater number of species are afterwards found in it, and the little animal is still simple. It loses however no time in developing gemmæ, which soon change it to the perfect compound form of the adult. In many cases the two separated faces of the original ovum continue for some time to adhere to the lower end of the little animal like the valves of a bivalve shell.

I have sought in vain, in all the freshwater Polyzoa, for some orifice through which the ova may escape from the cells; and yet, from the large size and incompressible nature of these ova, such an orifice, were it present, could hardly escape detection. Meyen*, it is true, states that he has witnessed in *Alcyonella fungosa* the escape of an egg through an opening in the vicinity of the anus; but, notwithstanding a similar observation already noticed as made by Van Beneden on the marine *Laguncula repens*, this I feel certain has been an imperfect observation of Meyen, and that the escape of the egg was the result of some accidental laceration of the tissues in this spot. There is then no natural aperture through which the ova can escape, and their liberation I am convinced can only take place after the destruction of the soft parts of the Polyzoon has afforded to them a mode of egress through the mouth of the cell.

3. *Reproduction by free Embryos.*—While engaged in the examination of a specimen of *Plumatella fruticosa*, I observed in the water which contained it, a small egg-shaped body of a white colour. On placing this under the microscope, I distinctly saw through the transparent external skin that it enclosed a young polyzoon, and on now rupturing this skin with the point of a needle, the little polyzoon was set at liberty. This consisted of a solitary well-developed polypide enclosed in a completely formed cell, from which it every now and then protruded the upper part of its body by a process of evagination, just as in the adult animal. The cell appeared to consist of the endocyst alone, and the whole of its external surface to the line of invagination was densely clothed with long vibratile cilia. The little animal would sometimes remain stationary with the upper part of the polypide protruded from the cell, but most constantly the entire polypide was retracted and the mouth of the cell closed, and then the little embryo would present the appearance of a minute sphere covered with long cilia, by whose action it was carried about through the water with rapid and elegant motion.

Some time after discovering the free embryo of *Plumatella fruticosa*, I observed similar locomotive bodies in the water in which I had been keeping a specimen of *Alcyonella fungosa*. These, in the retracted state, were of a more elongated form than the little embryos already described, from which they moreover differed in invariably containing two polypides in a single cell. They were exceedingly active in their motions, moving always with the *cul-de-sac* of the cell foremost, and at the same time revolving on their axis in an exceedingly elegant manner; they frequently assumed a pear-shaped figure, with the narrow end corresponding to the orifice of the cell.

In both the embryos now described the general structure is quite similar. A soft, transparent and eminently contractile sac, partly clothed with cilia, has the unciliated portion invaginated into the ciliated, down which it extends for some distance, and then turning back upon itself is reflected upwards, when it experiences another invagination before becoming attached beneath the tentacular crown of the polypide. The first invagination is rendered permanent in this stage of the embryo by numerous bands, so closely resembling the superior and inferior parieto-vaginal muscles of the adult as to lead at first to the belief that they are these very muscles visible in the embryo. Such however is not the case. Neither these bands, nor the invagination with which they are connected, have any existence in the adult; and it is the second invagination just mentioned which the latter alone retains. The great retractor muscle of the polypide is well developed in the embryo.

The subsequent development of the embryo I have not been able exactly to follow; it seems however probable that it consists in the obliteration of the inferior invagination, and the disappearance of the cilia from the surface of the sac, with the formation of an ectocyst, the embryo at the same time

* *Loc. cit.*

becoming complicated by the development of gemmæ; indeed the commencement of gemmation may be observed before any other change is apparent.

Meyen* was the first to record the presence of locomotive embryos in the freshwater Polyzoa. He observed them in *Alcyonella fungosa*, but his description differs in some points from that here given, and he mistakes the ciliated sac for the external membrane of an egg containing two embryos. This egg, he tells us, becomes ruptured at its anterior extremity and allows the embryos gradually to escape. The bodies however here described are of a nature totally different from eggs; they are in reality *embryos* complicated by a previous development of gemmæ, and thus containing a double system of digestive and respiratory organs, and destined to undergo an ulterior development in all their parts. The little animals originally described by Müller† as infusorial animalcules, under the name of *Leucophra heteroclyta*, are shown by Meyen to be identical with the locomotive embryos of *Alcyonella fungosa*, a fact which corroborates a previously expressed notion of Raspail as to the identity of *Leucophra heteroclyta* and *Alcyonella fungosa*‡.

I have now described the three distinct modes of reproduction which may be observed in the freshwater Polyzoa. The colony extends itself by the production of gemmæ, which, after development, remain permanently adherent; it establishes new colonies by eggs and free embryos. In *Cristatella* and *Lophopus* I have also observed the multiplication of a colony by a process of self-division. In *Cristatella* this commences by a constriction which takes place generally towards the middle of the colony, and which gradually deepens, till at last it divides the entire mass into two separate portions, which move off in opposite directions. In *Lophopus* the process is very similar; large specimens of this Polyzoon have the endocyst constricted at intervals, so as to give to the colony the appearance of a variously-lobed body enveloped in the gelatinous-looking ectocyst; it is at the point of these constrictions that the self-division takes place, separating the entire colony into two or more smaller ones.

It may perhaps be thought that I ought to have enumerated this multiplication of colonies by a self-division as a fourth form of reproduction; but as in all these cases the division is wholly confined to the cœnœcium, the polypides themselves invariably remaining entire, it is truly referable to the first of the modes just enumerated, being really a reproduction by gemmæ with separation of the gemmæ in masses. It is analogous to the gemmiparous generation in *Hydra*, and is totally distinct from the true fissiparous generation of the lower forms of simple animals.

ZOOGRAPHICAL OUTLINE.

Diagnosis of Genera and Species, and Synonomy.

Genus 1. CRISTATELLA, Cuvier (1798).

Gen. Char.—Cœnœcium sacciform, hyaline, with a common flattened disc adapted for locomotion. Orifices placed on the surface opposite to the disc, and arranged in several concentric marginal series. Lophophore crescentic. Ova lenticular, with an annulus and marginal spines.

Species unica. *Cristatella mucedo*, Cuvier.

Characters the same as those of the genus.

SYNONYMS.

1755. *Der Kleinere Federbusch-Polyp.* Rösel, Insect. Belustig. Supp. p. 559. tab. 91. (Original figure.)

* *Loc. cit.*

† O. F. Müller, Animalcula Infusoria, p. 158.

‡ Raspail, *loc. cit.*

1766. *La seconde sorte de Polypes à Bouquets.* Ledermuller, Amusm. Mic. 2de cinq. p. 94. pl. 87. (The figures are imperfect copies from Rösel.)
1798. *Cristatella mucedo.* Cuvier, Tab. Élém. p. 656.
1816. *Cristatella vagans.* Lamk. An. sans Vert. 1st edit. vol. ii. p. 97.
1817. *Cristatella mucedo.* Cuv. Règne An. 1st edit. vol. iv. p. 68.
1820. *Cristatella vagans.* Schweigger, Handbuch der Naturg. p. 423.
1824. *Cristatella vagans.* Lamouroux, Enc. Méth. Zooph. 1824. p. 226. pl. 472. (Figures copied from Rösel.)
1824. *Cristatella vagans.* Goldfuss, Naturhistorisch. Atlas. (Fig. copied from Rösel.)
1828. *Alcyonella, secundus evolutionis gradus.* Raspail, Hist. Nat. de l'Alcyon. fluv., Mém. de la Soc. d'Hist. Nat. de Paris, vol. iv. p. 129.
1830. *Cristatella mucedo.* Cuvier, Règ. An. 2nd edit. vol. iii. p. 296.
1834. *Cristatella mirabilis.* Dalyel, Rep. Brit. Assoc. an. 1834. p. 604. and Edin. New Phil. Journ. vol. xvii. p. 414.
1834. *Cristatella vagans.* De Blainville, Man. d'Act. p. 489. pl. 85. fig. 7. (Fig. copied from Rösel.)
1834. *Cristatella vagans.* De Blainville, Dict. Sc. Nat. Art. *Cristatelle*, fig. 7. (Fig. copied from Rösel.)
1836. *Cristatella vagans.* Lamarck, An. sans Vert. 2nd edit. vol. ii. p. 110.
1837. *Cristatella mucedo.* Turpin, Ann. Sc. Nat. 2nd series, tom. vii. p. 65. pl. 2, 3. (Original figures.)
1837. *Cristatella mucedo.* Gervais, Ann. Sc. Nat. 2nd series, tom. vii. p. 77. pl. 4. (Original figures.)
1838. *Cristatella mucedo.* Johnston, Brit. Zooph. 1st edit. p. 308. pl. 43. (Figures copied from Turpin.)
1839. *Cristatella mucedo.* Gervais, Ann. Franc. et Étraug. d'Anat. tom. iii. p. 133.
1840. *Cristatelle moisissure.* Gervais, Dict. Sc. Nat. Suppl. Art. *Alcyonelle*, Planches Supplémentaires, Pol. fluviatiles. (Original figures.)
1843. *Cristatella mucedo.* Thompson, Rep. Brit. Assoc. an. 1843. p. 285.
1844. *Cristatella mucedo.* Allman, Ann. of Nat. Hist. vol. xiii. p. 330.
1846. *Cristatella mucedo.* Allman, Rep. Brit. Assoc. an. 1846. Trans. of Sect. p. 88.
1847. *Cristatella mucedo.* Johnston, Brit. Zooph. 2nd edit. p. 387. pl. 73. (Fig. copied from Turpin.)
1848. *Cristatella mucedo.* Van Beneden, Bryoz. Fluv. de Belg. p. 16, Mém. de l'Acad. Roy. de Belgique, 1848.
1849. *Cristatella mirabilis.* Dalyell, Rare and Remarkable Animals of Scotland, vol. ii. (Original figures.)

The original figures are those of Rösel, Turpin, Gervais, Ann. Sc. Nat., Gervais, Dict. Sc. Nat. Suppl., and Dalyell.

Distribution.—Germany, France, Belgium, England, Scotland, Ireland.

Genus 2. LOPHOPUS, Dumortier (1835).

Gen. Char.—Cœnœcium sacciform, hyaline, with a disc which serves for attachment but not for locomotion; orifices scattered. Lophophore crescentic. Ova elliptical, with an annulus, but without marginal spines.

Species unica*. *Lophopus crystallinus*, Pallas.

Spec. Char.—Same as that of the genus.

* I have not been able to find sufficient grounds for viewing the *L. Bakeri*, Van Beneden, as a distinct species.

Synonyms.

1744. *Polype à Panache.* Trembley, Mém. sur les Pol. d'eau douce, p. 210. tab. 10. fig. 8, 9. (Original figures.)
1746. *Polype à Panache.* Bæck, Acta Suecica, 1746. p. 198. tab. 6. fig. 3, 4. (Figures copied from Trembley.)
1753. *Bell-flower Animal.* Baker, Employment for the Microscope, p. 306. pl. 12. fig. 15–22. (Original figures.)
1766. *Tubularia crystallina.* Pallas, Elenchus Zooph. p. 88.
1767. *Tubularia campanulata.* Linnæus, Syst. Nat. Edit. xii.
1789. *Tubularia reptans.* Linn. Syst. Nat. Cura Gmelin, p. 3835.
1789. *Campanulated Tubularia.* Shaw, Nat. Miscel. tab. 354. (Original figure.)
1806. *Tubularia campanulata.* Turton, Linn. Syst. Nat. vol. iv. p. 668.
1816. *Plumatella cristata.* Lamarck, Hist. des An. sans Vert. 1st edit. vol. ii. p. 107.
1820. *Plumatella cristata.* Schweigger, Handbuch der Naturg. p. 424.
1821. *Naisa reptans.* Lamouroux, Exp. Méth. p. 16. tab. 68. figs. 3, 4. (Figures copied from Trembley.)
1824. *Naisa reptans.* Deslongchamps, Encyc. Méth. Zooph. 1824. p. 561.
1826. *Plumatella cristata.* Blainville, Dict. Sci. Nat. tom. xlii. Art. *Plumatella.*
1828. *Alcyonella, tertius evolutionis gradus.* Raspail, Hist. Nat. de l'Alc. Fluv., Mém. de la Soc. d'Hist. Nat. de Paris, vol. iv. p. 129.
1834. *Plumatella cristata.* Blainville, Man. d'Actin. p. 490.
1835. *Lophopus crystallinus.* Dumortier, Bull. de l'Acad. de Brux. 1835. p. 424. pl. 5, 6. (Original figures.)
1836. *Plumatella cristata.* Lamarck, An. sans Vert. 2nd edit. vol. ii. p. 122.
1837. *Plumatella campanulata.* Gervais, Ann. Sc. Nat. 2nd ser. tom. vii. p. 78.
1838. *Alcyonella stagnorum.* Johnston, Brit. Zooph. 1st edit. p. 311. fig. 48. p. 314. (Figure copied from Trembley.)
1839. *Plumatella crystallina.* Gervais, Ann. Franc. et Étrang. d'Anat. tom. iii. p. 134.
1844. *Alcyonella stagnorum.* Allman, Ann. Nat. Hist. vol. xii. p. 330.
1847. *Alcyonella stagnorum.* Johnston, Brit. Zooph. 2nd edit. p. 391. fig. 73. p. 395. (Fig. copied from Trembley.)
1848. *Lophopus cristallinus.* Van Beneden, sur les Bryoz. fluv. de Belg. p. 23, Mém. de l'Acad. Roy. de Belg. 1848.
1848. *Lophopus Bakeri.* Van Beneden, sur les Bryoz. fluv. de Belg. p. 24. pl. 2, Mém. de l'Acad. Roy. de Belg. (Original figure.)
1849. *Lophopus crystallinus.* Allman, Rep. Brit. Assoc. an. 1849. Trans. of Sect. p. 72.

The original figures are those of Trembley, Baker, Shaw, Dumortier, and Van Beneden.

Distribution.—France, Belgium, England, Ireland.

Genus 3. Alcyonella, Lamarck (1816).

Gen. Char.—Cœnœcium composed of membrano-corneous branched tubes, which adhere to one another by their sides; orifices terminal. Lophophore crescentic. Ova elliptical, with an annulus, but without marginal spines.

Number of known species, 3.

1. *Alcyonella fungosa*, Pallas.

Spec. Char.—Cœnœcium fungoid, formed of numerous branched vertical tubes, destitute of a furrow. Ova broad.

SYNONYMS.

1768. *Tubularia fungosa.* Pallas, Descript. Tub. Fung. Nov. Comment. Acad. Sci. Imp. Petropol. tom. xii. p. 565. tab. 14. (Original figures.)
1782. *Spongia lacustris.* Schmiedel, Icones Plantarum et Anal. Partium.
1786. *Leucophra heteroclita.* Müller, Animal. Infusor. p. 158. tab. 22. fig. 27–34. (Locomotive embryo, original figures.)
1789. *Alcyonium fluviatile.* Bruguière, Encyc. Méth. 1789. p. 24. pl. 472. fig. 3. (Original figure, bad.)
1802. *Alcyonium fluviatile.* Bosc. Vers. vol. iii. p. 132.
1816. *Alcyonium fluviatile.* Lamouroux, Pol. flex. p. 354.
1816. *Alcyonella stagnorum.* Lamarck, An. sans Vert. 1st edit. vol. ii. p. 102.
1820. *Alcyonella stagnorum.* Schweigger, Handbuch der Naturg. p. 423.
1821. *Alcyonella stagnorum.* Lamouroux, Exposit. Méth. p. 71. tab. 76. fig. 5–8. (Figures copied from Bruguière.)
1824. *Alcyonella stagnorum.* Lamouroux, Enc. Méth. 1824. Zooph. p. 38.
1828. *Alcyonella fluviatilis* vel *A. ultimus evolutionis gradus.* Raspail, Hist. Nat. de l'Alcyonelle fluv., Mém. de la Soc. d'Hist. Nat. de Paris, tom. iv. p. 130. pl. 12–16. (Original figures.)
1828. *Alcyonella stagnorum.* Meyen, Isis, tom. xxi. p. 1225. pl. 14. (Original figures.)
1831. *Alcyonella stagnorum.* Ehrenberg, Symbolæ Physicæ Evert. Dec. I. Pol. fol. *a.*
1834. *Alcyonella stagnorum.* Blainville, Man. d'Actin. p. 491. pl. 85. fig. 8. (Figure copied from Raspail.)
1835. *Alcyonella stagnorum.* Carus, Tabulæ Illustrantes, pars 3. tom. 1. (Figure, locomotive-embryo, copied from Meyen.)
1836. *Alcyonella stagnorum.* Dumortier, Mém. sur les Pol. comp. d'eau douce, p. 24.
1836. *Alcyonella stagnorum.* Lamarck, An. sans Vert. 2nd edit. vol. ii. p. 116.
1837. *Alcyonella stagnorum.* Teale, Trans. Phil. and Liter. Soc. of Leeds, vol. i. part 1. p. 116. pl. 12. (Original figure.)
1837. *Plumatella campanulata* var. *B. dumetosa.* Gervais, Ann. Sc. Nat. 1837. p. 78.
1838. *Alcyonella stagnorum.* Johnston, Hist. Brit. Zooph. 1st edit. p. 311. pl. 45. (Figures partly original and partly copied from Raspail.)
1839. *Alcyonella fluviatilis.* Gervais, Ann. Franc. et Étrang. d'Act. tom. iii. p. 135.
1839. *Alcyonella.* Van Beneden, Bull. de l'Acad. de Brux. tom. vi. part 2. p. 276. figs. 3, 3′. (Original figures.)
1840. *Alcyonella fluviatilis.* Gervais, Dict. Sci. Nat. Suppl. Art. *Alcyonelle.* (Original figures.)
1847. *Alcyonella stagnorum.* Johnston, Brit. Zooph. 2nd edit. p. 391. pl. 74. (Figures partly original, partly copied from Raspail.)
1848. *Alcyonella stagnorum.* Siebold, Lehrbuch der Vergleich. Anat. § 38, note 1 ; § 40, note 2 ; § 43, note 4.
1848. *Alcyonella fungosa.* Van Beneden, Recherch. sur les Bryoz. fluv. de Belg. p. 18, Mém. de l'Acad. Roy. de Belg. 1848.
1849. *Alcyonella anceps.* Dalyell, Rare and Remark. Anim. of Scotland, vol. ii. (Original figures.)
1849. *Alcyonella gelatinosa.* Dalyell, Rare and Remark. Anim. of Scotland, vol. ii. (Original figures.)
1850. *Alcyonella fungosa.* Allman, Proc. Roy. Irish Acad. vol. iv. p. 470.

The original figures are those of Pallas, Muller (embryo), Bruguière, Schmiedel, Raspail, Meyen, Teale, Johnston, Van Beneden, and Dalyell.

Distribution.—Russia, Prussia, Germany, Denmark, France, Belgium, England, Scotland.

2. Species nova. *Alcyonella Benedeni*, Allman.

Spec. Char.—Cœnœcium fungoid, formed of numerous vertical furrowed tubes. Ova narrow.

Distribution.—England.

3. *Alcyonella flabellum*, Van Beneden.

Spec. Char.—Cœnœcium flabelliform, composed of prostrate furrowed tubes. Ova broad.

Synonyms.

1848. *Alcyonella flabellum.* Van Beneden, Recherches sur les Bryoz. fluv. de Belg. p. 19, Mém. de l'Acad. Roy. de Belg. 1848. (Original figures.)

1850. *Alcyonella flabellum.* Allman, Proc. Royal Irish Acad. vol. iv. p. 470.

Distribution.—Belgium, England.

Genus 4. Plumatella, Lamarck (1816).

Gen. Char.—Cœnœcium confervoid, branched, composed of a series of membrano-corneous tubular cells, each of which is continued into a short ramulus with a terminal orifice. Branches distinct from one another. Lophophore crescentic. Ova elliptical, with an annulus, but without marginal spines.

Number of known species 10, of which 9 are British.

1. *Plumatella repens*, Linnæus.

Spec. Char.—Cœnœcium irregularly branched, cells sub-claviform, destitute of furrow and keel. Tentacula about 60; margin of calyciform membrane distinctly festooned. Ova broad.

Variation α.—Cœnœcium closely adherent, creeping along the surface of various submerged bodies, to which the branches are attached in their entire length.

Variation β.—Cœnœcium attached only towards the origin, branches soon becoming free.

Synonyms.

It is scarcely possible to conceive of a species burdened with a more discordant and perplexing synonomy than that which encumbers the history of *P. repens.* In order to reduce this chaos to some sort of order, the first step is of course the determination of the exact animal which the original founder of the name had in view in his description.

In the tenth edition of the 'Systema Naturæ,' published in 1758, we find Linnæus introducing an animal under the name of *Tubipora repens*, and placing it among his *Lithophyta* with the following diagnosis:—

"T. corallio repente filiformi dichotomo: tubis flexilibus cylindricis distantibus erectis.

"Habitat in aquæ dulcis plantis in Nymphæa, &c. minuta."

The figures here referred to are Trembley's "Polype à Panache," as copied by Bæck in 'Acta Suecica,' Rösel's figures of his "Federbusch-Polyp," and Schäffer's figures of his "Corallenartiger Kamm-Polyp," a reference so discordant as to render it very difficult to determine the animal Linnæus had in view in his *Tubipora repens.* Linnæus's short description, however, plainly excludes the "Polype à Panache;" and that the original of the *Tubipora repens* was really Schäffer's animal seems confirmed by the 'Fauna

Suecica,' published in 1761, where *Tubipora repens* is also given, but with Schäffer's animal quoted as the only synonym.

In the twelfth edition of the 'Systema Naturæ,' published in 1767, *Tubipora repens* is altogether omitted; but in this edition a new species is introduced under the name of *Tubularia campanulata*, with the following short diagnosis:—

"T. reptans tubis campanulatis."

The animal thus defined is without any doubt the "Polype à Panache" of Trembley, though to the real synonyms of the "Polype à Panache" there is added Schäffer, tab. 1. fig. 2. The *Tubularia campanulata* is intended to replace the *Hydra campanulata* of the tenth edition, which however, as there described, is certainly an imaginary species, founded on the fifth and sixth figures of Bæck's plate in the 'Acta Suecica,' which are evidently drawn from some animal very imperfectly observed, though most probably intended for the "Polype à Panache."

In 1773 we find O. F. Müller giving the name of *Tubularia repens* to a polyzoon which he found in the fresh waters in Denmark, and which he viewed as identical with Schäffer's "Kamm-polyp." If Müller be correct in this view—and there is certainly every reason to think he is,—the true synonyms of the *Tubularia repens* of Müller will be *Tubipora repens*, Linnæus, and "Corallenartiger Kamm-polyp," Schäffer.

It is evident that Linnæus had a very imperfect idea of his *Tubipora repens*, but we are now happily no longer left in doubt as to the nature of the animal in question; for though both Schäffer's and Linnæus's descriptions are very meagre, Müller's, on the contrary, is full and perspicuous, though unfortunately not accompanied by an original figure; so that we are compelled to have recourse to the figures of Schäffer, to which Müller refers us, and which, though very imperfect, would seem sufficient for the purposes of identification: one represents a small portion of the cœnœcium of the natural size creeping spirally round the stem of some aquatic plant; the other is a portion magnified, with three polypides in different states of exsertion.

From this time we find writers relying almost exclusively on the description of Müller, and after some notices of minor importance, we find the name given by Müller introduced into the 'Systema Naturæ' by Gmelin, who in his edition of this great work, published in 1789, makes mention of the *Tubularia repens* with Müller's diagnosis.

In 1804 a new element of confusion was introduced into the synonymy of this species by Vaucher, who mentions its occurrence, and adds incidentally, that its ova are *elongated*: this naturalist accompanies his notice with a figure, which, however, in no respect agrees with Müller's description; and I have no hesitation in considering the animal which Vaucher, under the belief that it was the same as that described by Müller, calls *Tubularia repens*, to be quite distinct from this species; it comes nearer to *Plumatella emarginata* of the present Report; and indeed, were it possible from Vaucher's data to form any opinion of value on this subject, I should not be disinclined to view it as identical with the latter, though the description and figures of Vaucher are so very imperfect, as to render it impossible to decide with satisfaction on his species. The *T. lucifuga* of Vaucher, on the other hand, comes much nearer to the true *Tubularia repens*, and is probably identical with it, for the number of tentacula which he ascribes to the species is evidently the result of having observed the polypide in a very partially exserted state, and therefore goes for nothing in the description.

We next find Müller's *Tubularia repens* enumerated by Turton in his edition of the 'Systema Naturæ,' 1806. In 1816 we have Lamarck substituting the generic name of *Plumatella* for that of *Tubularia*, as applied to the freshwater Polyzoa, and describing, under the name of *Plumatella repens*, an animal for which he adduces Schäffer's figure, but which he characterizes from the erroneous description and figures of Vaucher; the *P. repens* of Lamarck, therefore, while it must be viewed as synonymous with Vaucher's *Tubularia repens*, can find no place in the synonymy of the true *Tubularia repens* of Müller. Lamouroux, first in 1816 (Pol. Flex.), and afterwards in 1821 (Exp. Méth.), substitutes the name of *Naisa repens* for *Tubularia repens*, employing Müller's diagnosis, though referring to Vaucher, and in the latter work reproducing his figure. De Blainville, in 1834, enumerates without any diagnosis *Plumatella repens*, quoting as synonyms the *Tubularia repens* both of Gmelin (Syst. Nat.) and Vaucher. Gervais, in Ann. Franc. et Etrang. d'Anat., 1839, enumerates also without description the *Plumatella repens*, quoting among his synonyms not only Schäffer and Müller, but also Vaucher. The *Plumatella repens* of Johnston (Brit. Zooph. edit. 1 and 2, 1838 and 1847) is the true animal of Schäffer and Müller. Lastly, Van Beneden (Recherches sur les Bryozoaires fluviatiles, 1848) describes, under the name of *Plumatella repens*, a Polyzoon which I cannot safely refer to the original *Tubularia repens*; Müller's character, "Tubuli basi angustati apice crassiores," does not at all agree with it, while the elongated ova approach it to Vaucher's *Tubularia repens*, and to the *Plumatella emarginata* of this Report and of my Synopsis, published in the 'Annals and Magazine of Natural History,' 1844, from which however it is separated by the absence of a furrow. The *Plumatella campanulata*, on the contrary, of Van Beneden is doubtless identical with the true *Tubularia repens* of the Danish naturalist, and with the animal here described under the name of *Plumatella repens* var. *α*.

While the "Corallenartiger Kamm-polyp" of Schäffer thus formed the basis of the various synonyms now enumerated, the animal described by Rösel (Insecten Belustigung, 1755) under the name of "Federbusch-polyp," was made the basis of another series of synonyms. This polyzoon was first systematically named by Pallas, who described it in his 'Elenchus,' published in 1766, giving to it the name of *Tubularia gelatinosa*. We afterwards find Blumenbach (Handbuch der Naturg. 1777) describing it under the name of *Tubularia campanulata*, with the following diagnosis, which is evidently formed from the incorrect account given by Rösel:—

"T. crista lunata orificiis vaginæ annulatis corpore intra vaginam abscondito."

Next comes Gmelin (Syst. Nat. 1789), who also describes it, employing both the name and diagnosis of Blumenbach. We have already seen that the *Tubularia campanulata* of the 'Systema Naturæ,' 1767, was a totally different animal, namely the "Polype à Panache" of Trembley. Rösel's animal is next described in Dr. Turton's edition of the 'Systema Naturæ,' 1806, under the name of *Tubularia reptans*, the *Tubularia campanulata* of this edition being the same as that of the edition of 1767. From this time forwards, the specific name *campanulata* continued to be employed by the greater number of naturalists for Rösel's Federbusch-polyp, and we find accordingly this little animal so designated by Lamarck, De Blainville, Dumortier, and Gervais.

The next question of importance is the determination of the exact relation which the two series of synonyms just enumerated hold to one another. In order to form an accurate opinion on this point, it will be necessary to bear in mind the fact, that *P. repens* presents two distinct variations. In the first of these (Var. *α*), which must be viewed as the normal and typical condition, the animal may be seen attaching itself to flat surfaces, as the under side of stones, and of the floating leaves of the water-lily and other aquatic plants. In this condition it is closely adherent throughout its entire length to the surface on which it is developed, and forms elegant dendritic or confervoid growths, radiating from a common centre. In the second (Var. β) it will be found fixed to surfaces of small extent, as thin, submerged stems, straws, &c., and as it continues to increase in size, the branches having no extensive surface of attachment, soon become free, and a more or less entangled bushy mass will be produced. Now, I believe the "Corallenartiger Kamm-polyp" of Schäffer to correspond to the *P. repens* var. α of this Report, while the "Federbusch-polyp" of Rösel corresponds to the variation β, and if so, the two animals must be viewed as identical in species. Müller believed them to be distinct, but he founded this opinion on certain characters in the figures and description of Rösel, some of which were obviously erroneous, while others afforded no grounds for specific distinction at all. The distinction, therefore, drawn by Müller is nugatory, and the specific name *campanulata*, originally applied by Blumenbach to Rösel's animal, and adopted by subsequent writers, is applicable to no distinct species, and must therefore be expunged.

If the above criticism be admitted—and it is what I have arrived at after a very laborious examination—the synonyms of *P. repens* will stand thus:—

Variation α.

1754. *Corallenartiger Kamm-polyp.* Schäffer, Armpolypen, tab. 1. figs. 1, 2. (Original figures.)
1758. *Tubipora repens.* Linnæus, Syst. Nat. Edit. x.
1761. *Tubipora repens.* Linnæus, Fauna Suecica, 2219.
1773. *Tubularia repens.* Müller, Verm. ter. et fluv. vol. i. pars 2. p. 16.
1776. *Tubularia repens.* Müller, Zool. Dan. Prod. 3064.
1781. *Der Polyp mit dem Feder-busch.* Eichhorn, Naturg. der kleinst. Wasserthiere, tab. 4. (Original figure.)
1789. *Tubularia repens.* Gmelin, Linn. Syst. Nat. p. 3835.
1804. *Tubularia lucifuga*?. Vaucher, Bull. de la Soc. Philomat. ann. xii. No. 81. pl. 19. f. 4, 5, 6, 7, 8 *. (Original figures, bad.)
1806. *Tubularia repens.* Turton, Linn. Syst. Nat. vol. iv. p. 668.
1816. *Plumatella lucifuga*?. Lamarck, An. sans Vert. 1st edit. vol. ii. p. 108.
1816. *Naisa repens.* Lamouroux, Pol. flex. p. 223.
1821. *Naisa repens.* Lamouroux, Expos. Méth. p. 16. (Not the figure tab. 68. f. 2, which is a copy of Vaucher's *Tubularia repens.*)
1824. *Naisa lucifuga*?. Deslongchamps, Encyc. Méth. Zoophytes, 1824. p. 562.
1826. *Plumatella lucifuga*?. Blainville, Dict. Sc. Nat. tom. xlii. p. 12.
1826. *Plumatella calcaria*?. Carus, Tabulæ Illustrantes. (Original figure.)
1828. *Alcyonella, tertius evolutionis gradus.* Raspail, Mém. de la Soc. d'Hist. Nat. de Paris, vol. iv. p. 130.
1831. *Alcyonella stagnorum.* Ehrenberg, Symb. Phys. Evert. Dec. 1. Pol. fol. *a*.
1834. *Plumatella repens.* } Blainville, Actinologie, p. 490.
1834. *Plumatella lucifuga.* }
1836. *Plumatella lucifuga*?. Lamarck, An. sans Vert. 2nd edit. vol. ii. p. 124.
1836. *Plumatella repens.* Dumortier, Mém. sur les Pol. comp. d'eau douce, p. 21.

* Figs. 9 and 10 evidently belong to *T. repens* on the same Plate, and are transposed by an error of the engraver, while figs. 4 and 5 belong to *T. lucifuga*, though by a similar error they are placed with *T. repens*..

1838. *Plumatella repens.* Johnston, Brit. Zooph. 1st edit. p. 322. fig. 51. p. 332. (Original figure.)
1839. *Plumatella repens.* Gervais, Ann. Franc. et Étrang. d'Anat. tom. iii. p. 134.
1842. *Plumatella repens.* Allman, Proc. Roy. Irish Acad. ann. 1842. No. 38.
1843. *Plumatella repens, first variation.* Allman, Rep. Brit. Assoc. ann. 1843. Trans. of Sections, p. 74.
1843. *Plumatella repens.* Thompson, Rep. Brit. Assoc. ann. 1843. p. 285.
1844. *Plumatella repens.* Allman, Ann. Nat. Hist. vol. xii. p. 330.
1847. *Plumatella repens.* Johnston, Brit. Zooph. 2nd edit. p. 402. fig. 76. p. 403. (Original figure.)
1848. *Plumatella campanulata.* Van Beneden, Recherches sur les Bryoz. fluv. p. 20. pl. 1. f. 5, 6, 7, Mém. de l'Acad. Roy. de Belg. 1848. (Original figures.)
1849. *Plumatella repens.* Dalyell, Rare and Remark. Anim. of Scotland, vol. ii. (Original figures.)

The original figures are those of Schäffer, Eichhorn, Vaucher, Raspail, Carus, Johnston, Brit. Zooph. 1st edit., Johnston, Brit. Zooph. 2nd edit., Van Beneden and Dalyell.

Variation β.

1755. *Federbusch-polyp.* Rösel, Insect. Belustig. Supp. p. 447. tab. 73, 74, 75. (Original figures.)
1766. *La première sorte de Polypes à Bouquet.* Ledermuller, Amus. Micros. 2[me] cinq. p. 94. tab. 87. (Figures imperfect copies from Rösel.)
1766. *Tubularia gelatinosa.* Pallas, Elenchus Zooph. p. 85.
1777. *Tubularia campanulata.* Blumenbach, Handbuch der Naturgeschichte.
1789. *Tubularia campanulata.* Gmelin, Linn. Syst. Nat. 3834.
1806. *Tubularia reptans.* Turton, Linn. Syst. Nat. vol. iv. p. 669.
1816. *Plumatella campanulata.* Lamarck, Ann. sans Vert. 1st edit. vol. ii. p. 108.
1816. *Naisa campanulata.* Lamouroux, Hist. des Pol. flex. p. 224.
1820. *Plumatella campanulata.* Schweigger, Handbuch der Naturg. § 76.
1824. *Naisa campanulata.* Deslongchamps, Encyc. Méth. 1824. Zooph. p. 562.
1826. *Plumatella campanulata.* Blainville, Dict. Sc. Nat. vol. xlii. p. 12.
1826. *Plumatella campanulata.* Risso, Hist. Nat. de l'Europe Méridion. vol. v. p. 508.
1834. *Plumatella campanulata.* Blainville, Actinologie, p. 490. pl. 85. fig. 6. (Figure copied from Rösel.)
1835. *Lophopus campanulatus?.* Dumortier, Bull. Ac. Brux. 1835. p. 424.
1836. *Plumatella campanulata.* Lamarck, Ann. sans Vert. 2nd edit. vol. ii. p. 123.
1837. *Plumatella campanulata.* Gervais, Ann. Sc. Nat. 2nd series, tom. vii. p. 78.
1839. *Plumatella campanulata.* Gervais, Ann. Franc. et. Étrang. d'Anat. tom. iii. p. 134.
1848. *Plumatella repens, second variation.* Allman, Rep. Brit. Assoc. ann. 1843. Trans. of Sect. p. 74.

The only original figure of this variation is that of Rösel.

Distribution of the Species.—Germany, Prussia, Sweden, Denmark, Russia, France, Belgium, Italy, England, Scotland, Ireland.

2. *Plumatella stricta* *, Allman.

Spec. Char.—Cœnœcium adherent, creeping. Cells cylindrical, narrow, not furrowed or carinated. Ova narrow.

SYNONYM.

1848. *Plumatella repens.* Van Beneden, Recherches sur les Bryoz. Fluv. de Belg. p. 21. pl. 1. fig. 1–4, Mém. de l'Acad. Roy. de Belg. 1848. (Original figure.)

Distribution.—Belgium.

3. *Plumatella punctata,* Hancock.

Spec. Char.—Cœnœcium adherent, creeping, irregularly branched ; branches composed of a series of large conical cells tapering towards the orifice, destitute of a furrow, the upper portion of the cell almost colourless, and freckled with minute opake white spots. Tentacula about 60, calyciform membrane distinctly festooned. Ova broad.

SYNONYM.

1850. *Plumatella punctata.* Hancock, Ann. Nat. Hist. 2nd series, vol. v. p. 200. pl. 5. f. 6, 7, and pl. 3. f. 1.

Distribution.—England.

4. *Plumatella fruticosa,* Allman.

Spec. Char.—Cœnœcium irregularly branched, attached only at its origin; cells cylindrical, destitute of furrow, but obscurely keeled. Ova narrow.

SYNONYMS.

1844. *Plumatella fruticosa.* Allman, Ann. Nat. Hist. vol. xii. p. 330.
1846. *Plumatella fruticosa.* Allman, Proc. Roy. Irish Acad. ann. 1846.
1847. *Plumatella fruticosa.* Johnston, Brit. Zooph. 2nd edit. p. 404.

Distribution.—Ireland.

5. Nova species. *Plumatella coralloides,* Allman.

Spec. Char.—Cœnœcium attached only at its origin, and forming dense erect tufts of dichotomously branched tubes, destitute of furrow and keel. Tentacula about 60. Ova broad.

Distribution.—England.

6. *Plumatella emarginata,* Allman.

Spec. Char.—Cœnœcium adherent, creeping; cells cylindrical, with a very distinct furrow, which gives an emarginated appearance to the orifices, and becomes continuous below with a prominent keel. Tentacula about 40. Ova narrow.

SYNONYMS.

1804. *Tubularia repens?.* Vaucher, Bull. de la Soc. Philom. ann. xii. No. 81. pl. 19. f. 1, 2, 3, 9, 10 †.
1816. *Plumatella repens?.* Lamarck, An. sans Vert. 1st edit. vol. ii. p. 108.
1824. *Naisa repens?.* Deslongchamps, Encyc. Méth. 1824. Zooph. p. 561.
1836. *Plumatella repens?.* Lamarck, An. sans Vert. 2nd edit. vol. ii. p. 123.
1844. *Plumatella emarginata.* Allman, Ann. Nat. Hist. vol. xii. p. 330.
1847. *Plumatella emarginata.* Johnston, Brit. Zooph. 2nd edit. p. 404.

Distribution.—France ?, Ireland.

* This species, the only freshwater Polyzoon not hitherto found in Britain, has been formed for the *P. repens* of Van Beneden, which, as has already been said, does not correspond with the true *Tubularia repens* of Müller.

† See page 332.

7. *Plumatella Allmani*, Hancock.

Spec. Char.—Cœnœcium adherent, creeping; cells claviform, keeled. Tentacula 42. Calyciform membrane distinctly festooned. Ova narrow.

SYNONYMS.

1850. *Plumatella Allmani.* Hancock, Ann. Nat. Hist. 2nd series, vol. v. p. 200. pl. 5. f. 3–5. (Original figures.)

Distribution.—England.

8. Nova species. *Plumatella elegans*, Allman.

Spec. Char.—Cœnœcium adherent, creeping; cells of uniform diameter, furrowed and carinated. Calyciform membrane but slightly festooned. Ova broad.

Distribution.—Ireland.

9. Nova species. *Plumatella Dumortieri*, Allman.

Spec. Char.—Cœnœcium adherent, irregularly branched; cells somewhat dilated towards the orifices, furrowed, carinated. Tentacula about 50, festooning of calyciform membrane deep and distinct. Ova broad.

Distribution.—England.

10. Nova Species. *Plumatella jugalis*, Allman.

Spec. Char.—Cœnœcium adherent, consisting of two series of branches connected by a common tube and extending in opposite directions; cells of uniform diameter, with a furrow which passes below into a keel. Tentacula about 40, calyciform membrane with shallow festoons. Ova not known.

Distribution.—England.

Genus 5. FREDERICELLA, Gervais (1838).

Gen. Char.—Cœnœcium confervoid, composed of a membrano-corneous branched tube, with the branches distinct from one another and terminated by the orifices. Lophophore nearly circular, tentacular crown campanulate. Ova bean-shaped, destitute of annulus and spines.

Species unica*. *Fredericella sultana*, Blumenbach.

Spec. Char.—The same as that of the genus.

SYNONYMS.

1777. *Tubularia sultana.* Blumenbach, Handbuch der Naturgeschichte. (Original figure).
1789. *Tubularia sultana.* Gmelin, Linn. Syst. Nat. p. 3835.
1806. *Tubularia sultana.* Turton, Linn. Syst. Nat. vol. iv. p. 669.
1816. *Naisa sultana.* Lamouroux, Pol. flex. p. 224.
1828. *Plumatella gelatinosa.* Fleming, Brit. Anim.
1830. *Difflugia protæiformis.* Meyen, Isis, 1830, p. 187.
1834. *Difflugia protæiformis.* Meyen, Nov. Act. Acad. Cæs. Leop. vol. xvi. Suppl.
1836. *Plumatella sultana.* Dumortier, Mém. sur les Pol. comp. fluv. p. 22.
1838. *Plumatella sultana.* Johnston, Brit. Zooph. 1st edit. p. 323.
1838. *Fredericella sultana.* Gervais, Bull. Soc. Philomat. 1838.
1839. *Fredericella.* Van Beneden, Bull. Ac. Brux. tom. vi. 2de partie, p. 277. fig. 2. (Original figure.)

* In my 'Synopsis of Freshwater Zoophytes,' published in the Annals of Natural History, 1844, I have described as a distinct species with the specific name *dilatata*, a Fredericella in which the branches become dilated towards the extremities; subsequent investigations, however, have led me to look upon the *F. dilatata* of that publication as a merely accidental variation of *F. sultana*, and I have accordingly suppressed the species in the present Report.

1839. *Fredericella sultana.* Gervais, Ann. Franc. et Étrang. d'Anat. tom. iii. p. 136.
1840. *Fredericella sultana.* Gervais, Dict. Sci. Nat. Suppl. vol. i. Pl. Suppl. Pol. Fluv. (Original figures).
1843. *Fredericella sultana.* Thompson, Rep. Brit. Assoc. ann. 1843. p. 285.
1844. *Fredericella sultana.* } Allman, Ann. Nat. Hist. vol. xiii. p. 331.
1844. *Fredericella dilatata.* }
1844. *Fredericella sultana.* Allman, Proc. R. I. Acad. 1844. No. 44.
1847. *Fredericella sultana.* Johnston, Brit. Zooph. 2nd edit. p. 405.
1848. *Fredericella sultana.* Van Beneden, Recherches sur les Bryoz. fluv. de Belg. p. 25, Mém. de l'Acad. Roy. de Belg. 1848.
1850. *Fredericella sultana.* Hancock, Ann. Nat. Hist. 2nd series, vol. v. p. 173. pl. 2. f. 1. 4 & 6. and pl. 3. f. 1. (Original figures.)

The original figures are those of Blumenbach, Van Beneden, Gervais and Hancock. There is also an original figure apparently referable to this species, though unaccompanied by a name, illustrating a paper by Mr. Varley in the Lond. Phys. Journal, No. 2, 1844.

Distribution.—Germany, France, Belgium, England, Scotland, Ireland.

Genus 6. Paludicella, Gervais (1836).

Gen. Char.—Cœnœcium membrano-corneous, branched, branches composed of a series of claviform cells placed end to end and separated from one another by complete septa; orifices tubular, lateral placed near the wide extremity of each cell. Lophophore orbicular; no oral valve or calyciform membrane. Ova lenticular with a narrow annulus.

Species unica. *Paludicella Ehrenbergi*, Van Beneden.

Spec. Char.—Same as that of the genus.

Synonyms.

1831. *Alcyonella articulata.* Ehrenberg, Symb. Phys. Evert. Dec. 1. Pol. fol. *a.*
1832. *Alcyonella diaphana.* Nordmann, Mikrograph. Beiträge, vol. ii. p. 75.
1836. *Paludicella articulata.* Gervais, Comptes Rend. 1836.
1837. *Paludicella.* Gervais, Ann. Sc. Nat. 2nd series, tom. vii. p. 80.
1839. *Paludicella articulata.* Gervais, Ann. Franc. et Étrang. d'Anat. tom. iii. p. 75.
1839. *Paludicella.* Van Beneden, Bull. Ac. Brux. tom. vi. 2nd part. p. 278. fig. 1. (Original figure.)
1840. *Paludicelle articulée.* Gervais, Dict. Sc. Nat. Suppl. vol. i. pl. 1. Pol. Fluv. fig. 6. (Original figure.)
1842. *Paludicella articulata.* Allman, On the Muscular Syst. of Palud. &c. Roy. Irish Acad. 1842. No. 38. with a plate. (Original figure.)
1843. *Paludicella articulata.* Thompson, Rep. Brit. Assoc. ann. 1843. p. 285.
1844. *Paludicella articulata.* Allman, Ann. Nat. Hist. vol. xiii. p. 331.
1847. *Paludicella articulata.* Johnston, Brit. Zooph. 2nd edit. p. 405. fig. 77. p. 406. (Original figure.)
1848. *Paludicella Ehrenbergi.* Van Beneden, Recherches sur les Bryoz. fluv. de Belg. p. 27, Mém. de l'Acad. Roy. de Belg. 1848.
1850. *Paludicella procumbens.* Hancock, Ann. Nat. Hist. 2nd series, vol. v. p. 201. pl. 5. fig. 1, 2. and pl. 4. (Original figures.)

The original figures are those of Van Beneden, Gervais, Allman, Johnston, and Hancock.

Distribution.—Prussia, France, Belgium, England, Ireland.

Registration of the Periodical Phænomena of Plants and Animals.

The following tables are the first fruits of the labours of the Committee appointed by the Association for the purpose of preparing tables and obtaining results on the periodical phænomena of plants and animals.

The Committee could have wished that a larger number of the tables which they have circulated had been returned, and they hope the publication of the following papers will induce others to forward to them the result of their observations.

On account of the deficiencies under many of the heads, it has been thought advisable to omit some of the columns which are given in the circulated tables. Where, however, any of the omitted columns contained information of importance, it has been added in the form of "remarks," as in pages 348, 349.

For the convenience of reference, the Committee have thought it better to republish the list of plants and animals with the numbers attached. They have allowed observations on other plants and animals to be printed at length in the columns, although the confining the observations to the published list spares much space in the printing. They would call the attention of observers to the importance of making observations on the same plants and animals for the purposes of comparison. Two observations on the same plant or animal in different years are of more value than a large series of single observations in attaining the objects of this registration.

The Committee request that observers wishing for a fresh supply of tables will apply to Professor Phillips, York, and that they will inclose to him any observations they may have made at least a week before the Annual Meeting of the Association, in order that they may be laid before the Section of the Association in which the Committee has originated.

For general directions for observing, the Committee must refer to their Report, published at page 321 of the volume of the Transactions for 1845.

LIST OF PLANTS AND ANIMALS,

WITH THE NUMBERS REFERRED TO IN THE FOLLOWING TABLES.

LIST OF VEGETABLE KINGDOM.

List of Plants to be observed for the periods of Foliation and Defoliation.

1. Acer campestre, *L.*
2. —— pseudo-platanus, *L.*
3. —— saccharinum, *L.*
4. —— tataricum, *L.*
5. Æsculus hippocastanum, *L.*
6. —— lutea, *Pers.*
7. —— pavia, *L.*
8. —— macrostachys, *Mich.*
9. Amygdalus communis, *L.*
10. —— persica, *L.* (*β. Madeleine*).
11. Aristolochia sipho, *L.*
12. Betula alba, *L.*
13. —— alnus, *L.*
14. Berberis vulgaris, *L.*
15. Bignonia catalpa, *L.*
16. —— radicans, *L.*
17. Carpinus americana, *Mich.*
18. —— betulus, *L.*
19. —— orientalis, *L.*
20. —— Celtis cordata, *Desf.*
21. —— orientalis, *L.*
22. Cercis siliquastrum, *L.*
23. Chionanthus virginica, *L.*
24. Corchorus japonicus, *L.*
25. Corylus avellana, *L.*
26. —— colurna, *L.*
27. —— tubulosa, *Willd.*
28. Cratægus coccinea, *L.*
29. —— monogyna, *Jacq.*
30. Cratægus oxyacantha, *L.*
31. Cytisus laburnum, *L.*
32. —— sessilifolius, *L.*
33. Euonymus europæus, *L.*
34. —— latifolius, *Mill.*
35. —— verrucosus, *Scop.*
36. Fagus castanea, *L.*
37. —— sylvatica, *L.*
38. Fraxinus excelsior, *L.*
39. —— juglandifolia, *Lam.*
40. —— ornus, *L.*
41. Ginkgo biloba.
42. Gleditschia inermis, *L.*
43. —— horrida, *Willd.*
44. —— triacanthos, *L.*

45. Gymnocladus canadensis, *Lam.*
46. Halesia tetraptera, *L.*
47. Hippophaë rhamnoïdes, *L.*
48. Hydrangea arborescens, *L.*
49. Juglans regia, *L.*
50. —— nigra, *L.*
51. Lonicera periclymenum, *L.*
52. —— symphoricarpos, *L.*
53. —— tatarica, *L.*
54. —— xylosteum, *L.*
55. Lyriodendron tulipifera, *L.*
56. Magnolia tripetala, *L.*
57. —— yulan, *Desf.*
58. Mespilus germanica, *L.*
59. Morus nigra, *L.*
60. Philadelphus coronarius, *L.*
61. —— latifolius, *Schrad.*
62. Platanus acerifolia, *Willd.*
63. —— occidentalis, *L.*
64. Populus alba, *L.*
65. —— balsamifera, *L.*
66. —— tremula, *L.*
67. Prunus armeniaca, *L.* (β. *abricotier*).
68. —— cerasus, *L.* (β. *bigar.* [*noir*).
69. Prunus domest. (β. *gr. dam. viol.*).
70. —— padus, *L.*
71. Ptelia trifoliata, *L.*
72. Pyrus communis (β. *bergamot*).
73. —— japonica, *L.*
74. —— malus (β. *calvill. d'été*).
75. —— spectabilis, *Ait.*
76. Quercus pedunculata, *Willd.*
77. —— sessiliflora, *Smith.*
78. Rhamnus catharticus, *L.*
79. —— frangula, *L.*
80. Rhus coriaria, *L.*
81. —— cotinus, *L.*
82. —— typhina, *L.*
83. Ribes alpinum, *L.*
84. —— grossularia, *L.*
85. —— nigrum, *L.*
86. —— rubrum, *L.*
87. Robinia pseudo-acacia, *L.*
88. —— viscosa, *Vent.*
89. Rosa centifolia, *L.*
90. —— gallica, *L.*
91. Rubus idæus.
92. —— odoratus, *L.*
93. Salix alba, *L.*
94. Sambucus ebulus, *L.*
95. —— nigra, *L.*
96. —— racemosa.
97. Sorbus aucuparia, *L.*
98. —— domestica, *L.*
99. Spiræa bella, *Sims.*
100. —— hypericifolia, *L.*
101. —— lævigata, *L.*
102. Staphylea pennata, *L.*
103. —— trifolia, *L.*
104. Syringa persica, *L.*
105. —— rothomagensis, *Hòrt.*
106. —— vulgaris, *L.*
107. Tilia americana, *L.*
108. —— parvifolia, *Hoffm.*
109. —— platyphylla, *Vent.*
110. Ulmus campestris, *L.*
111. Vaccinium myrtillus, *L.*
112. Viburnum lantana, *L.*
113. —— opulus, *L. fl. simpl.*
114. —— ——, *L. fl. plen.*
115. Vitex agnus-castus, *L.*
116. —— incisa, *Lam.*
117. Vitis vinifera (β. *chas. dore*).

List of Plants to be observed for the periods of Flowering and Ripening of the Fruit.

201. Acanthis mollis, *L.*
202. Acer campestre, *L.*
203. —— pseudo-platanus, *L.*
204. —— saccharinum, *L.*
205. —— tataricum, *L.*
206. Achillea biserrato, *Bbrst.*
207. —— millefolium, *L.*
208. Aconitum napellus, *L.*
209. Æsculus hippocastanum, *L.*
210. —— lutea, *Pers.*
211. —— macrostachys, *Mich.*
212. —— pavia, *L.*
213. Ajuga reptans, *L.*
214. Alcea rosea, *L.*
215. Allium ursinum, *L.*
216. Alisma plantago, *L.*
217. Althæa officinalis, *L.*
218. Amygdalus communis, *L.*
219. —— persica, *L.* (β. *Madeleine*).
220. Anchusa sempervirens, *L.*
221. Andromeda polifolia, *L.*
222. —— acuminata, *Ait.*
223. —— racemosa, *L.*
224. Anemone nemorosa, *L.*
225. —— hepatica, *L.*
226. —— ranunculoïdes, *L.*
227. Angelica archangelica, *L.*
228. Antirrhinum majus, *L.*
229. Apocynum androsæmifolium, *L.*
230. Arabis caucasica, *Willd.*
231. Arbutus uva-ursi, *L.*
232. Aristolochia clematites, *L.*
233. —— sipho, *L.*
234. Arum maculatum, *L.*
235. Asarum europæum, *L.*
236. Asclepias tuberosa, *L.*
237 —— incarnata, *L.*
238. —— syriaca, *L.*
239. —— vincetoxicum, *L.*
240. Asperula odorata, *L.*
241. —— taurina, *L.*
242. Aster dumosus, *L.*
243. —— novæ angliæ, *L.*
244. —— paniculatus, *Willd.*
245. Astragalus onobrichis, *L.*
246. Astrantia major, *L.*
247. Atropa belladonna, *L.*
248. Avena sativa, *L.*
249. Bellis perennis, *L.*
250. Berberis vulgaris, *L.*
251. Betula alba, *L.*
252. —— alnus, *L.*
253. Bignonia catalpa, *L.*
254. —— radicans, *L.*
255. Bryonia alba, *L.*
256. —— dioica, *Jacq.*
257. Buphthalmum cordifolium, *W.*
258. Buxus sempervirens, *L.*
259. Campanula persicifolia, *L.*
260. Carduus marianus, *L.*
261. Carpinus americana, *Mich.*
262. —— betulus, *L.*
263. —— orientalis, *L.*
264. Cassia marylandica, *L.*
265. Ceanothus americanus, *L.*
266. Celtis cordata, *Desf.*
267. —— orientalis, *L.*
268. Cercis siliquastrum, *L.*
269. Chrysanthemum leucanthemum, *L.*
270. Chelidonium majus, *L.*
271. Chenopodium bonus Henricus, *L.*
272. Chionanthus virginica, *L.*
273. Chrysocoma linosyris, *L.*
274. Clethra alnifolia, *L.*
275. Colchicum autumnale, *L.*
276. Colutea arborescens, *L.*
277. Convallaria bifolia, *L.*
278. —— majalis, *L.*
279. Convolvulus arvensis, *L.*
280. —— sepium, *L.*
281. Corchorus japonicus, *L.*
282. Coreopsis tinctoria, *Nutt.*
283. —— tripteris, *L.*
284. Cornus mascula, *L.*
285. —— sanguinea, *L.*
286. Coronilla emerus, *L.*
287. Corydalis digitata, *Pers.*
288. Corylus avellana, *L.*
289. —— colurna, *L.*
290. —— tubulosa, *Willd.*
291. Cratægus coccinea, *L.*
292. —— oxyacantha, *L.*
293. —— monogyna, *Jacq.*
294. Crocus mæsiacus, *Curt.*
295. —— sativus, *Sm.*
296. —— vernus, *Sw.*
297. Cyclamen europæum, *L.*
298. —— hederæfolium, *Ait.*
299. Cynara scolymus, *L.*
300. Cytisus laburnum, *L.*

301. Cytisus sessilifolius, *L.*
302. Daphne laureola, *L.*
303. —— mezereum, *L.*
304. Dianthus caryop., *L.* (v. *grenad.*).
305. Dictamnus albus, *L.*
306. —— ——, *fl. purpureo.*
307. Digitalis purpurea, *L.*
308. Echinops sphærocephalus, L.
309. Epilobium spicatum, *Lam.*
310. Erica tetralix, *L.*
311. —— vulgaris, *L.*
312. Erythrina crista-galli, *L.*
313. Escholtzia californica, *Chmss.*
314. Euonymus europæus, *L.*
315. —— latifolius, *Mill.*
316. —— verrucosus, *Scop.*
317. Fagus castanea, *L.*
318. —— sylvatica, *L.*
319. Fragaria vesca, *L.* (β. *hortensis*).
320. Fraxinus excelsior, *L.*
321. —— juglandifolia, *Lam.*
322. —— ornus, *L.*
323. Fritillaria imperialis, *L.*
324. Galanthus nivalis, *L.*
325. Gentiana asclepiadea, *L.*
326. —— cruciata, *L.*
327. Geranium pratense, *L.*
328. Gladiolus communis, *L.*
329. Glechoma hederaceum, *L.*
330. Gleditschia horrida, *Willd.*
331. —— inermis, *L.*
332. —— triacanthos, *L.*
333. Gymnocladus canadensis, *Lam.*
334. Hallesia tetraptera, *L.*
335. Hedera helix, *L.*
336. Hedysarum onobrychis, *L.*
337. Helenium autumnale, *L.*
338. Helleborus fœtidus, *L.*
339. —— hiemalis, *L.*
340. —— niger, *L.*
341. —— viridis, *L.*
342. Helianthus tuberosus, *L.*
343. Hemerocallis cærulea, *Andrs.*
344. —— flava, *L.*
345. —— fulva, *L.*
346. Hieracium aurantiacum, *L.*
347. Hippophaë rhamnoïdes, *L.*
348. Hordeum hexastichum, *L.*
349. —— vulgare, *L.*
350. Hibiscus syriacus, *L.*
351. Hydrangea arborescens, *L.*
352. —— hortensis, *Sm.*
353. Hydrocharis morsus-ranæ, *L.*
354. Hypericum perforatum, *L.*
355. Iberis sempervirens, *L.*
356. Iris florentina, *L.*
357. —— germanica, *L.*
358. Juglans nigra, *L.*
359. —— regia, L.
360. Kalmia latifolia, *L.*
361. Koelreuteria paniculata, *L.*
362. Lamium album, *L.*
363. Leucojum æstivum, *L.*
364. —— vernum, *L.*
365. Ligustrum vulgare, *L.*
366. Lilium candidum, *L.*
367. —— flavum, *L.*
368. Linum perenne, *L.*
369. Liriodendron tulipifera, *L.*
370. Lonicera periclymenum, *L.*
371. —— symphoricarpos, *L.*
372. —— tatarica, *L.*
373. —— xylosteum, *L.*
374. Lupinus polyphyllus, *Dougl.*
375. Lychnis chalcedonica, *L.*
376. Lysimachia nemorum, *L.*
377. Lythrum salicaria, *L.*
378. Magnolia tripetala, *L.*
379. —— yulan, *L.*
380. Malope trifida, *L.*
381. Malva sylvestris, *L.*
382. Melissa officinalis, *L.*
383. Mellitis melissophyllum, *L.*
384. Menispermum canadense, *L.*
385. Mentha piperita, *L.*
386. Mespilus germanica, *L.*
387. Mitella grandiflora, *Pursch.*
388. Morus nigra, *L.*
389. Narcissus pseudo-narcissus, *L.*
390. Nepeta cataria, *L.*
391. Nymphæa alba, *L.*
392. —— lutea, *L.*
393. Orchis latifolia, *L.*
394. Orobus vernus, *L.*
395. Oxalis acetocella, *L.*
396. —— stricta, *L.*
397. Papaver bracteatum, *L.*
398. —— orientale, *L.*
399. Paris quadrifolia, *L.*
400. Philadelphus coronarius, *L.*
401. —— latifolius, *Schrad.*
402. Phlox divaricata, *L.*
403. —— setacea, *L.*
404. Physalis alkekengi, *L.*
405. Plantago major, *L.*
406. Platanus acerifolia, *Willd.*
407. —— occidentalis, *L.*
408. Polemonium cæruleum, *L.*
409. Polygonum bistorta, *L.*
410. Populus alba, *L.*
411. —— balsamifera, *L.*
412. —— tremula, *L.*
413. Primula elatior, *L.*
414. Prunus armeniaca, *L.* (β. *abricotin*).
415. —— cerasus (β. *bigarr. noir*).
416. —— domest. (β. *gr. dam. viol.*).
417. —— padus, *L.*
418. Ptelia trifoliata, *L.*
419. Pulmonaria officinalis, *L.*
420. —— virginica, *L.*
421. Pyrus communis (*bergamotte*).
422. —— cydonia, *L.*
423. —— japonica, *L.*
424. ——malus(*calvilled'hiver*).
425. —— spectabilis, *Ait.*
426. Quercus pedunculata, *Willd.*
427. —— sessiliflora, *Smith.*
428. Ranunculus acris, *L.* (*fl. plen.*).
429. —— ficaria, *L.*
430. —— lingua, *L.*
431. Rhamnus catharticus, *L.*
432. —— frangula, *L.*
433. Rheum undulatum, *L.*
434. Rhododendron ferrugineum, *L.*
435. —— ponticum, *L.*
436. Rhus coriaria, *L.*
437. —— cotinus, *L.*
438. —— typhina, *L.*
439. Ribes alpinum, *L.*
440. —— grossularia, *L.* (*fr. virid.*).
441. —— —— (*f. rubenl.*).
442. —— nigrum, *L.*
443. —— rubrum, *L.*
444. —— ——*fruct. alb.*
445. Robinia pseudo-acacia, *L.*
446. —— viscosa, *Vent.*
447. Rosa centifolia, *L.*
448. —— gallica, *L.*
449. Rosmarinus officinalis, *L.*
450. Rubia tinctorum, *L.*
451. Rubus idæus, *L.*
452. —— odoratus, *L.*
453. Ruta graveolens, *L.*
454. Salix alba, *L.*
455. Sagittaria sagittifolia, *L.*
456. Salvia officinalis, *L.*
457. Sambucus ebulus, *L.*
458. —— nigra, *L.*
459. —— racemosa.
460. Sanguinaria canadensis, *L.*
461. Satureja montana, *L.*
462. Saxifraga crassifolia, *L.*
463. Scabiosa arvensis, *L.*
464. —— succisa, *L.*
465. Scrophularia nodosa, *L.*
466. Secale cereale, *L.*
467. Sedum acre, *L.*
468. —— album, *L.*
469. —— telephium, *L.*
470. Solanum dulcamara, *L.*
471. Sorbus aucuparia, *L.*
472. —— domestica, *L.*
473. —— hybrida, *L.*
474. Spartium scoparium, *L.*
475. Spiræa bella, *Sims.*
476. —— filipendula, *L.*
477. —— hypericifolia, *L.*
478. —— lævigata, *L.*
479. Staphylea pinnata, *L.*
480. —— trifolia, *L.*
481. Statice armeria, *L.*
482. —— limonium, *L.*

483. Symphytum officinale, *L.*
484. Syringa persica, *L.*
485. —— rothomagensis, *Hort.*
486. —— vulgaris, *L.*
487. Taxus baccata, *L.*
488. Thymus serpyllum, *L.*
489. —— vulgaris, *L.*
490. Tiarella cordifolia, *L.*
491. Tilia americana, *L.*
492. —— microphylla, *Vent.*
493. —— platyphylla, *Vent.*
494. Tradescantia virginica, *L.*
495. Trifolium pratense, *L.*
496. —— sativum, *L.*
497. Triticum sativum, *L. a. æstivum.*
498. —— ——, *β. hybern.*
499. Tussilago fragrans, *L.*
500. —— petasites, *L.*
501. Ulmus campestris, *L.*
502. Vaccinium myrtillus, *L.*
503. Veratrum album, *L.*
504. Verbena officinalis, *L.*
505. Veronica gentinoïdes, *L.*
506. Veronica spicata, *L.*
507. Viburnum lantana, *L.*
508. —— opulus, *fl. simpl.*
509. —— ——, *fl. plen.*
510. Vinca minor, *L.*
511. Viola odorata, *L.*
512. Vitex agnus-castus, *L.*
513. —— incisa, *Lam.*
514. Vitis vinifera, *L.* (*β. chasselas doré.*)
515. Waldsteinia geoïdes, *Kit.*

List of Plants to be observed at the Vernal and Autumnal Equinoxes and Summer Solstice, for the hours of opening and closing their Flowers.

601. Anagallis arvensis, *L.*
602. Arenaria purpurea, *Pers.*
603. Calendula officinalis.
604. —— arvensis, *L.*
605. Campanula speculum, *L.*
606. Cichorium endivia, *L.*
607. Convolvulus tricolor, *L.*
608. Crepis rubra, *L.*
609. Datura stramonium, *L.*
610. —— ceratocaula, *Jacq.*
611. Dianthus prolifer, *L.*
612. Hemerocallis fulva, *L.*
613. Lactuca sativa, *L.*
614. Leontodon taraxacum, *L.*
615. Malva sylvestris, *L.*
616. Mesembryanthemum crystallinum, *L.*
617. —— coccineum, *Haw.*
618. —— pomeridianum, *L.*
619. Mirabilis longiflora, *L.*
620. —— jalapa, *L.*
621. Nymphæa alba, *L.*
622. Œnothera biennis, *L.*
623. Ornithogalum bellatum, *L.*
624. Picridium tingitanum, *Desf.*
625. Portulaca oleracea sativa, *L.*
626. Sonchus oleraceus, *L.*
627. Trapa natans, *L.*
628. Tigridia pavonia, *L.*
629. Tradescantia virginica, *L.*
630. Tragopogon pratensis, *L.*
631. —— porrifolius, *L.*

LISTS FOR THE ANIMAL KINGDOM.

MAMMALS.

701. Meles taxus (*Badger*), appearance and retreat.
702. Mustela erminea (*Stoat*), periods of moult.
703. Myoxus avellanarius (*Doormouse*), commencement and termination of winter sleep.
704. Vespertilio pipistrellus (*Bat*), first appearance and disappearance.

BIRDS.

Regular Summer migrants, of which the first appearance is to be observed.

705. Anthus arboreus (*Tree Pipit*).
706. Caprimulgus europæus (*Goat-sucker*).
707. Columba turtur (*Turtle-dove*).
708. Coturnix dactylisonans (*Quail*).
709. Crex pratensis (*Land-rail*).
710. Cuculus canorus (*Cuckoo*).
711. Cypselus apus (*Swift*).
712. Hirundo riparia (*Bank Martin*).
713. —— rustica (*Swallow*).
714. —— urbica (*House Martin*).
715. Lanius collurio (*Red-backed Shrike*).
716. Motacilla yarrellii (*Pied Wagtail*).
717. Muscicapa grisola (*Spotted Flycatcher*).
718. Perdix coturnix (*Quail*).
719. Saxicola œnanthe (*Wheatear*).
720. Saxicola rubeta (*Whinchat*).
721. Sylvia atricapilla (*Blackcap Warbler*).
722. —— cinerea (*Whitethroat*),
723. —— curruca (*Lesser Whitethroat*).
724. —— hortensis (*Garden Warbler*).
725. —— locustella (*Grasshopper Warbler*).
726. —— luscinia (*Nightingale*).
727. —— arundinacea (*Reed Warbler*).
728. —— phragmitis (*Sedge Warbler*).
729. —— phœnicurus (*Redstart*).
730. —— rufa (*Chif-chaf*).
731. —— sylvicola (*Wood Wren*).
732. —— trochilus (*Willow Warbler*).
733. Turdus torquatus (*Ring Ouzel*).
734. Yunx torquilla (*Wryneck*).

Rare, or only occasional, Summer migrants.

735. Emberiza hortulana (*Ortolan Bunting*).
736. Lanius rufus (*Woodchat Shrike*).
737. Motacilla flava, *Temm.* (*Gray-headed Wagtail*).
738. Muscicapa luctuosa, *Temm.* (*Pied Flycatcher*).
739. Oriolus galbula (*Golden Oriole*).
740. Sylvia tethys (*Black Redstart*).
741. Upupa epops (*Hoopoe*).

Regular Winter migrants.

742. Anser segetum (*Bean Goose*).
743. Corvus cornix (*Hooded Crow*).
744. Cygnus ferus (*Hooper* or *Wild Swan*).
745. Fringilla montifringilla (*Mountain Finch*).
746. Fringilla spinus (*Siskin*).
747. Scolopax rusticola (*Woodcock*).
748. Turdus pilaris (*Fieldfare*).
749. —— iliacus (*Redwing*).

Occasional Winter migrants.

750. Bombycilla garrula (*Bohemian Waxwing*).
751. Coccothraustes vulgaris (*Grosbeak*).
752. Loxia curvirostra (*Crossbill*).

Of accidental occurrence.

753. Procellaria leachii (*Fork-tailed Petrel*).
754. Procellaria pelagica (*Stormy Petrel*).

Species to be observed for the periods of departure.

755. Cypselus apus (*Swift*).
756. Hirundo riparia (*Bank Martin*).
757. Hirundo rustica (*Swallow*).
758. —— urbica (*House Martin*).

Species to be observed for the periods of collecting into flocks and pairing off in the Spring.

759. Fringilla cannabina (*Common Linnet*).
760. Sturnus vulgaris (*Starling*).

Species to be observed for the periods of commencing song or note.

761. Columba palumbus (*Ring-dove*).
762. Emberiza citrinella (*Yellow-hammer*).
763. Fringilla cannabina (*Linnet*).
764. —— chloris (*Greenfinch*).
765. —— cœlebs (*Chaffinch*).
766. Parus major (*Great Titmouse*).
767. Turdus merula (*Blackbird*).
768. —— musicus (*Thrush*).
769. —— viscivorus (*Missel-thrush*).

Species to be observed for the periods of building.

770. Corvus frugilegus (*Rook*).
771. Corvus pica (*Magpie*).
772. Fringilla domestica (*House Sparrow*).

REPTILES.

773. Natrix torquata (*Common Snake*).
774. Zootoca vivipara (*Common Lizard*). } First appearance.

775. Bufo vulgaris (*Common Toad*).
776. Rana temporaria (*Common Frog*).
777. Triton palustris (*Warty Eft*). } Ditto; also period of spawning.

FISH.

778. Acipenser sturio (*Sturgeon*).
779. Cupea alosa (*Allis*).
780. —— finta (*Shad*).
781. Salmo salar (*Common Salmon*).
782. —— trutta (*Salmon Trout*). } Period of ascendiug rivers.

783. Clupea harengus (*Common Herring*).
784. Scomber vulgaris (*Common Mackerel*). } First arrival on the coast.

MOLLUSKS.

785. Helix aspersa } First appearance.
786. —— nemoralis }

INSECTS.

First appearance of the following species.

(Coleoptera.)

787. Geotrupes stercorarius.
788. Lytta vesicatoria.
789. Meloë proscarabæus.
790. Melolontha vulgaris.
791. —— solstitialis.
792. Pœcilus cupreus.
793. Telephorus rusticus.
794. Timarcha tenebricosa.

(Orthoptera.)

795. Acrida viridissima.
796. Locusta.

(Neuroptera.)

797. Æschna maculatissima.
798. Calepteryx virgo.
799. Ephemera vulgata.
800. Libellula depressa.
801. Panorpa communis.
802. Sialis lutarius.

(Hymenoptera.)

803. Anthrophora retusa.
804. Apis mellifica.
805. Bombus.
806. Formica.
807. Vespa vulgaris.

(Lepidoptera.)

808. Catocala nupta.
809. Gonepteryx rhamni.
810. Hipparchia janira.
811. Plusia gamma.
812. Polyommatus alexis.
813. Pontia brassicæ.
814. —— cardamines.
815. Pontia napi.
816. —— rapæ.
817. Vanessa io.
818. —— polychloros.
819. —— urticæ.

(Diptera.)

820. Bibio hortulanus.
821. —— marci.
822. Bombylius medius.
823. Culex pipiens.
824. Eristalis tenax.
825. Hæmatopota pluvialis.
826. Mesembrina meridiana.
827. Rhyphus fenestralis.
828. Stomoxys calcitrans.
829. Tipula oleracea.
830. Trichocera hiemalis.
831. Xylota pipiens.

Table for the Registration of Periodic Phænomena, kept by James Hardy.

Pennanshiel, Cockburnspath, Berwickshire. In about Lat. 55° 53′ 44″ N., Long. 2° 17′ W. Valley of Pease Burn, on the West. Woods on the western slope. House and the highest lands about 500 feet. Bounded on the West by woods, on the North and South by cultivated lands of nearly equal height, and on the East by Coldingham Moor (Heath and Bogs). Lands exposed and unsheltered. Rock Greywacke. Soil light, in several places moory; adapted for turnips and oats.

1849.	Foliation.	Flowering.	Arrival or first appearance.	Departure or disappearance	Pairing.	Deposition of eggs or birth of young.
Feb. 1.		324 newly.				
„ 5.	51 expanding.					
„ 12.		288, a few ♂ catkins.				
March 3.	51 in many instances	288, several.				
„ 4.		225 and 296, Peasedean... 252 in vicinity.	787, and a moth, and 804.			
„ 5.		Bryum capillare and Tortula subulata.				
„ 6.		Salix caprea, Phascum subulatum, and 429, one of.				
„ 7.		249, one of.				
„ 8.			One of 716, Emberiza miliaria.			
„ 11.		296.				
„ 12.	84 wild, in wood		Three of 716, Boreus hyemalis, and 827.			
„ 13.			704, Peasedean.			
„ 14.		Eriophorum vaginatum.				
„ 15.			Dolerus palmatus appeared.			
„ 16.		429, several, and 389	805, one of; 819, several; Eristalis similis at willows.			
„ 17.		Draba verna, Tussilago farfara.	Lacerta agilis.			
„ 18.		413, in garden (not wild)	Anguis fragilis.			
„ 19.		Larch and Potentilla Fragariastrum.	Andrena Clerkella appeared...			Missel thrush has nest completed.
„ 20.			Trombidium holosericeum.			
„ 21.		Chrysosplenium oppositifolium.				
„ 22.	95 not fully, and 84 shoots.	Leontodon Taraxacum.				
„ 23.		Jungermannia epiphylla				

„ 26.	30 in low places		Mniophila muscorum.			
„ 31.			Cynips sp. (776 abroad, a ♂.)			
April 2.	Many larches	224 beginning	Geotrupes sylvaticus.			
„ 4.	30 by upper wood-sides			747 still here		Lapwing has eggs.
„ 10.	70 beginning to open buds in sheltered glens.		A few tadpoles, very minute.	747 still here	Long-tailed tit, in pairs.	
„ 13.				742 last seen	Long-tailed tit has nest; and gold crest pairing.	
„ 14.	91	440, 224, several.				
„ 15.	89.					
„ 16.	Larches of considerable greenness.					
„ 23.					765.	
„ 26.	2 and 110 in Peasedean	Viola canina	719 and S. rubecola on sea-coast, not inland.			768 has eggs in Peasedean.
„ 27.			732 and not earlier.			
„ 28.	Pyrus aucuparia		713 and common sandpiper, 799.			Missel thrush has one egg.
„ 29.			712, and S. rubecola in low heaths.			
May 1.	2, one in wood	Prunus spinosus: sooner in Peasedean.	Polydrusus cervinus.			
„ 2.	111, 12 young trees only, and Salix caprea.	395, and 111 (beginning).	719, inland.			
„ 3.		Caltha palustris	Polydrusus chrysomelinus, Aphis Betulæ and 816.			
„ 4.			714, appeared inland, 710		759 still in large flock.	Wood-pigeon has eggs. Lapwing (young).
„ 5.		502, p. general	Charadrius morinellus (a pair)			
„ 6.		Orobus tuberosus	721.			
„ 7.			Sciaphilus muricatus.			
„ 8.	Salix vitellina		Adrastus limbatus.			
„ 9.		320, 319 (wild), Anthoxanthum odoratum, Ranunculus auricomus.				
„ 10.	47 (sea-coast)	415, Broom and Stitchwort, Peasedean.	722.			
„ 11.			Aphrophora spumaria (very minute).			
„ 12.			Vespa rufa. More of the Dottrel.		764 still in flocks; 765 pairing; and 732.	

1849.	Foliation.	Flowering.	Arrival or first appearance.	Departure or disappearance.	Pairing.	Deposition of eggs or birth of young.
May 13	2 and 12, pretty general	Luzula campestris, Stellaria holostea, Geranium molle.				
„ 14.						Numenius torquata and Vanellus cristatus (young); Alauda arvensis (eggs).
„ 15.	203				732 pairing.	
„ 16.		Saxifraga granulata, sea-coast; Veronica serpyllifolia.	711 near Cockburnspath		764 and 759 still in flock.	
„ 17.		251, Polygala vulgaris, 213, and Juniperus communis.				
„ 18.	25, and 37 nearly	428, fl. albo pleno	705, 815 hatched, became chrysalis on Nov. 10, 1848.		764, but still in flocks.	
„ 19.		Geum rivale, Viola palustris, Luzula maxima.	821, Aphis of Centaurea Jacobæa, 826.		Charadrius pluvialis still in flocks.	Tetrao scoticus, 8 eggs, *sat on.*
„ 22.			Anthomyia canicularis.			
„ 23.		415 at Penmanshiel, Ornithogalum umbellatum.				
„ 24.	77, beginning	Ranunculus repens			764 not yet paired.	
„ 25.						Mole has young.
„ 26.			Phytomyza, Empis ignota, and 829, 706.		759 probably.	
„ 27.	77, many half out	Geranium sylvaticum, Arenaria trinervis, Sherardia arvensis, Galium cruciatum.	728, 801			Emberiza miliaria, young flown.
„ 28.		Lotus corniculatus, Hyacinthus non-scriptus, Tormentilla officinalis, 215.	Ctenicerus cupreus.			
„ 29.			Athöus hæmorrhoidalis, Haltica helxines, Ragonycha pallida, and Phædon aucta.			
June 1.	13, but probably earlier, 77.	Plantago lanceolata, Pedicularis sylvatica.	Hipparchia Pamphilus			Missel thrush with fledged young.
„ 2.		Aquilegia vulgaris, Rumex acetosella.	Telephorus pellucidus, Empis livida, Tipula maculosa, 802.			
„ 3.		292, 300, 376.				

„ 4.	....	Arenaria rubra, Pyrus aucuparia, 486, 508.				
„ 8.	....	Vicia sativa.				
„ 12.	38 now complete........	393 et O. maculata, Trientalis Europæa, 240, Rubus saxatilis and Helianthemum vulgare.	Syrphus lucorum.			
„ 17.	....	307, Vicia sepium and Rhinanthus Crista-Galli.				
„ 21.	....	Anthemis arvensis.				
„ 27.	....	310	825.			
July 2	....	467 before this.				
„ 3.	....	370, 488 before this	812.			
„ 4.	....	447, 405	810.			
„ 8.	....	....	....	....	....	Partridge has young.
„ 9.	....	489.				
„ 10.	....	458, 207.				
„ 11.	....	Erica cinerea before this...	813.			
„ 12.	....	497 at sea-coast; Galium verum, Spiræa ulmaria.				
„ 13.	....	Galeopsis tetrahit	Stomoxys irritans.			
„ 14.	....	398 and Euphrasia officinalis.				
„ 15.	....	Narthecium ossifragum.				
„ 16.	....	349 (see April 21st).				
„ 17.	....	Valeriana officinalis.				
„ 18.	....	Campanula rotundifolia.				
„ 20.	....	248, sown March 21st.				
„ 22.	....	....	....	711 still here.		
„ 24.	....	Agrostemma Githago.				
„ 30.	....	Centaurea cyanus, and 497, sown April 21st.				
Aug. 1.	....	Arctium Lappa, Sonchus arvensis.	Aphis avenæ.			
„ 9.	....	311, and Drosera rotundifolia.	Myrmica rubra, winged ♂, migrating.			
„ 10.	....	464.				
„ 18.	....	....	Bibio Pomonæ.			
„ 23.	....	....	Aphis Rumicis, migrating.			

1849.	Foliation.	Fructification.	Arrival or first appearance.	Departure or disappearance.	Pairing.	Deposition of eggs or birth of young.
Sept. 6.	....	Oats cut, sown March 15.				
„ 7.	....	Barley ripe, sown April 21.				
„ 9.	....	....	....	757 and 758, assembling on a hill top and sporting together.		
„ 13.	....	All the oats sown in March [cut.	....	757 seen still.		
„ 14.	....	Barley cutting............	....	757 had left in gale of yesterday.		
„ 16.	....	....	....	732 still here.		
„ 17.	....	....	....	757 has returned again.		
„ 18.	....	....	....	757 not here today.		
„ 25.	....	....	....	716 left about.		
„ 28.	....	Spring wheat cut, sown April 21.				
Oct. 4.	....	....	742.			
„ 16.	....	....	743 first seen.			
„ 22.	....	....	Emberiza nivalis, one near sea-banks.			

REMARKS.

February 1st. Pair of Lapwings returned to the moors. 2nd. 767 sung about this date, and Blephariptera serrata appeared on windows. 4th. 765 once heard; 766 in song: Wren also singing. 5th. Curtoneura fungivora and Aricia erratica on sheltered walls: abundance of Molobri. 6th. Aphodius prodromus and A. inquinatus, Coccinella 18-guttata, Deliphrum tectum and Omalium rivulare abroad; also Nedyus contractus and Apion marchicum, Helephorus grandis and Chlorops circumdata. 9th. Scatophaga squalida abroad. 10th. Psylla of the spruce fir abroad. 11th. 765, many in song. 12th. 765 and one of 762 in song: Partridge calling at evening. 13th. 762, one in song. 14th. Partridges in pairs. 16th. 762 in song. 17th. Flocks of 761 on turnip fields. 18th. Appearance of a dull aurora. 19th. Aurora borealis in the evening: towards 10 o'clock a portion advanced across the sky, till past the zenith, when it divided, the extreme points turned toward the south; and it gradually disappeared, after a succession of beams that moved athwart the partial arch it had formed, from east to west, contrary to the course of the wind. In this manner it gradually drifted away. A shower came on ¼ of an hour after. 20th. Aurora about 10 o'clock. 23rd. Hemerobius fasciatus, Fab.? out. 28th. Emberiza schœniculus singing: 745 still with us.

March 1st. 764 singing, without the shrill terminal note. Simulium auricomum, Blephariptera vilis, and Heteromyza atricornis appeared. 3rd. Small moth (Oporinia tortricella) in woods: Lapwing calling in evening. 4th. Accentor modularis, singing. 5th. Thrushes numerous. 6th. Plovers calling in moors. 12th. Primula vulgaris, first in flower: many of 804 at the Sallows: 761 in song. 13th. Oats sown. 14th. 764 in song, with harsh note in ending: 747 still here. 15th. Fructification—Weissia controversa, about: Oats sown. 16th. Bullfinch in song: 742 appeared: one of Aphodius fimetarius: Scatopse notata, several. 18th. Fructification—var. of Primula veris. Aurora after 10 o'clock. March 19th; and it gradually disappeared, after a succession of beams, that moved from east to west, contrary to the course of the wind, athwart the partial arch it had formed. 21st. Many mosses withering: Oats sown. 30th. 742 still here. 31st. Have not seen 748 for several weeks past; it is chiefly near the terms of its migration that it visits us.

April 20th. Vegetation much injured by late severe weather and frosts. 21st. Wheat sown (bearded) and Barley. 26th. Sula bassana cast ashore: Motacilla boarula at Pease Bridge. 29th. It is to be remarked, that probably owing to the severe weather in the middle of the month, the Wheatear has not yet appeared inland; nor has the Stonechat, a migrating bird in most instances. Nearer the sea vegetation is more forward than in this vicinity. Helix nemoralis and H. arbustorum were both out on the seacoast on 26th; the former is rarely found inland. Tringa variabilis in flocks on the rocks at sea-coast, April 26th. Not seen on May 10th.

May 2nd. Arion ater out. Uria Troile driven ashore at seacoast in summer plumage, May 10th. 714 builds on the sea banks; it was not there on 26th ult. 10th. Orchis mascula on sea banks: Eolis papillosa near shore. 12th. No Vespæ seen earlier. 19th. Cerastium viscosum, Alchemilla vulgaris, Veronica chamædrys, Myosotis arvensis, Salix repens, and Eleocharis cæspitosa. 26th. 706 first heard. 27th. Cerastium vulgatum and Alopecurus pratensis in flower. 29th. Bibio Johannis, very numerous.

June 1st. Young Grasshoppers (Locusta biguttula?) out; and red Dragon-fly (Agrion minium).

July 9th. Barley earing, sown April 21st. 14th. Oats beginning to shoot, sown March 13th. 22nd. 497 shooting, sown April 21st: 502 ripened. 26th. 804 swarming the second time.

August 8th. Barley Chlorops in imago state (Ch. tæniopus). 23rd. Curlews frequent the sea-shore. 28th. Chaffinches in flocks.

September 17th. 716 flying about the house and chattering. 17th. Aurora at ½ past 10, arch-shaped. 27th. No corn carried yet.

October 1st. Corn carrying. 3. Snow on Cheviots. 10th. Very faint aurora. 16th. Dilophus febrilis, second brood, and Bibio clavipes. 20th. Yellow Hammer in song, and 761. 23rd. E. miliaria still here: 827 on sea banks.—October 5th. A specimen of Locusta migratoria, sent from Reston, six miles distant. It was alive. The tips of its wing-cases were somewhat rubbed, indicating age. Found in a potato-field eight days previously.

November 9th. 748 observed.

December 10th. 750 seen, a pair. 13th. Plover still in moors. 15th. Aphides, Fungicolous Gnats, Simulia, Sciaræ, Chironomi, Anthomyiæ, and Halticæ on firs and pines. On Dec. 7th two Chironomi taken, and Sciara nitidicollis on walls. On Dec. 11th, Chironomus picipes, a species of Mycetophila, Thyamis lurida, Apion Rumicis, A. flavipes, Corticaria pubescens, and Psychoda nervosa out: in windows Phytomyza Syngenesiæ, Blephariptera serrata, and Pollenia atramentaria, Mg. Dec. 31st. Boreus hyemalis appeared. Tingis Cardui and Apion flavipes still alive on leaves of the Foxglove.

Meteorological Conditions.—Four years' observations (1835–1838) made by the Rev. J. Wallace, at Abbey St. Bathans, 468 feet above the level of the sea, and 4 miles from this place, afford the following results:—Mean height of thermometer, 43·9°; mean height of barometer at 32° F., 29·286; mean point of deposition of dew, 39·8; mean relative humidity, 880; quantity of rain in inches, 34·6; temperature of spring water, 45·875°.

Table for the Registration of Periodic Phænomena, kept by MATTHEW MOGGRIDGE.

The observations below (except where other localities are stated) range over the Parishes of Swansea, Llansamlet, Llangefelach, Oystermouth, and Llanhiridian. Altitude 0 to 300 feet. Geol. formation—Coal-measures. Soil chiefly woodcock loam and stone brash; some lime. All botanical observations refer to the same site (if on trees, the same tree) as last year, except where the contrary is apparent. Where observations are repeated on the same No. the plant is the same, except as before.

1849.	Foliation.	Flowering.	Fructification.	Defoliation.	Arrival or first appearance.	Departure or disappearance.	Pairing.	Deposition of eggs or birth of young.
Oct. 1.			292, 458	37	760.			
„ 2.				110	748, 749.			
„ 3.				77, 36.				
„ 4.				108	759.			
„ 5.			508.					
„ 6.				77.				
„ 8.				5.				
„ 10.			320.					
„ 11.				95.				
„ 12				110.				
„ 13.			209		747.			
„ 16.					743.			
„ 19.				95.				
„ 21.				12, 13.				
„ 22.				110.				
„ 23.				77.				
„ 24.				72		741.		
„ 28.				66.				
„ 31.				15.				
Nov. 1.				95.				
„ 2.				110.				
„ 3				5.				
„ 4.			252.					
„ 6.				13.				
„ 7.				30.				
„ 8.				44.				
„ 9.				25.				
„ 10.				2, 38.				

„ 11.				110.				
„ 12.				15.				
„ 13.				96.				
„ 14.				37.				
„ 15.				88.				
„ 16.				59.				
„ 21.				87		758.		
„ 24.				96.				
Dec. 9.				96.				
„ 10.				15.				
„ 17.	51.							
„ 21.				15.				
„ 30.				94.				
1850.								
Jan. 13.				94.				
„ 26.					768.			
Feb. 10.	73	288, 423					770.	
Mar. 2.		252.						
„ 10.	95, 96.							
„ 11.		303.						
„ 14.		429						770.
„ 19.	65, 24	467.						
„ 21.		395.						
„ 22.		224.						
„ 28.						747.		
„ 29.	84, 85.							
„ 30.	86, 2.							
„ 31.	31, 30, 5.							
April 1.		249.						
„ 4.								770.
„ 5.	95, 96.							
„ 8.	24	281.						
„ 10.		215			758			770.

1850.	Foliation.	Flowering.	Fructification.	Defoliation.	Arrival or first appearance.	Departure or disappearance.	Pairing.	Deposition of eggs or birth of young.
Apr. 12.	70, 34, 12, 25, 13.							
,, 13.		329.						
,, 14.		325						770.
,, 15.					757.			
,, 16.	65.							
,, 17.	84	440.						
,, 18.	94, 95, 96	459			723			771, nidification.
,, 20.					795.			
,, 22		421.						
,, 23.		376.						
,, 24.					710.			
,, 25.	37	487.						
,, 26.	2	203.						
,, 27.	63.							
,, 28.	41	278.						
,, 29.	106	486.						
,, 30.					785.			
May 1.		320.						
,, 2.	48	389			786, 790.			
,, 3.		215			807.			
,, 4.	66	486.						
,, 5.	33.							
,, 6.		234			773.			
,, 7.	76, 77.							
,, 8.		370.						
,, 9.	110.							
,, 10.		269.						
,, 11.	1	413.						
,, 12.	108	209.						
,, 13.		292.						
,, 14.		486, 484.						
,, 15.	1	202.						
,, 16.		300.						
,, 17.					706.			

„ 18.	33.							
„ 20.		363.						
„ 21.		471.						
„ 22.	104	484			787.			
„ 23.	31.	300.						
„ 24.		374.						
„ 25.	110	291.						
„ 26.	30.							
„ 27.		495.						
„ 28.					755.			
„ 29.	30.	435.						
„ 30.	66.							
„ 31.	292	307.						
June 1.	15, 25	291.						
„ 2.		292			710 changed his note.			
„ 3.	6, 8	210.						
„ 4.	41.	405.						
„ 5.	59, 63	435			Glow-worm.			
„ 6.	95.	458.						
„ 7.	33.	314.						
„ 8.		508.						
„ 9.		370.						
„ 10.	211	365						365.
„ 11.		458.						
„ 12.		208.						
„ 13.	59.							
„ 14.		310.						
„ 15.		314.						
„ 16.		388.						
„ 17.		494.						
„ 18.		313.						
„ 19.		458.						
„ 20.	41.							
„ 21.	36.	328.						
„ 22.		391.						
„ 23.		455.						
„ 24.		489.						
„ 25.	87.	445.						

1850.	Foliation.	Flowering.	Fructification.	Defoliation.	Arrival or first appearance.	Departure or disappearance.	Pairing.	Deposition of eggs or birth of young.
June 26.	88.							
,, 27.	8				720.			
,, 28.		310.						
,, 29.	15	458.						
,, 30.		208.						
July 1.		354.						
,, 2.	36.							
,, 3.		228.						
,, 4.		278.						
,, 5.		445.						
,, 6.		498.						
,, 7.		207.						
,, 8.	36	317			719			317.
,, 9.		280.						
,, 10.		498.						
,, 11.		207.						
,, 12.		377	502.					
,, 13.		457.						
,, 14.		430.						
,, 15.		216.						
,, 16.		280.						
,, 17.		497.						
,, 18.		327.						
,, 19.		482.						
,, 20.		15.						
,, 21.		457.						
,, 22.			234.					
,, 23.		50.						
,, 24.	15.							
,, 25.	44	457.						

REMARKS.

October 1st, 1849. 37 exposed, $\frac{1}{2}$ fallen: 760 large flocks. 2nd. A few of 748 seen previously: 110, leaves $\frac{1}{3}$ gone. 3rd. Many leaves falling, the colour little changed. 4th, 759 flocking. 6th. Leaves $\frac{1}{3}$ fallen 8th. Many leaves fallen. 11th. Leaves $\frac{1}{2}$ fallen, while 96 is quite green. 12th. Leaves nearly gone. 13th. 747; several seen the last few days. 19th. Nearly bare; 96 green. 21st. Some of 12 bare, others green; 13, $\frac{2}{3}$rds l. gone. 22nd. Some trees bare. 24th. 741 on the sea-side, and where one was shot 7th of April, 1840. 31st. Leaves still green.

November 1st. Complete; 96 green. 2nd. Complete. 3rd. Complete. 7th. Nearly complete. 10th. A few leaves of each still on. 11th. Young trees green. 12th. Green, but $\frac{1}{3}$ leaves fallen. 13th. Green, but $\frac{1}{2}$ leaves fallen. 14th. On young plants l. little changed. 21st. One of 758 seen. 24th. $\frac{4}{5}$ths l. fallen without losing colour.

December 9th. Green to the last. 10th. Green to the last; some leaves left. 17th. Same plants as noted in spring; leaves in all stages from bud to $\frac{1}{3}$ grown. 30th. Leaves brown, but not fallen.

January 26th, 1850. 768 singing.

February 10th. Nidification: 423, leaves opening. 770, old nest on a detached tree in a warm garden; same as first noted in 1849.

March 10th. Leaves opening; 95 forwardest. 11th. Llanhiridiau parish. 14th. Nidification general. 19th. 65 leaves, $\frac{1}{4}$ full size. 28th. Latest in Swansea market. 29th, 30th. Leaves about $\frac{1}{3}$. 31st. Leaf-buds bursting.

April 1st. 249 abundantly; some almost always in flower. 4th. A new nest commenced on the tree noted already. 5th. Leaves $\frac{1}{4}$; same as 10th March. 8th. 24; leaves $\frac{1}{4}$, bl. some full out. 10th. Nest, noted 4 inst. finished. 12th. 70, leaves $\frac{1}{3}$; 34, leaves opening; as are 12, 13 and 25. 14th. Young rooks crying. 15th. Two feeding, same place as 758. 16th. $\frac{1}{3}$ at 190 feet. 17th. Leaves $\frac{1}{2}$ at 215 feet. 18th. 94, 95, 96, leaves $\frac{1}{4}$. 24th. Llanedi, Carmarthenshire, 180. 25th. Leaves bursting. 26th. Leaves $\frac{1}{2}$. 27th. Buds bursting. 28th. Leaves of 41 just showing. 29th. Leaves $\frac{1}{4}$; 486 just out; white.

May 1st, 2nd. Bison, Gower; limestone 30 ft. 3rd. Bison, Gower; limestone 20 ft. 4th. 66, leaves bursting: 486 just out; purple. 5th. Oystermouth, 30 ft., leaves $\frac{1}{2}$. 6th. Oystermouth, 80 ft. 7th. 76 bursting; 77, $\frac{1}{3}$th. 8th. On a S. wall, Swansea parish, 55 ft. 9th. Leaves $\frac{1}{3}$. 10th. Pennard. 11th. Leaves bursting; Bison. 12th. Leaves $\frac{3}{4}$; Bison. 13th. Just out. 14th. 484 just out; 486, purple, fully out. 15th. Leaves $\frac{1}{2}$. 16th. Just out; Swansea parish. 17th. Bison, 20 ft. 18th. Some leaves full-sized. 21st. Mumbles, 5 ft. 22nd. 104, leaves $\frac{3}{4}$. 23rd. 31, leaves $\frac{2}{3}$. 27th. Just out. 28th. Sea-shore, Bison. 29th. 435, Swansea, 40 ft. 31st. 307 just out, Bison, 70 ft.

June 1st. Leaves, 15 opening. 2nd. Bison, limestone. 3rd. 6, leaves $\frac{4}{5}$ths; 8, leaves $\frac{5}{8}$ths. 4th. 41, leaves (one) $2\frac{2}{10}$ inches across. 5th. 59, leaves $\frac{1}{5}$th; 63, leaves $\frac{2}{3}$rds. 6th. Oystermouth, limestone, 20 ft. 7th. 33, leaves $\frac{4}{5}$ths; Oystermouth, limestone, 25 ft. 8th. Bison, 20 ft.: outer florets. 9th. Just out, Oystermouth, coal-measures. 10th. Just out, Oystermouth, lime. 11th. Just out; this is the plant taken to compare with 459. 12th. Swansea, 70 ft. 13th. Leaves $\frac{2}{3}$. 14th. Oystermouth, lime, 50 ft. 19th. Leaves $\frac{1}{2}$ out. 21st. 36, leaves $\frac{4}{5}$ths. 24th. Bison, lime, 30 ft. 25th. Just out. 28th. Full out. 29th. Just out. 30th. Wild; near Miskin, 110 ft.

July 1st. Monmouthshire.—Christchurch, Devonian, 20 ft. 2nd. Fully out, Caerleon, Devonian, 20 feet. 3rd, 4th. Caerleon, Devonian, 20 ft. 5th. Moneythusloyne coal-measures, 320 ft. 6th. Moneythusloyne coal-measures, 300 ft. 7th. Christchurch, 15 ft. 8th. Just out, Swansea. 9th, 10th. Oystermouth, 15 ft. 11th. Swansea coal-measures, 10 ft. 12th. 502, Swansea garden, 40 ft. 13th. Full height of foliage; flower buds showing. 14th. Full out; some fruit $\frac{1}{2}$ ripe. 15th. Cadoxton, 19 ft. 16th. Llansamlet, var. incarnata, 25 ft. 17th. Nicholaston, lime, 55 feet. 18th. Penrice, lime, 60 ft. 19th. Oxwich, lime, 1 ft. 22nd. Bison, 6 ft. 23rd. Oystermouth, lime, 10 ft. 24th. $\frac{3}{4}$ths. 25th. 457 just out.

In my former lists the observations have (sometimes even in one day) ranged over different parishes, counties and geological æras: with the present form this would have been difficult to express: I have therefore confined myself to the district described in the first sheet, except where the contrary appears in "Miscellaneous Remarks," and especially to continued observations on the same plant.—Matthew Moggridge, The Willows, Glamorgan.

Table for the Registration of Periodic Phænomena, kept by Edward H. M. Sladen.

Ninfield, near Battle, Sussex. Soil generally sandy (with considerable mixture of iron) and favourable to the growth of timber. Oak grows commonly; but there is none of large size. Clay appears here and there, and there is some good brick earth. The village stands high, looking over Pevensey Marsh towards Beachy Head and the Southdowns on one side, and towards the high ground of Battle, and as far as Fairlight Mill to the East of Hastings, on the other. It is also within open view of the sea, from which it is distant in a direct line between two and three miles, and the spray occasionally marks the windows.

N.B. The Goitre occurs in an adjoining village, and is attributed by the medical men to the iron in the soil and water.

The Hydrangea hortensis lives in the garden all the year, partly dying down in the winter. Also the common Myrtle lives in the open ground all the year without protection, having stood so for ten years past.

1849.	Foliation.	Flowering.	Fructification.	Defoliation.	Arrival or first appearance.	Departure or disappearance.	Pairing.	Deposition of eggs or birth of young.
Feb. 1.	51				806.			
,, 3.		288.						
,, 13.							767 (song).	
,, 18.							768 (song).	
,, 21.	84, 86.							
,, 23.		429.						
,, 24.							760.	
,, 27.		389			787.			
March 6.	85	224.						
,, 8.		414.						
,, 12.	95.							
,, 15.	30	511.						
,, 16.	104.							
,, 19.	24, 65.							
,, 26.	106	219.						
,, 27.		329.						
,, 30.	60.							
,, 31.		440, 443			817.			
April 13.					721, 730, 734.			
,, 24.					726.			
,, 25.					713, 732.			
,, 29.	5				710.			
,, 30.					715.			

May 1.	76.				707.			
„ 2.	109.							
„ 3.					722, 812.			
„ 5.					714.			
„ 6.	38.							
„ 11.	49.							
„ 12.	37, 18	292, 486.						
„ 17.	82.	313			711.			
„ 21.					790, 774.			
„ 29.					793.			
June 1.					794.			
„ 5.		370.						
„ 8.					801.			
„ 26.		498.						
„ 28.					791.			
July 5.		354.						

REMARKS.

February 1st. 51 began its foliation in January: Passiflora cærulea in flower on a south wall of the house during December 1848 and January 1849.
March 20th. Prunus spinosa flowering.
April 30th. 751 shot in two neighbouring villages. A specimen sent to me.
May 3rd. 789 burrowing (female). 21st. First Dragon-fly with thick blue body. Species unknown to me.
June 1st. Chrysis ignita seen. 2nd. Glow-worms (Lampyris noctiluca) shining at night.

On the 20th of August (being still at Walmer) I observed the Hirundines congregated on the roofs of the houses on the beach, in the same way as they assemble usually in the autumn, and on mentioning the circumstance to a friend, resident in a neighbouring village inland, I was told the same phænomenon had been observed there. My friend stated at the same time that it was believed by some persons that the Swallows leave the spots where Cholera is prevalent. There were two or three cases about this time, but only one fatal, that I heard of. I observed Swallows and Martins till I left the neighbourhood, in the middle of September.

On the 26th of August found Sirex juvencus at Walmer. I caught two or three specimens just as they were in the act of emerging from holes in the gate-post next the beach, in the Castle-meadow.—Edward H. M. Sladen.

SUGGESTIONS TO ASTRONOMERS

FOR THE

OBSERVATION

OF THE

TOTAL ECLIPSE OF THE SUN

ON JULY 28, 1851.

DRAWN UP BY A

COMMITTEE OF THE BRITISH ASSOCIATION.

Not Published.

General Committee of the British Association for the Advancement of Science.

Edinburgh, August 7, 1850.

Resolved,—

That a Committee, consisting of Sir John Herschel, the Astronomer Royal, Professor Forbes, and Professor Powell, with power to add to their number, be empowered to communicate with the astronomers of Pulkowa on the observations to be made at the next approaching Total Eclipse of the Sun, July 28, 1851; and to draw up Suggestions for the guidance of observers generally.

[The following Suggestions have been drawn up by the Committee above-named, with the assistance of M. Otto Struve of Pulkowa.]

SUGGESTIONS TO ASTRONOMERS

FOR THE

OBSERVATION

OF THE

TOTAL ECLIPSE OF THE SUN,

ON JULY 28, 1851.

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1. The principal observations for which a total eclipse of the sun presents peculiarly favourable opportunities may be classed under the following heads:—

> Observations applying specially to the physical structure of the sun and moon, as those of the corona, and of the rose-coloured prominences (seen so markedly in the eclipse of 1842).
>
> Photometric, thermometric, and actino-chemical observations, illustrating the difference in the nature and amount of radiation from different parts of the sun's disc.
>
> Optical observations, particularly on the state of polarization of the light in different phases of the eclipse, and on the phænomena of irradiation, and of distortion of a dark limb by the formation of beads or threads.

The phænomena of the first class have never been seen except in a total eclipse of the sun; and they appear so deserving of attention (especially the red prominences, which, if belonging to the sun, indicate physical peculiarities of structure on a most stupendous scale, and perhaps of corresponding importance), that it seems highly desirable that the arrangements for observation should be planned with especial reference to them. For the observation of the phænomena of the other classes, the opportunities (though absolutely rare) are much more frequent; they will, however, be most effectually secured by the same arrangements which secure those of the first class.

2. It is *à priori* probable, that the phænomena (especially those depending on prominences from the body of the sun) will not be the same when viewed from stations on different sides of the central line of the shadow's path; and such differences appear, in fact, to have been observed in the eclipse of 1842. This consideration at once suggests the propriety of placing some observers at no great distance from the southern boundary of the total obscuration, and others at no great distance from the northern boundary. Near the centre of the shadow's path, the picturesque effect of the eclipse is the greatest, the phænomena are most symmetrical, and the longer duration permits observers to watch the phænomena with greater coolness; and here also it seems desirable that competent persons should be planted.

It appears not improbable that some of the phænomena may change with a change of absolute time; and for this reason, as well as for eliminating the chances of weather, and for obtaining variations of appearance due to differences of climate and of hours of the day, it is desirable that observations be made at different points along the line of the shadow's path.

3. In examining upon a map the course of the shadow in this eclipse, it will be seen that Stavanger, Christiansand, Copenhagen, Lund, Ystad, Cöslin, Thorn, Lowiez, Zamosc, Tarnopol, Kaminiez, Odessa, Eupatoria, Gumri, Erivan, are south of the southern boundary, but probably not so far as to prevent their being used as convenient head-quarters from which an excursion for observation may be made: that Bergen, Grimstadt, Arendal, Helsingborg, Cimbrishamn, Bornholm, Kulm, Plock, Warsaw, Lublin, Vladimir, Brody, Nikolaiew, Kherson, Perekop, Feodosia, Redut-Kale, Achalzich, Schuscha, are within the southern boundary: that Friederichsvärn, Göteborg, Carlskrona, Kalmar, Danzig, Ostrolenka, Lomja, Bialystock, Brest-Litowsk, Jitomir, Machnowka, Lipowcz, Uman, Babrinez, Jenikale, Tiflis, Schemacha, are nearly on the central line: that Christiania, Friederichstadt, Königsberg, Gumbinnen, Augustowo, Grodno, Slonin, Pinsk, Radomist, Kiev, Jelisawetgrad, Berdiansk, Stavropol, Gheorgiewsk, Wladikawkas, are within the northern boundary: and that Carlstad, Memel, Tilsit, Krementschug, Ekaterinoslav, Mariupol, Mosdok, Derbent, are at a small distance beyond the northern boundary.

4. Now it appears extremely desirable that, if possible, observers should arrange themselves in confederations, each confederation consisting of three directing-astronomers, who should by concert station themselves at three places respectively near the northern boundary, near the centre, and near the southern boundary; these places being not very widely separated in the longitudinal direction of the

shadow's movement. Thus Arendal, Friederichsvärn, Christiania; Kulm, Danzig, Königsberg; Warsaw, Ostrolenka or Lomja, Augustowo; Brody, Brest-Litowsk, Grodno; Nikolaiew, Babrinez, Jelisawetgrad; &c., would be favourable combinations. Two or three such confederations should be formed at different parts of the shadow's path.

5. It is desirable that, at each station, there should be three or four observers. One should be furnished with a telescope magnifying about twenty times, with a pretty large aperture; and this will probably be found the most important. A second should have a telescope magnifying 100 times. Each of these telescopes should have in its field, but not crossing the centre, two wires of an interval of 1′, or some other convenient distance, for giving an approximate measure of any small object which may be observed. It is desirable that by the position of these wires, or in some other way, the observer should be able rapidly to refer the positions of objects seen in the telescope to vertical and horizontal directions. A third person should have a watch or chronometer (if the error of the chronometer is known, the astronomical value of the observations will be increased, but their physical value will be equally great without it) and writing materials, and should be prepared at any signal first to note the time, and secondly, to write down the phænomenon. A fourth should observe the general appearances, as seen with the naked eye. If the party were more numerous, a good sextant, or other double-image instrument, might be found useful in the hands of one person.

6. It is important that the dark glasses used for observing the sun up to the moment of total obscuration be so mounted that they can be slipped off in an instant. And it is desirable that each telescope should be furnished with several dark glasses, some showing the sun with a red disc, some with a white or greenish disc. These may be mounted, in a form which admits of rapid change, in a sliding or a turning frame; or their cells may be fitted loosely with bayonet-notch. If the observer is satisfied with the use of one colour or combination for the dark glasses, no arrangement is more convenient than that of wedges of the coloured glass, achromatized (as to dispersion) by wedges of colourless glass; the intensity is then changed gradually by merely sliding the combination of glasses. It may also be desirable to possess the power of altering the aperture of the telescope rapidly: this perhaps may be done by attaching by hinges to the object-glass cell one or more flat rings, which can be turned off or on the object-glass by pulling a string at the eye end.

7. It is desirable also that the observers should be provided with some instrument for the measure of radiant heat, as a thermomultiplier (of a coarse kind) with galvanometer, an actinometer, or a simple thermometer with rough black bulb (whose indications will be more accurate if the bulb be inclosed in a glass sphere from

which the air is exhausted). In the selection of the instrument, it must be borne in mind that in Western Europe the sun will be high, and that the season of the year is (generally speaking) favourable to energetic radiation; and also that it is desirable that the observation with the selected instrument occupy as short time as possible. For meteorological observations, a dry thermometer and a thermometer with wet bulb (or other hygrometer) will probably suffice.

8. It would be most desirable also to be furnished with some apparatus for measure of the intensity of light, but we are unable at present to particularize any which can be considered unobjectionable. The appearance of a lighted candle will give some very rude information. The flame of a candle may also be used for giving a good idea of the intensity of light, by viewing the object, whose brightness is to be ascertained, through the flame (thus, in ordinary sunlight, the light of the sky near the sun is seen through the flame without apparent diminution; but the light of a full moon cannot be seen through it at all). For the observation of shadows, a graduated scale, several feet long, with a disc of white paper to be slid upon it, with its plane perpendicular to the scale, may be useful.

9. Some instrument should also be provided for ascertaining the state of polarization of the light. In the limited duration of a total eclipse, time is wanting for the use of instruments giving an accurate measure of the degree of polarization; for the rough estimation of the position of the plane of polarization, and of its general magnitude, perhaps a Nicol's prism, furnished with plates of quartz cut in Savart's manner, or a Savart's polariscope, may be found convenient and sufficiently accurate. For the observation of the sun's disc before the total darkness, a dark glass of some kind should be used with the Nicol's prism. A common glass prism should be provided for examination of the chromatic composition of the light.

10. At any fixed observatory within the path of the shadow, which is furnished with a telescope mounted equatorially, and moved by very good clock-work (adapted in its rate to the diurnal movement of the sun), it is extremely desirable that arrangements should be made for Daguerreotyping or Talbotyping the image of the sun, or of the light surrounding the moon when the sun is hidden. It is necessary to observe that materials of very different degrees of sensibility will be required in different stages of the eclipse; the light of the uneclipsed sun being intensely bright, and that of the corona surrounding the moon, or even that of the red flames projecting into the corona, being exceedingly feeble.

If the plate or paper be so sensitive to photogenic action that an image can be formed in a fraction of a second of time, no equatoreal movement will be required. If an image can be formed in one or two seconds, a rude equatoreal motion, such as may be given to a temporary stand, will probably suffice. If this motion is given by hand, it must be done by turning a winch in accordance with the beats of a chronometer or the vibrations of a pendulum.

11. The observers at each station should be prepared with accurate computations of the local times of beginning and ending of the general eclipse, and of beginning and ending of total darkness, with particular attention to the accuracy of computation of the duration of total darkness. It will be remarked that the computation of duration admits of great exactness for places near the central line of shadow, but that it is liable to considerable errors for places near the north or south boundary. They should also have accurate computations of the position, with respect to the vertical, of the points of the sun's limb at which the general eclipse begins and ends, and of the points of the moon's limb at which the sun disappears and reappears: the latter will be liable to sensible error.

Every observer should be furnished with one or more cards, upon each of which a circle is described: upon one of these the points of beginning and ending of the general eclipse and of the totality are to be marked; the others are to be used for hasty records of the places of any remarkable phænomena during the eclipse.

12. The observations to be made, and the mode of proceeding, should be arranged some days before the eclipse, and should be fully described in written instructions, with which each observer should be so perfectly acquainted as to have little need to refer to them at the time. Two cautions, however, must be borne in mind. The phænomena about the time of total obscuration are so striking that the most perfect discipline will then probably fail, and it will be almost useless to prescribe any observations which will prevent the observers from looking about them for a few moments to see the wonderful spectacle. And the whole time is so short, that it will be very desirable that each observer's attention be confined to very few phænomena. No party, probably, will be able to make all the observations mentioned below; it will be desirable, therefore, carefully to select those which can be made with the greatest probability of success, and to give the utmost attention to those only.

13. A quarter of an hour before the first contact of the sun and moon, the observations of radiation with the actinometer, &c. should be begun. [These should be continued through all stages of the eclipse.] The commencement of an eclipse is a very indistinct phænomenon, and perhaps for the principal part of the time before the total obscuration little can be done except to make, from time to time, observations of radiation and meteorological observations. But when the limb of the moon crosses that of the sun at right angles, and afterwards, the observers will be well able to estimate (as far as can be done by the eye) the difference in the intensity of light on different parts of the sun's disc. From this time also it will be proper to examine whether the entire circumference of the

moon, or any portion of it external to its intersection with the sun's limb, can be seen. It may be necessary for this purpose to use a telescope with a small number of lenses, all the surfaces of which are well polished and perfectly clean.

14. When the lune becomes narrow, occupying about a quadrant of the sun's circumference, the state of polarization of the sun's light in different parts of that quadrant may be examined. In these and subsequent observations of the same kind, it must be borne in mind that the diffused light reflected from *air* will probably give traces of polarization, and it may be well in all cases to remark whether the brightest parts of the light under inspection are as evidently polarized as the faintest. Attempts should now be commenced for discerning whether a comparison can be instituted between the darkness of the shadows of a small object (as a pencil, or a small rod) formed by the sun and by the lighted candle; and whether the distance of the paper disc, when their shadows are equally black, can be ascertained. [If this is found practicable, this observation should be continued to and through the total obscuration.] The light should be analysed, in regard to its chromatic composition, by the use of a prism, and special record made as to whether any of the colours are unusually vivid or deficient. The general state of the sky and atmosphere should be carefully observed and fully recorded.

15. As the totality approaches, the sextant observer may measure the interval between the cusps; and the telescope observers should examine carefully the state of the moon's limb as to roughness, particularly in the central part (which will be the last to touch the sun's limb), and should carefully remark whether the moon's limb can be seen beyond the sun's limb. These observations should be made with rapid changes of the dark glasses. At the very time of completion of the obscuration, Baily's beads should be looked for, and if possible with change of the dark glasses, and with change of the aperture of the object-glass, and perhaps by putting the telescope, for a moment, out of focus. (See Appendix No. I.) It will probably be best, for the relief of the eye, that the observers should now and then quit the telescope for an instant. The time of total obscuration is to be communicated to the chronometer-bearer by a single syllable. It is to be remarked that, even though the error of the chronometer be not known, the accurate observation of the duration of the totality will give valuable information as to the diameters of the sun and moon, and as to the moon's latitude.

16. The naked-eye observer, in the mean time, is to look at the sun with a dark glass, occasionally changing the glass, occasionally trying the polarization, occasionally relieving his eye. He may also specially remark whether the colour of objects appears to change, and whether the light in different parts of the sky is differently coloured. But when the totality is near, he is

simply to observe, with the weakest of the dark glasses or (if possible) with the eye uncovered, and to note the way in which the light is distributed, as to intensity, in different directions round the sun; whether there are beams of light, and in what direction; whether there are the rudiments of a ring round the moon; whether there is any light on the side opposite the bright lune. It is recommended that he do not quit this observation for any other; but if a trustworthy person of good general observation were near, it would be desirable that he should remark whether there appears to be any fluctuation or trembling of the light which falls upon the ground and upon walls, and whether the shadow appears, as to sense, to sweep over the earth.

17. The important use of the photographic apparatus will commence shortly before the total obscuration. It will be desirable to take photographic images of the cusps, but it will be particularly desirable that they should be varied by causing the pencil of light to pass through a prism, so as to produce prismatic dispersion in the direction transverse to the cusp, and thus to exhibit on the plate or paper an actino-chemical analysis of the light which has passed at the highest degree of obliquity through the sun's atmosphere. When the sun is totally hidden, simple images should be taken, at several repetitions, if possible, during the obscuration.

18. On the instant of total obscuration the corona will be formed. It is important that the observer with the low-power telescope and the observer with the naked eye should be prepared to remark whether any part of the corona is visible before the sun is completely obscured, and in what order the complete ring is formed, whether all at once or by progress from one or more points. Also, whether the ring is equally broad in different parts, and what is the proportion of its breadth to the moon's breadth; whether it is double, or divided as a succession of annuli; whether it is divided by radial lines; whether its texture appears fibrous, and what is the position of the fibres; whether it is sensibly coloured; and, if possible, whether its light is polarized. The light should be examined by the dispersive prism, and the excess or deficiency of any particular colour recorded.

19. As soon as possible, and also as late as is prudent during the obscuration, an attempt should be made to judge whether the corona is concentric with the moon, or with the sun.

20. The moment that the sun's bright edge is eclipsed, the observer with the most powerful telescope should watch for the appearance of red prominences in the direction of the moon's advance. From this time to the end of the totality each of the observers should repeatedly examine the whole circumference of the moon, to discover whether there are any of these prominences visible. The observer with the most powerful telescope should devote himself entirely to this subject. If any are seen, it is of the utmost im-

portance to note whether they undergo any change; whether new ones appear, and in what part of the circumference; whether they increase on one side and diminish on the other, &c. For details on this very important observation, see Appendix No. II. The times of any striking phænomena should be recorded, no description beyond reference by a single word being attempted at the time; and their places should be noted on the card-circle.

21. The telescope-observers should endeavour to judge whether the disc of the moon is sensibly illuminated. Little confidence can be placed in the appearance of light, unless some of the larger spots can be seen. The sextant-observer should measure the moon's diameter. If there is leisure, one actinometer-observation should be made.

22. An attempt should be made (as has already been mentioned under article 14) to ascertain whether the light of the corona is sufficient to cast a distinguishable shadow, and whether a distance can be found for the candle at which the intensities of the shadows are sensibly equal. But it is certain that the light of the corona is extremely feeble, and the observer must therefore be prepared to remove the candle to a considerable distance. Some estimate may be formed of the intensity of light by remarking the distance at which the letters and figures of a book can with difficulty be distinguished. All observers, as far as possible, should use the same page: for instance, the title-page of the Nautical Almanac for 1851, or the title-page of these "Suggestions," in which the same type is used. To give this observation its greatest value, each observer should as soon as possible examine at what distance he can distinguish the same letters in full sunshine, and at what stage of twilight and in what position he finds the difficulty nearly the same as during the eclipse.

23. Should any stars or planets be seen, their places should be noted (mentally) sufficiently to enable the observer to identify them afterwards upon a celestial globe. In particular, the observer should note the place of the smallest star which he can see. The apparent colours of the stars should be noted; and the observers should also record what they judge to be the colours of the same stars when seen in a dark night.

24. Among the coarser kinds of observation to be made with the naked eye during the totality may be mentioned the following. Whether bushes of light radiate from the corona, in what number, and in what directions. Whether there are beams in the direction of the ecliptic, like pyramids with their bases united at the sun, in the manner of the zodiacal light. Whether there is a red band of light near the horizon, or in any part of it. Whether the outlines of hills can be seen. Whether the smoke of chimneys can be seen. Whether any plants (as the sensitive plant, the convolvulus, or the silk-tree acacia) close their leaves or petals. Whether animals appear frightened.

25. As the duration of the totality will be, in most places, approximately known, the chronometer-bearer should be prepared to give about *ten seconds'* notice to the observers of the re-appearance of light. At places near the north or south boundary this may be scarcely sufficient. Each observer should then remark,—first, whether there is anything peculiar in the circumference of the moon; secondly, whether the reappearance of the sun is heralded by anything like a twilight on the moon's limb; thirdly, whether the corona disappears in separate parts; fourthly, whether beads or strings are seen; fifthly, whether the moon's circumference is visible beyond the sun's visible limb; sixthly, whether the brilliancy of the sun's limb is equal to or less than that of the portions of the disc immediately within it. The first appearance of white light should be noted by signal, as before.

26. It would now be interesting for the naked-eye observer to remark, if possible, whether the light of the sun appears to sweep over the country; whether there is any fluctuation of light on the ground, or on walls, &c.; and also whether dew or fog is formed.

27. Any observations for intensity, polarization, &c. which were omitted before the total obscuration, can now be made in a leisurely manner: and some measures of the interval between the cusps may be made with the sextant.

28. During the remainder of the eclipse there will be little of interest to be done, except to repeat the observations of radiation, and to make any observations applying to the meteorological state of the atmosphere. The instant of termination of the eclipse (a phænomenon which admits of accurate observation) should be noted. The actinometer-observations should be continued to a quarter of an hour after the last contact.

Appendix No. I.

The following suggestions, applying specially to the observation of the beads or strings sometimes seen, are principally extracted from the "Suggestions for the observation of the Annular Eclipse, Oct. 9, 1847," in the *Report of the Seventeenth Meeting of the British Association*, Transactions of the Sections, p. 16.

Whether the points of the cusps are rounded?

Whether in the neighbourhood of the cusp the limb either of the sun or moon appears distorted? Whether the beads appear steady or waving, disappearing and reappearing? Whether they present any peculiar changes when viewed through differently-coloured glasses, the observer alternating the colours, which should be as dissimilar as possible, such as red and green?

Whether they are seen when the telescope is out of focus?

Whether they are seen when the eclipse is projected on a screen?

The drawing out of the beads into threads when very near junction; and whether they waver and change, and the number of them.

Whether before and after the formation of the threads the moon's dark disc is elongated towards the point of contact?

The beads are ascribed by some to lunar mountains. What mountains exist at that part of the limb?

The exact interval of time between the first formation of beads and the first complete contact, and that between the last complete contact and the last disappearance of beads (or other irregularities in or about the cusps), should be determined.

The remarkable fact of a recurrence of cusps, and the possible explanation of it, should be attentively considered.

In reference to the phænomena of the corona, and their possible explanation, the observer is referred to Professor Powell's papers in the *Memoirs of the Astronomical Society*, vol. xvi. p. 301, "On Luminous Rings round Shadows," and vol. xviii. p. 69, "On Irradiation."

Appendix No. II.

It is recommended to observers who may devote themselves especially to the phænomena of the rose-coloured prominences:—

1. Immediately before the total obscuration, to watch for the appearance of the prominences on all parts of the sun's limb, but particularly at the part just about to be eclipsed by the moon's limb; and, the moment that the sun's bright edge is eclipsed, to watch in the direction of the moon's advance for any such prominence; to note mentally its form, and particularly the proportion of its height to its breadth at the base, which may be afterwards recorded in a sketch; and *to make quite sure* whether or not the moon gradually eclipses it.

2. In like manner, and with the same view, to direct the second scrutiny (immediately after the previous one) to the diametrically-opposite portion of the moon's limb, watching for the summits of any prominences, and whether they enlarge as the total eclipse proceeds.

3. In the third place, the observer having satisfied himself on the two previous points, will carefully examine the moon's limb all round, and may now record, on the previously prepared circular diagram, the *positions* of any such prominences round the moon's limb. Let this be done in the first instance without regard to their form or size, but only with regard to their distribution round

the circle; and let this be carefully verified once at least. Let him note whether any kind of arch of light connects two or more of the prominences.

4. Let the *dimensions* and *forms* of the prominences be studied. For the former purpose reference should be made to the two parallel threads in the eye-piece of the telescope. For the latter, observe—Whether the prominences have hard and permanent, or waving and ill-defined outlines. Whether they are invariably broadest at the base, and have on the whole a tapering shape. Whether they seem to stand erect, or whether any or all of them are aslant, like teeth on the edge of a circular saw. Whether any of them taper inwards next the dark limb of the moon: whether they appear isolated; and, if so, how the space between the red patch and the moon's limb is occupied. Whether the prominences vary in outline during the scrutiny. Whether any appear to grow up or to diminish; and, if so, whether such change is what the moon's motion would naturally account for.

5. Let the *illumination* of the prominences be studied. First, as to general colour; by inspecting them with the undefended eye, both with and without a telescope (without any dark glass). Next, as to distribution of colour, select a well-defined prominence and examine it all over *repeatedly* with a considerable magnifying power, and observe if it appears absolutely uniform in colour and brightness, or whether it shows any marks of structure or shadow or variation of tint. It seems very difficult to suggest any comparative experiment for recording the brightness of the illumination of the prominences.

6. As the total phase goes off, let the eye be fixed on one or more of the prominences, and see whether they instantly and totally vanish, or for how many seconds they can be kept in view.

It may be well to refer to M. Arago's narrative of what was seen in 1842 and on former occasions, in the *Annuaire du Bureau des Longitudes* for 1846, and to a paper by M. Faye in the *Comptes Rendus de l'Académie*, 1850, Nov. 4.

Appendix No. III.

Allusion having been made to instruments for determining the plane of polarization, it may be proper to give the following information:—

Nicol's prism is described in the *Edinburgh Philosophical Journal*, vol. xx. p. 83, and in the *Philosophical Magazine*, vol. iv. p. 289; and instruments on this construction are sold by Soleil in Paris and Watkins and Hill in London.

Savart's polariscope is described in Peclet's *Traité de Physique*, and is sold by the same artists.

The accompanying Map (Plate V.) has been constructed principally from computations furnished to the Committee by Lieut. W. S. Stratford, R.N., Superintendent of the Nautical Almanac, verified in some parts by duplicate computations made under the direction of the Astronomer Royal.

The elements employed for computation of the geocentric places of the sun and moon are those of the Nautical Almanac. The sun's semidiameter, as given in the Nautical Almanac, is increased by $\frac{1}{1000}$ part, the moon's parallax by $\frac{1}{1200}$ part, and the moon's semidiameter by $\frac{1}{360}$ part, in conformity with the results of extensive investigations by the Astronomer Royal. It is to be remarked that the semidiameter thus found for the moon is that corresponding to an illuminated moon seen on a dark sky: if the apparent semidiameter when the dark moon is seen on the sun's bright disc be sensibly smaller, the breadth of the shadow and the duration of total darkness will be less than those given in the map.

The numbers in the 1st, 2nd, 3rd, 7th, and 8th columns are computed for the points opposite to them in the central line of shadow, but they will apply with sufficient accuracy for other neighbouring points within the shadow. The numbers in the 4th, 5th, and 6th columns are also computed for the points opposite to them in the central line of shadow; but they require large corrections to make them applicable to other points within the path of the shadow but not on its central line. These corrections are given by the numbers at the top and bottom of the map, corresponding to the various lines drawn longitudinally through the shadow's path. An example will best illustrate the mode of finding these corrections.

It is required to find the duration of total darkness and the angles from the upper point of the sun's disc for disappearance and reappearance, at Vladimir.

Opposite Vladimir, the duration of total darkness on the central line is 189^s. The longitudinal line passing through Vladimir, if traced to the bottom of the map, is found to correspond to the factor 0·7. Hence the duration of total darkness at Vladimir will be $189^s \times 0{\cdot}7 = 132^s$.

Opposite Vladimir, the angles from the sun's upper point at disappearance and reappearance are respectively 64° and 116°. The longitudinal line passing through Vladimir, if traced to the top of the map, is found to correspond to the correction 46° towards S. Hence the angles from the sun's upper point for disappearance and reappearance at Vladimir will be

$$64° + 46° = 110° \text{ and } 116° + 46° = 162°.$$

NOTICES

AND

ABSTRACTS OF COMMUNICATIONS

TO THE

BRITISH ASSOCIATION

FOR THE

ADVANCEMENT OF SCIENCE,

AT THE

EDINBURGH MEETING, JULY AND AUGUST 1850.

ADVERTISEMENT.

The Editors of the following Notices consider themselves responsible only for the fidelity with which the views of the Authors are abstracted.

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MATHEMATICS AND PHYSICS.

Mathematics.

On a Question of Probabilities which occurs in the use of a fixed Collimator for the Verification of the Constancy of Position of an Azimuth Circle. By the Astronomer Royal.

The author said, his chief object in bringing this communication before the Section was to obtain the assistance of its mathematicians in extricating him from a difficulty, or at least a doubt, in which he found himself involved. In determining an azimuth, say of the moon, or of any other object, there were three independent elements which he used, and the probable errors of which he wished to compare with each other. There was first the assumed fixity of the circle itself, when its zero of azimuth was once determined; there was next the indication of a fixed collimator, which was used as an independent check when its position in azimuth was once determined; and thirdly, the daily observations of stars were used as a means of obtaining the required azimuth. The object was to determine and compare the probable error of the zero of azimuth determined by each of these elements. Suppose now that the zeros of azimuth determined by these three elements on any one day were affected by the respective errors x, y, z. The results for determined azimuth of the moon on that day would be affected by the same errors x, y, z; but the comparison of these results would not give us the numerical values of x, y, z, but of their differences $x-y, x-z, y-z$. These data however would suffice to give us the *most* probable values of x, y, z for that day, if we had their *probable* values X, Y, Z. We should only have to make the sum $\left(\frac{x}{X}\right)^2+\left(\frac{y}{Y}\right)^2+\left(\frac{z}{Z}\right)^2$ minimum; and this condition, in addition to the equations given by the comparison of results above mentioned, furnished three equations to give the *most* probable values of x, y, z for that day. But as the *probable* values X, Y, Z are yet unknown, the *most* probable values x, y, z for that day must be expressed by means of the symbols X, Y, Z. Now taking a series of such symbolical expressions for x, on a series of days, and treating them by the ordinary rules of probabilities as if they were observed errors, there was no difficulty in determining, from that series of errors, the *probable* error, still symbolically expressed; and making this equal to X, an equation was obtained between X, Y, Z. In a similar way, by treatment of the values of y and of z, two other equations were obtained; and from these, X, Y, Z were determined. The result was very striking; it was, that the probable error of the fixity of the instrument was ten times less than that of the stars, which, however, included the personal equation of the observer, errors of clock, transit telescope and others. The doubt, however, which assailed him was, whether he was justified in applying the doctrine of probabilities to obtain from those series the probable error of quantities which were not themselves mere results of actual observation, in which case there would be no doubt of its legitimate application, but where the quantities were, in each term of the series, partly the result of observation and partly deductions of formulæ. From this doubt he requested their assistance, either to extricate him or convince him of the incorrectness of the method he used. Another question he begged to propose to the mathematicians for their assistance. It was well known that an equation of any order, containing only one unknown quantity, could be lowered one dimension, if one of its roots could be obtained numerically. Now, the question he wished to propose was, whether any mathematician knew any similar mode of lowering a system of several equations of high degree, which involved the same number of unknown but independent quantities?

On Polyzones inscribed on a Surface of the Second Order. By Sir W. R. HAMILTON, *M.R.I.A.*

On the Laws of the Elasticity of Solids. By W. J. MACQUORN RANKINE, *C.E., F.R.S.E., F.R.S.S.A. &c.*

This paper is intended to form the foundation of the theoretical part of a series of researches connected with the strength of materials. Its immediate object is to investigate the relations which must exist between the elasticities of different kinds possessed by a given substance, and between the different values of those elasticities in different directions.

The different kinds of elasticity possessed by a solid substance are distinguished into three:—First, *longitudinal elasticity*, representing the forces called into play in a given direction by condensation or dilatation of the particles of the body in the same direction. Secondly, *lateral elasticity*, representing those called into play in a given direction by condensation or dilatation of the particles of the body in a direction at right angles to that of the force; and thirdly, *transverse elasticity*, or *rigidity*, being the force by which solid substances resist distortion or change of figure, and the property which distinguishes solids from fluids. The author's researches refer chiefly to substances whose elasticity varies in different directions. His first endeavour is, to determine the laws of elasticity of such substances, so far as they are independent of hypotheses respecting the constitution of matter, a method which has not hitherto been followed.

The *first theorem* or law states the existence of three rectangular axes of elasticity in each substance possessing a certain degree of symmetry of molecular action. The elasticity of a body, as referred to these three axes, is expressed by twelve coefficients, three of longitudinal, and six of lateral elasticity, and three of rigidity, which are connected by the following laws:—

Theorem Second.—The coefficient of rigidity is the same for all directions of distortion in a given plane.

Theorem Third.—In each of the coordinate planes of elasticity, the coefficient of rigidity is equal to one-fourth part of the sum of the two coefficients of longitudinal elasticity, diminished by one-fourth part of the sum of the two coefficients of lateral elasticity in the same plane.

The investigation having now been carried as far as is practicable without the aid of hypotheses, the author determines, in the first place, the consequences of the supposition of Boscovich, that elasticity arises entirely from the mutual action of atomic centres of force. In the following theorems a *perfect solid* means a body so constituted.

Theorem Fourth.—In each of the coordinate planes of elasticity of a perfect solid, the two coefficients of lateral elasticity and the coefficient of rigidity are all equal to each other.

Theorem Fifth.—For each axis of elasticity of a perfect solid, the coefficient of longitudinal elasticity is equal to three times the sum of the two coefficients of rigidity for the coordinate planes which pass through that axis, diminished by three times the coefficient of rigidity for the plane normal to that axis.

Thus in perfect solids all the coefficients of elasticity are functions of *three* independent coefficients—those of rigidity. In no previous investigation has the number of independent coefficients been reduced below *six*.

To represent the phænomena of *imperfect* solids, there is introduced the *hypothesis of molecular vortices* in addition to that of atomic centres; that is to say, each atomic centre is supposed to be surrounded by a fluid atmosphere, retained round the centre by attraction, and diffused from it by the centrifugal force of revolutions constituting *heat*. The author has already applied this hypothesis to the theory of the elasticity of gases and vapours (Trans. Roy. Soc. Edin. vol. xx. part 1). Applied to solids it leads to the following conclusion:—

Theorem Sixth.—In an imperfect solid, each of the coefficients of longitudinal and lateral elasticity is equal to the same function of the coefficients of rigidity which would have been its value in a perfect solid, added to a coefficient of fluid elasticity, which is the same in all directions.

Thus the number of independent coefficients for such substances is four. The rest of the paper is occupied by the deduction from those principles of some important consequences respecting coefficients of compressibility and extensibility, and the elasticities corresponding to directions not coinciding with the three axes.

Light, Heat, Electricity, Magnetism.

On a Method for computing Magnetic Charts of Declination. *By* Samuel Beswick.

I here exhibit a declination chart for the whole Atlantic for the epoch of 1840, the lines of which have been computed by a theoretical formula which I will now describe. It is founded on a principle proposed by Prof. Gauss, which resolves the magnetic force of the earth into two portions, one of which, X, acts in the direction of the geographical meridian, and the other, Y, perpendicularly to that meridian. Now by a well-known law of the composition of forces, a resultant force is found from the combined action of the above two portions of the horizontal force. But as all places of observation must be situated between the two points of convergence of the horizontal force, it is clearly necessary that two such equivalent forces must be found—one for each hemisphere. These forces acting upon the needle at the place of observation will produce an effect proportionate to their comparative angles of distance; which effect will be the declination of the needle for that place. Hence arises the following formula:—

$$\frac{c + d \times a}{a + b} = y$$

$$c \pm y \quad = x \text{ the declination.}$$

By this formula I have computed tables of declination, from which has been formed the large magnetic chart for the whole Atlantic, which I here exhibit. It presents some striking features of comparison with a magnetic chart formed by Col. Sabine from tables of observation. This chart is also for the whole Atlantic, and for the same epoch, 1840. And the tables computed by this formula, compared with Sabine's tables of observation, are so similar, that the differences are always within the range of errors of observation.

The process for adapting this formula to all epochs—which is the grand desideratum in this department of science—has been given in detail in the Phil. Mag. for March of the present year. The superiority of this method consists in its simplicity, precision, and the exactitude of its results. It is capable of computing magnetic charts for any epoch. By its means I traced the anomalous Asiatic line of no declination for 1800, 1820, 1830, 1835, 1840, 1845, 1849, and 1850; and in each case the results give but slight differences from observation. From the successive applications of this theoretical formula to the Asiatic lines of declination, I have discovered that the curves, which are concave to the north in the vicinity of the Uralian mountains, are rising northwards; the curves convex to the north in the districts east of Asia are falling in a south-western direction, whilst the contiguous curves convex to the Chinese Sea are rising and will ultimately form one class of curves with those immediately north. These Asiatic curves may not be inaptly compared to the undulations of a wave, or to a ribbon streaming in the breeze. I am now engaged in the computation of a magnetic chart for the whole terrestrial surface for the year 1851, and shall have great pleasure in exhibiting it to the Section at the next Meeting.

Notice on the Artificial Magnets made by M. Logeman, *Optician at Haerlem, by the process of* M. Elias. *By* Sir David Brewster, *K.H., D.C.L., F.R.S. Lond. & V.P.R.S. Edin.*

On my return from the continent in June, I received from M. Logeman a beautiful horse-shoe magnet, weighing one English pound (0·482 kilogramme), which, if loaded with suitable precautions, such as had been pointed out by Haecker in Poggendorff's 'Annalen,' vol. lvii. p. 375, is capable of supporting a weight of 28½ English pounds, or 13 kilogrammes. M. Haecker has found, from numerous experiments, that the power P of a magnet weighing N kilogrammes is $P=10{\cdot}33\sqrt[3]{N^2}$, but the magnets executed by the best makers in Europe have not been found to possess this power, or at least not greatly to surpass it. The magnet given me by M. Logeman, is stated to possess *twice* the power indicated by the formula, and with a piece of post paper interposed between the poles and their armature, to be still capable of supporting a load equal at least to that supported directly by the best magnets hitherto produced.

M. Logeman mentioned that he could produce magnets of the same quality that would support 400 and even 600 English pounds.

Having seen the great interest which one of M. Logeman's small magnets excited when exhibited at Lord Rosse's soirée in May, I was anxious to obtain from him, and dispose of for his benefit, a magnet of great power, for the purpose of exhibiting at the meeting of the Association. M. Logeman accordingly executed another magnet, which just arrived in time to be exhibited at one of the early meetings of the Mathematical and Physical Section.

This second magnet weighed 12½ English pounds, or 5·729 kilogrammes, and could support a weight of 150 English pounds, or 68 kilogrammes. The price of it was 8*l.* sterling.

After finishing this magnet, M. Logeman felt a desire to submit a still more powerful one to the Association, and after great labour he completed it in proper time, but owing to gross mismanagement on certain railways, it was not delivered to me till the meeting of the Association was over.

This splendid magnet weighs *fifty-two* English pounds, or 28 kilogrammes, and is capable of supporting 430 pounds English, or 196 kilogrammes. The price is 20*l.* sterling.

The permanence of the magnetism in these magnets is as remarkable as their great power. If the armature is torn away twenty or even a thousand times, it will still carry as great a weight as before.

The process by which these magnets are made, is to make the magnet with its armature pass several times along a helix of copper wire traversed by a current of one or more elements of Grove's battery.

On a new Membrane investing the Crystalline Lens of the Ox. By Sir David Brewster, *K.H., D.C.L., F.R.S. Lond. & V.P.R.S. Edin.*

The Ox from whose eye the lens was taken was killed on the 13th of December, 1838, and the lens was extracted on the 14th, at 11 A.M.

	inch.
Its thickness was	0·507
Its diameter	0·702

After lying for a considerable time in distilled water, the capsule of the lens had separated from the lens itself, the space between them being filled with albuminous water of a greater refractive power than the distilled water. The capsule at last burst near the vertex of the lens; but a short time before this took place, another capsule or bag was raised up by the expansion of the lens, and the space between it and the lens filled with albuminous water of a still greater refractive power. This water was contained in a membrane never before described, and investing the whole of the lens within the capsule. This membrane, during the swelling of the lens, rose to different heights in different places, giving the surface of the lens an irregular appearance. This membrane was striated, but the striæ gave no colours, while the fibres of the lens immediately below this membrane exhibited beautiful colours.

The lens itself had two concentric polarizing structures, the central ones being *positive* and the external ones *negative*.

On the Optical Properties of the Cyanurets of Platinum and Magnesia, and of Barytes and Platinum. By Sir David Brewster, *K.H., D.C.L., F.R.S. Lond. & V.P.R.S. Edin.*

The author gave a very general notice of the optical properties of these interesting salts, which he had received from his friend M. Haidinger of Vienna. Although these crystals gave different colours by reflected and transmitted light, they were not in the proper sense of the word *dichroitic*. In the general and remarkable property of giving coloured pencils differently polarized by reflected light, they resembled *murexide* and the *chrysammate* of potash, the optical properties of which were several years ago described to the Association*. In these new salts the coloured reflected tint is polarized in a plane perpendicular to the plane of reflexion, when the plane of reflexion coincides with the direction of the principal axis, and in that plane when the plane of reflexion is at right angles to the direction of the principal axis. At intermediate directions the plane of polarization continues in the plane of reflexion, but in passing from 0° to 90° of azimuth, the light of the principal coloured pencil passes gradually into the other pencil which is polarized in the plane of reflexion, a small portion of the former being still left at an azimuth of 90° polarized perpendicular to the plane of reflexion. The *cyanuret of barytes and platinum* has a powerful double refraction and a high dispersing power. It has two axes, the principal one of which is positive, like the axis of quartz; and it possesses the property of internal dispersion, the dispersed light being a *brilliant green*, while the transmitted light is *yellow*. The colour of the pencil reflected from its surfaces in all azimuths is *blue*, but the strongest of the reflected pencils, viz. that which is polarized perpendicular to the plane of reflexion, is a *brilliant blue* near the maximum polarizing angle, becoming *purple* at greater, and less blue at smaller angles of incidence. We have here then the remarkable phænomenon of double reflexion, in which the principal coloured pencil is not only polarized in a plane perpendicular to the plane of reflexion, but varies in intensity, at the same angle of incidence, with the angle of azimuth which the plane of reflexion forms with the principal axis of double refraction.

On the Polarizing Structure of the Eye.
By Sir David Brewster, *K.H., D.C.L., F.R.S. Lond. & V.P.R.S. Edin.*

M. Haidinger of Vienna discovered the beautiful property of the eye, in virtue of which it is able, without any assistance, to determine the plane in which light is polarized, by means of two yellow *brushes* or *pencils*, as they have been called, or *sectors*, as Sir David Brewster calls them, from their resemblance to the sectors of circular crystals, as discovered and described by Mr. Fox Talbot. Viewing the phænomenon as one of circular crystallization, the author endeavoured to point out the particular structures and membranes of the eye by which the phænomenon of circular crystallization was produced in the polarized light, and the analysis effected.

* See Report for 1846, p. 7.

He was thus induced to ascribe the circular structure to the cornea and the crystalline lens, in both of which he had found it to exist,—the yellow tint to the elastic capsule which he had found when in a state of distension to depolarize the required yellow tint, and the analysis to the different membranes, such as the hyaloid, the membrane of Jacob, and other tissues which lie in front of the sensitive layer of the retina. The difficulty however which beset this explanation was, that the two yellow sectors, and the opposite pair of blue ones, should have been inclined 45° to the plane of primitive polarization, whereas they are parallel and perpendicular to that plane. In order to account for this part of the phænomenon, it is necessary to suppose that the particles or minute crystals which radiate from a centre are inclined 45° degrees to the radial line.

On some new Phænomena in the Polarization of the Atmosphere. *By* Sir David Brewster, *K.H., D.C.L., F.R.S. Lond. & V.P.R.S. Edin.*

In the brief notice given by the author of these phænomena, he ascribed the phænomena of atmospheric polarization to the joint effect of the light polarized by reflexion and by refraction, the light polarized by refraction compensating that polarized by reflexion at the neutral points of Arago, Babinet and Brewster, and showing itself separately when reflected from certain coloured clouds placed 90° from the sun.

The author also pointed out, by means of a diagram, a method by which the polarizing condition of the whole atmosphere might be determined by carrying round an unobstructed horizon a set of polarized bands kept in a perpendicular position by a level, and marking the azimuths of the different points where a compensation takes place at different times. The distances between these points will give the altitude of the neutral points, whether these points are above or below the horizon and invisible.

Notice regarding the recent Improvements in Photography. *By* Sir David Brewster, *K.H., D.C.L., F.R.S. Lond. & V.P.R.S. Edin.*

Sir David Brewster exhibited to the meeting a series of Talbotypes executed by the process invented by H. F. Talbot, Esq., and other processes which have since come into use.

The earliest series of Talbotypes submitted to the meeting were a collection of one hundred executed in Scotland by D. O. Hill, Esq. and Mr. Robert Adamson, and which Mr. Hill had presented to Sir David Brewster. This series, and indeed all those taken under Mr. Hill's superintendence, are distinguished by the artistic arrangements and drapery of the figures, a merit quite independent of their excellence as photographs. Hence these Talbotypes have been greatly admired and esteemed by artists, and have been justly regarded as valuable auxiliaries to art.

The second series was executed by Mr. Talbot's process by an amateur, Samuel Buckle, Esq. of Peterborough, and were distinguished by the fineness of their colour, the minute perfection of the picture in all its parts, and the peculiar beauty of the subjects which they represented. They consisted chiefly of views of Peterborough Cathedral, and the buildings connected with it.

The third series was executed by Messrs. Ross and Thomson, Edinburgh, photographers to the Queen, by the process in albumen invented by M. Niepce of Paris. They were the specimens referred to in the President's Address*, and consisted chiefly of views of Edinburgh, and copies of pictures and statues. They were considered by all who saw them superior to any photographs that had been produced either in this country or on the continent.

In addition to these Talbotypes, Sir David Brewster exhibited two landscapes produced by the gelatine process of M. Poitevin, which had been presented to him by M. Balard, Member of the National Institute of France.

* See an earlier part of this volume.

On the Effect of Height on the Diurnal Variation of the Horizontal Complement of the Magnetic Force. By J. A. Broun, *F.R.S.E.*

On the Variation with Season of the Differences of the Mean Pressure at Greenwich and Makerstoun. By J. A. Broun, *F.R.S.E.*

On Electrical Figures of Dust on Plate Glass. By J. A. Broun, *F.R.S.E.*

On the Effect of Height in the Atmosphere on the Diurnal Variation of Magnetic Declination. By J. A. Broun, *F.R.S.E.*

I brought before this Section at the Oxford Meeting, some notice of a series of magnetical observations, made under my direction, at the expense of General Sir Thomas Brisbane, for the purpose of determining the effect of height in the atmosphere upon the diurnal variations of the magnetic declination and force. This question is one of the greatest importance, as to the seat of the disturbing causes which produce magnetic variations; it is, however, one of the most difficult kind for a practical answer. Those acquainted with the working of magnetical instruments know how rare it is to get two instruments of the same kind, and in the same room, to continue, even for a short period, to tell the same story. If it is so in the same building, it is evidently a difficulty of no common kind to obtain consistent comparative results, when one of the instruments is placed on the summit of a mountain, frequently enveloped in cloud, with no better cover than a rickety tent, which threatens to fly away with observers and instruments in every blast that sweeps the bare surface of the hill.

The lower station occupied in this investigation was the Makerstoun Observatory, the upper station was the summit of the highest of the Cheviot hills, about eighteen miles E.S.E. of Makerstoun, and 2656 feet above the level of the sea, or 2440 feet, nearly half a mile, above Makerstoun. The stations were in sight of each other. On the first occasion, in the beginning of June 1847, the same tent was made to serve on Cheviot for observatory and residence. The frequent threats of the wind, the shaking of the ground by the motion of the tent poles and accidental touches of the instrument, from the proximity of the observers, rendered several of the few days' observations obtained of indifferent value; and I accordingly again went to Cheviot after the meeting of the Association in the end of August 1847. On this occasion I separated the sleeping apartment from the observatory, and rendered the latter, to a considerable extent, independent of any gale that might blow. The top of the hill has a covering of peat moss, in some places upwards of six feet thick. I had a trench of sufficient width cut into a bank of this moss, where it was about four feet thick, clearing out the moss till the rock was rendered bare. The remaining height of wall was obtained by large peat slabs, and the whole was roofed by means of a wooden ridge pole and thick tent cloth. This observatory was very steady, rather damp of course, but little else could be expected where thick clouds rest for many days together, and almost always during the night. The instruments placed in this observatory, were two portable magnetometers, the loan of which I owed to the kindness of Mr. Jones of London, the maker, and a barometer; there were thermometers outside. It is the results from the declination magnetometer to which I wish to draw the attention of the Section at present. This instrument was placed on a firmly braced tripod; the value of the scale divisions was 1'·444, determined with the greatest accuracy, by means of the horizontal circle attached to the instrument; the estimations were made by tenths of a scale division or 0'·14: as an error of 0'·1 in the mean of two readings was almost certain, this scale was evidently too small: in the mean of several observations, however, the probable error becomes very small. The observatory declinometer was employed at Makerstoun, the scale of which can be estimated with much certainty to half a tenth of a minute. The observations were made at both places at two minutes, and at one minute before each hour, of Göttingen mean time at the hour, and one minute after it; there were thus four comparative observations obtained at each hour. On the 27th and 28th of August, the day, during which continuous observations were made in all the magnetical observatories in the world, was observed, in the same manner on Cheviot and at Makerstoun. On Cheviot, observations of both the magnetometers were made every ten minutes for the twenty-four hours of the term, by myself and my assistant, Mr. Hogg. At Makerstoun, the observations were made by Mr. Welsh, with two assistants. The times of the observations were strictly the same, as I compared the chronometer on Cheviot with the observatory clock at Makerstoun, in the manner which I described at Oxford. Mr. Welsh reflected the sun-light from a mirror at Makerstoun upon our position on Cheviot, and he cut off the reflexion at previously agreed on minutes and seconds of the observatory clock, by which means the error of the chronometer on Cheviot was accurately determined. The large mass of comparative observations are only partially reduced, and it was only yesterday that, with Mr. Welsh's assistance, I have been able to complete the reductions to a sufficient extent to present some of the results to the Section. I omit any notice of the processes employed in the reduction and combination of the observations.

I have projected the hourly means from six days' simultaneous observations at Makerstoun and Cheviot. The following are the conclusions which I have deduced from these means:—

1st. The diurnal ranges of magnetic declination at Cheviot and Makerstoun in the end of the month of August, probably do not differ one-tenth of a minute, the difference of heights of the stations being nearly half a mile.

The following are a few specimens of the simultaneous changes of declination at the two places:—

Difference of the highest and lowest hourly means, from six days' observations, as in the curves .	Cheviot . .	15′·42
	Makerstoun	15′·41
Difference of six highest and six lowest hourly means, as in the curve	Cheviot . .	12′·58
	Makerstoun	12′·50
Mean difference of a series of maxima and minima occurring simultaneously during six days . .	Cheviot . .	13′·50
	Makerstoun	13′·40
Greatest range in any of the six days occurring simultaneously	Cheviot . .	20′·71
	Makerstoun	20′·62

In no case does the difference of ranges exceed one-tenth of a minute. As a further evidence of the exactness with which the two magnets followed each other, I may state that the differences of the change of declination at each station, for any two hours of the same day, do not differ from each other more than can be explained by error of observation, and by the apparent law, which I shall state immediately.

This remarkable result for the ranges, differs from that which I conceived was exhibited by the June observations; *they* appeared to show a greater range at Makerstoun than at Cheviot, by nearly one minute. I have already mentioned the sources of error to which the June observations were liable; but I should also notice, that the conclusion, as to the difference of ranges, was obtained from the mean of only three days' observations, to which I have no hesitation in giving a much smaller value than to three days in August. Besides this, however, upon taking five of the greatest ranges obtained in the June observations, during which the instrument seemed moderately steady, I find

Mean ranges from the June observations . . .	Cheviot . .	18′·16
	Makerstoun	18′·20

or almost exactly the same. I consider, therefore, that the August observations may be taken as conclusive, that the difference of ranges at the two stations is not more than one-tenth of a minute, the greatest range probably occurring on Cheviot.

2nd. The maximum of westerly declination occurs rather sooner, or nearer noon, at the highest station.

This conclusion was also arrived at from the June observations. I have projected the differences of the ordinates of the curves for Cheviot and Makerstoun on ten times the scale: from this projection it will be seen that the declination magnet moves more rapidly westwards in the forenoon at the upper than at the lower station, and that it begins to move eastward again at the upper station sooner than at the lower, so that the difference of ordinates diminishes with the greatest rapidity for two or three hours after the maximum. I have also projected the difference of the ordinates from the June observations, to show the agreement of both series in the conclusion, that the maximum westerly declination occurs nearest noon at the higher station.

Observations were made both in June and in August at the foot of the hill, but no greater difference from the simultaneous Makerstoun observations appeared than could be explained by errors of observation.

On the Mechanical Compensation of the Bifilar and Balance Magnets for Variations of the Magnetic Moment with Temperature. By J. A. Broun, *F.R.S.E.*

The bifilar magnetometer consists of a magnet suspended by two wires or threads, by twisting which, the magnet is forced to a position at right angles to that which it would naturally occupy, namely, at right angles to the magnetic meridian. The equation of equilibrium between X, the earth's horizontal magnetic force acting on m, the magnetic moment of the bar, and W, the weight of the magnet seeking the lower position, from which it has been raised by the twisting of the wires, is as follows:

$$mX = W\frac{a^2}{l}\sin v,$$

where a is the interval of the wires, and l is their length, and v is the angle of twist. If we suppose X, W, and v to be constant, then the magnet may change its position from variations of m, a, and l, all of which vary with temperature. It is the elimination of changes of position due to the variations of these three quantities that is so essential to obtain from this instrument the variations of the horizontal magnetic force. I shall not enter upon the troublesome, not to say inexact processes which have been adopted in order to determine the variation of m with temperature: the changes due to variations of a and l are computed from the known coefficients of expansion of the metal which separates the wires, and of the metal of the wires.

Differentiating the previous equation, and reducing, we find the coefficient, q, for the temperature correction to be

$$q = \frac{\Delta m}{m} + 2e - e',$$

where e is the coefficient of expansion for the metal which separates the wires, brass; and e' is the coefficient of expansion for the wires, generally silver: since when brass and silver are the two metals, e is nearly equal to e', we shall have

$$q = \frac{\Delta m}{m} + e,$$

where e may be supposed to represent the expansion of the interval of the wires at the top, the expansion of the length of the wires being compensated by the expansion of their interval below. We shall now make

$$q = 0 \text{ when } \frac{\Delta m}{m} = -e,$$

that is to say, when the interval of the wires at the top has a *contraction* coefficient equal to the value of $\frac{\Delta m}{m}$ for 1° Fahr. The physical explanation of this destruction of q is evident:—the contraction of the interval of the wires diminishes the force with which the north end of the magnet is kept *from* the north, while the reduction of the magnetism of the bar by the same increase of temperature diminishes the force with which it is pulled *to* the north by the earth's magnetism.

The following is the process by which I obtain the required *contraction*:—Let the upper extremities of the wires be attached to the ends of two brass rods, which approach each other within an interval equal to the diameter of the lower wheel which separates the wires, and let the other ends of the brass rods be *fixed* to a beam of wood, so that an increase of temperature will cause the *free* ends of the rods to *approach* each other, by an amount equal to the difference of their expansion and that of the wooden beam to which they are fixed; the contraction required is obtained when a proper length of brass rod is employed. In the case of Sir Thomas Brisbane's bifilar $\frac{\Delta m}{m}$ for 1° Fahr.=0·000266, the interval of the wires is nearly half an inch, and therefore the brass rods would require to be each about 7½ inches long, in order that the interval be diminished 0·000266 of itself (the coefficient of contraction), or 0·000133 inch, the difference of the coefficients of expansion of brass and wood being assumed equal to 0·0000085. Magnets with a temperature coefficient of 0·0001 would require brass rods of 3 inches in length, or smaller, as the interval of the wires is less than half an inch.

I propose the following process for the compensation of the balance magnet:—Let a brass rod be *fixed* to the magnet near its *south* end, but free to expand towards the north, and having its centre of gravity near the centre of motion; it is obvious that when the temperature increases, the north end of the magnet rises, from the diminution of its magnetic moment, but at the same time the expansion of the brass rod towards the north end will tend to depress it; by a proper regulation therefore of the length and weight of this brass rod (which will depend upon the weight of the needle and the distance of the centre of gravity from the centre of motion), the two effects of temperature may be made to destroy each other. For the Makerstoun balance, for which $\frac{\Delta m}{m}$=0·00008, I have computed that a brass rod 10 inches long, one-thirtieth the weight of the needle, placed as has been proposed, would compensate nearly for the variation of the magnetic moment.

In both cases such computation could only be considered as guides to the instrument-maker, who, by experiments at different temperatures, might be able to attain a very accurate compensation.

These compensations, it is conceived, will be most useful, especially for self-registering apparatuses. For other instruments, should the compensation not be quite perfect, while it would serve for all large variations, it might be insufficient for more delicate investigations; for these, however, the *residual* temperature coefficient could be obtained from the observations themselves, by the process which I have adopted in the correction of the Makerstoun observations.

On the Construction of Silk Suspension Threads for the Declination Magnetometer. By J. A. Broun, *F.R.S.E.*

Till the year 1777 the magnetic declination was observed by means of a magnetic needle balanced upon a steel pivot, as in the common mariner's compass; the amount of friction in this mode of placing the needle rendered it unfit for any delicate investigation, and the French Academy of Sciences, which had observed this deficiency, proposed the improvement of the suspension as the subject of a prize. Coulomb, who wrote one of the papers crowned, proposed in 1777 suspension by means of a thread formed of the silk fibres from the cocoon. This suspension was adopted immediately afterwards by Domenic Cassini, although the cup and pivot were used by others, as by Gilpin, in the present century. The importance of the subject will be easily understood when it is remembered that the labour of years and one of the chief objects in the formation of magnetic observatories, may be frustrated by a bad suspension thread.

The suspension thread acts in the following manner:—As the thread is composed of a series of fibres more or less twisted, the plane of detorsion, that is the vertical plane in which an unmagnetic bar will rest when suspended, is determined by the composition of a series of opposing forces: if the torsion of the individual fibres be at all considerable, very small motions of the magnet will cause them to occupy slightly different positions, or moderate changes of humidity acting to a greater extent upon the external than the internal fibres, and upon some of the external fibres more than upon others, will change the plane of equilibrium, and in this way force the magnet from its true position.

Cassini, in order to avoid these sources of error, formed his thread in the following manner:—Having cut the fibre into proper lengths, he stretched them singly by means of weights; he then joined them together and passed the thread thus formed several times between his fingers, which had been dipped in slightly gummed water: after leaving the thread with a weight suspended for twenty-four hours, he again passed the thread between his fingers, which were greased with tallow*. Cassini's observations were made in the Paris Observatory and in the caves below; as far as can be judged from their monthly means, the threads seem to have performed very indifferently. Since Cassini's time the improvement of the suspension thread seems to have made very little progress; in general the thread has been formed by the combination of a series of fibres, or by a reduplication of the same fibre, without any preparation, and just as it has been found on the reel. M. Kupffer, apparently despairing of satisfactory results from a silk suspension, substituted silver wires in the Russian declinometers; a similar suspension has also been adopted by M. Quetelet at Brussels. This seems to me a step backwards. Indeed M. Nervander of Helsingfors has found that such suspension cannot be trusted, since the wires are so affected by temperature, that when an unmagnetic bar is suspended it has a considerable diurnal motion; a fact which I had suspected and had pointed out as a probable source of error in determining the temperature coefficient of the bifilar magnet. M. Nervander has proposed to form the suspension thread by moistening with hot water the fibre cut into lengths, and submitting each length in this state to a considerable tension before combining to form the thread. I formed the thread for the declinometer in Sir Thomas Brisbane's Observatory at Makerstoun in the year 1843 in the following manner:—I had observed that the fibre, which is wound on a reel and termed untwisted silk, has in reality a considerable twist; each fibre is not simple but compound, and the simple fibres are at first more or less twisted around each other, as may be easily understood when the operation of forming the compound fibre from the cocoon is considered; the further process of reeling also induces a considerable twist. I first, therefore, removed all twist from the compound fibre by running as much as would form twenty-two times the length of the required thread between the finger and thumb, and then wound the continuous fibre on two smooth pins placed at the requisite distance, so that no twist should be introduced in the act of winding; after tying the extremities, a hook carrying a weight was inserted in place of the lower pin; the thread being formed of one continuous fibre was thus free to move round the upper pin and the weight-hook till each length bore nearly an equal strain. After the weight had been suspended for some time, the fibres were tied firmly together at short intervals by small pieces of cotton thread. This suspension has performed very well for seven years. Up to the present time, however, I am unacquainted with any comparative observations with differently constructed suspension threads. In the end of June I requested Mr. Hogg, an Assistant in Sir Thomas Brisbane's Observatory, to construct, as carefully as possible, three threads; one according to Cassini's process, one by M. Nervander's, and one by my own. Each thread was formed of the same number of lengths of fibre; they were suspended in the same closed box with glass sides; each carried a weight of nearly a pound, with a small index for reading the variations of the plane of detorsion. The torsion forces of the three threads were in the followings ratios :—

Cassini : Nervander : Brown = 12 : 11 : 6.

From twenty-five days' observations the mean changes of the plane of detorsion from day to day, independent of sign, were—

Cassini 2°·5 ; Nervander 2°·1 ; Brown 2°·0 ;

or reducing to the same torsion force, the ratios of the variations of the plane of detorsion were—

Cassini = 30 ; Nervander = 23 ; Brown = 12.

The differences of the variations of the plane of detorsion between 7 P.M. and 4 P.M. are fully more marked; when reduced to the same torsion force, the ratios were—

Cassini = 46 ; Nervander = 37 ; Brown = 14.

So that the thread prepared according to my own process is at least twice as good

* Journal de Physique, t. xl. p. 344.

as M. Nervander's, and thrice as good as Cassini's, when the variations from day to day are considered. When however we consider the total difference of the extreme positions of the weight-indexes during the whole period, the ratios for the same torsion force are—

Cassini = 26 ; Nervander = 14 ; Brown = 18 ;

in which case M. Nervander's construction has the advantage ; it is my belief however that this advantage would not continue, and that when the threads have been suspended for a longer period my own thread will show also less amplitude of the total variation. I should remark, that I believe the conditions in the preparation of the threads were as nearly as possible equal. Mr. Hogg had never made a thread before according to either construction, and he removed the torsion from the fibre for each of the threads, which was taken from the same reel.

Photography.—On a New Instrument called the Dynactinometer for comparing the Power of Object-Glasses, and for measuring the Intensity of the Photogenic Light. By M. CLAUDET.

The author announced several years ago (in 1844) that in achromatic lenses the photogenic focus did not coincide with the visual focus. Until that discovery no photographer was certain of obtaining a well-defined picture, because the image produced on the ground glass was no guide for the correctness of the photogenic image which was at a different focus. Soon after M. Lerebours of Paris investigated the subject, explained the cause of the difference, and indicated the means to avoid it. Since that time opticians have endeavoured to construct lenses in which the two foci agree, but M. Claudet proves that it is impossible to construct lenses in which the two foci generally agree for all the distances of objects, and with all the modifications and the quality of light. He has lately discovered that there is a continued variation between these two foci, and he enumerates a series of experiments which prove the truth of this fact and render necessary new formulæ for photogenic optical combinations. The author observes that a good telescope may make a very bad camera obscura, and a good camera a very bad telescope. He has by many experiments proved that the lenses the most active in the photogenic operation are those in which the two foci are the most separated, and for that reason he prefers these last.

In order to elucidate this phænomenon and generally to compare the power of all kind of lenses, he has contrived an instrument which he calls Dynactinometer, and which fulfills this double object. The instrument is composed of two discs, one black and the other white, each having a slit so arranged that the black disc can by a gradual superposition cover the whole white disc ; this last is marked with divisions like a watch-dial. In placing two cameras supplied with two different lenses before the dynactinometer, and making it revolve gradually by the hand, two Daguerreotype plates, placed one in each camera, receive at the same moment the image of the dial ; and as the black disc stops the effect on the segment as long as it covers it, it is evident that a greater power in one lens will show each corresponding segment more intense than the other. These segments being numbered, it is easy, in comparing the two segments on each plate, having the same intensity, to judge by the number the proportion of the effect. This is the principle of the dynactinometer ; by it M. Claudet has been able to observe that two spaces of the same area, taken one in the centre and the other near the circumference of the lens, although giving the same intensity of light, do not produce the same intensity of photogenic action, and also that lenses do not always present the same comparative power. From these facts he argues, that when the yellow rays are more or less abundant, they, by their known antagonistic action, interfere more or less with the photogenic effect, and that they destroy it when they are in certain proportions. This enabled him to offer an hypothesis of the cause of the variations between the two foci. The central parts of the surface of a lens concentrate with the photogenic rays more yellow rays than the other parts, and when these yellow rays are in excess they neutralize the action of the photogenic rays. In this case the centre does not operate photogenically, although it contributes to the visual image ; the central photogenic rays being less refracted than the rays near the circumference, the mean refrangibility of the photogenic rays alters according to the parts of the object-glass which operate photogenically; hence when the yellow rays are abundant the mean refrangibility of the photogenic rays is proportionally increased, because the centre does not contribute to the photogenic image. The colour of the glass of the lenses has also an influence in the concentration of yellow rays, their chromatic correction another; hence the anomaly of the same light affecting differently the separation of various object-glasses. The dynactinometer can also be applied for measuring the intensity of the photogenic light at any moment; and as a regular motion is required for this object, the movement is given to the black disc by means of clockwork.

Report of a Committee appointed to examine the Effects produced by Lightning on a Tree near Edinburgh. By Professor PHILLIPS, *F.R.S.*

The tree in question stands in the grounds of Mr. Wauchope, at Edmonstone, about four miles from Edinburgh, on the Dalkeith road. The surface slopes gently to the north; the substrata are part of the coal formation, and contain at a small depth an abundance of the rich 'black band' ironstone. The locality appears remarkably liable to lightning strokes; several other trees having been destroyed there since 1834.

The tree examined by the Commitee was struck on the 11th of June 1849, on a still sultry day. It is an oak-tree; it stood in rather a clear space, the surrounding trees being chestnut, elm, &c. It was a large tree (14 feet in girth); but there were others as high, and of rather greater diameter. When struck it was full of sap.

The mechanical effects of the lightning were violent. The main trunk of the tree, which appears to have stood about 12 feet high before sending off branches, was rent from top to bottom; some of the branches were broken off; all were thrown down and implicated together, and for some distance upward fissured and twisted: some of the roots were split a yard or more from the stem. A large mass from the northern side of the tree was driven out, and carried through the air 127 feet, in the direction of the magnetic meridian, to N.N.W. Its weight was $2\frac{1}{2}$ cwt.

The main stem was entirely denuded of the bark, which was scattered widely around, but most abundantly in a direction opposite to that in which the log of wood was conveyed. Shreds of wood were carried to the north-west and left hanging in the trees.

What remained standing of the stem, as well as the parts which had been displaced, was cleft into wedges, by vertical radiating fissures parallel to the laminæ of medullary rays; and these wedges were again cleft by other vertical fissures concentric to the axis of the tree, and coinciding with the annual bands of large vertical vessels, which are conspicuous in cross sections of the oak. Where these cleavages produced the fullest effect, the wood was divided into long slender prismatic shreds like lucifer matches. These split masses were much twisted.

For all these phænomena a simple mechanical cause appears sufficient, viz. an internal expansion and bursting of the main stem of the tree, along the surfaces which, by the structure of the tree, admitted of the most easy separation, and contained at the time abundance of liquid sap, capable of assuming the form and force of elastic vapour. Hence, in the first place, the destruction of the main stem by explosion; the projection of the bark and woody fragments, and the minute and regular cleavage of the fibres. The stem being destroyed as a support, the branches fell in ruinous aggregation round it.

It appears that a laburnum-tree, situated about 12 yards to the east, had been twice struck by lightning, first (I believe) in 1834, and again in 1844. It was split, but not barked.

An elm, situated about 100 yards to the north, was struck, and in like manner split, but not barked. These differences may perhaps be due to the difference of structure in the wood; but in all cases, before attempting to explain the phænomena observed as the effects of lightning, it is desirable to be informed of the time of year when the trees were struck.

The precise points of entrance and exit of the lightning cannot be stated in the case now before us. A small quantity of black powder was found in the fissured parts of the wood, at the base of the twisted branches, but nothing was observed which could determine the cause or the chemical effects of the electrical agent*.

On Isoclinal Magnetic Lines in Yorkshire. By Professor PHILLIPS, *F.R.S.*

The author stated, that about fifteen years since, in the course of some experimental researches on terrestrial magnetism, his attention was caught by the apparently deep flexures of the isoclinal lines in Yorkshire, flexures certainly independent of local magnetic polarities. As a general inference from his inquiries, he suggested the dependence of these flexures on the physical configuration of the country, the isoclinals advancing northward on and toward the hills, and retiring southward in the valleys. (See Brit. Assoc. Reports for 1836, p. 51.)

The observations on which this conclusion was based, were made by means of instruments which the author had himself constructed. For verification of these and other results, he procured, in 1837, an excellent six-inch dip circle of Robinson, and has now obtained an additional set of determinations with this new instrument, which may be confidently trusted, with careful manipulation and in *magnetic weather* not unfavourable, to one minute of a degree or less.

The results, being collected either by combination into five lines nearly parallel to the magnetic meridian, or into groups which represent separately the elevated and depressed portions of the surface, agree with the inferences which were presented to the Association in 1836; the isoclinals retiring southward in the vale of York, and advancing northward both on the eastern and the western hills.

The author showed the general probability of this result from other sources of evidence, remarking on the fact, that in plain and even countries the *local isoclinals* were parallel to or deviated but little from the *general isoclinals* obtained by the method of least squares, while in the hilly districts, as the Cumbrian tract, North Wales, South Wales, and the mountain tracts of Ireland, the *local isoclinals* were much but still systematically bent from their general direction, and sometimes (as between Criffel and Skiddaw) crowded together in a singular manner.

He noticed as desirable, for the complete reduction of delicate observations of this nature, a set of careful measures on the diurnal variation of dip. His own researches on this point indicated a single daily progression, with a maximum at 9 A.M., mean at 3 P.M., and minimum at 9 P.M. The hours however, and the amount of difference from maximum to minimum, appeared subject to much fluctuation. On an average about three minutes appeared to be the difference (in summer) between maximum and minimum.

Possibly the deduction of this variation, by resolving the horizontal and vertical forces in the direction of total force, would be preferable. [The late researches of Mr. A. Broun, by whom the periodical variations of the dip had been traced at Makerstoun, were here referred to.] The dip at York appeared to be, on an average of thirteen years, diminishing about 2′·3 in a year. The author proposed to increase the number of stations to fifty before submitting the results to a final and rigorous computation.

On the Refractive Indices of several Substances.
By the Rev. Prof. BADEN POWELL, *F.R.S. &c.*

Having on former occasions endeavoured to extend the list of observed indices for the standard rays of the solar spectrum given by prisms of different media, by means of an apparatus described, along with the statement of the results, in my report to the British Association, 1839, I now beg to offer to the Association the indices in like manner obtained for the four following media. The rare oil of spikenard I received through a friend from the late Mr. Hatchett, by whom it was carefully prepared perfectly pure; for the other three I am indebted to Mr. Nevil Story Maskelyne. The results in each case are the means of several repetitions. In two instances (the oils of lavendar and sandal-wood), the absorption of the violet rays (as in so many

* Since the Report was presented, Mr. Wauchope has cleared a larger portion of the roots, and has found them split and *blackened* considerably.

other oils) was such as to render the line H very indistinct; its index is therefore marked as doubtful.

μ for the standard rays.							
Medium.	B.	C.	D.	E.	F.	G.	H.
Oil of Spikenard, temp. 22° Centig.	1·4732	1·4746	1·4783	1·4829	1·4868	1·4944	1·5009
Oil of Sandal-wood, temp. 20°.........	1·5034	1·5058	1·5091	1·5117	1·5151	1·5231	1·5398?
Oil of Lavender, temp. 20°	1·4641	1·4658	1·4660	1·4728	1·4760	1·4837	1·4930?
Benzole, temp. 18° ...	1·4895	1·4961	1·4978	1·5041	1·5093	1·5206	1·5310

In my report (1839) I stated the impossibility of obtaining measures in chromate of lead from the absence of all appearance of lines, and the entire absorption of the blue and violet portion of the spectrum. I have since thought that in the absence of any determinations of the kind it might not be useless to give the very rough estimates which my former attempts enable me to obtain by means of the absorption of blue glass, which gave a point roughly corresponding to about B, another to D, and the extreme green space visible might be about E. The most refracted of the two spectra (given by the double refraction of the substance) was the worst defined; and in this the part corresponding to D is extremely uncertain. The mean of two sets of observations was as follows:—

Prism of chromate of lead, axis of prism perpendicular to axis of crystal, mean angle obtained by reflexion and by measurement=14° nearly.

	1st Spectrum.		2nd Spectrum.	
Ray.	Δ.	μ.	Δ.	μ.
Extreme red about B.......	22° ′	2·53	26° 30′	2·84
„ about D	23 10	2·55	29 ?	3·0
„ about E	24 30	2·70	30 30	3·10

While upon the subject I may be allowed to remark, that as attempts are now making, with so much promise, for procuring optical glass of a superior quality, it would be highly interesting if specimens were cut into prisms (portions of ½ an inch cube, or even less, will do, and two sides only need be polished, containing an angle of about 60°), so as to subject the glass to the *very delicate test of the visibility of the finer lines of the spectrum.* I have reason to think that working opticians are not generally aware that in many specimens, *apparently very clear,* only a *few* of the broader lines can be seen, and *very often none*; whereas in Fraunhofer's glass nearly 600 were visible.

Erratum in the Table, Brit. Assoc. Report, 1839, p. 10.
Nitric acid, Ray G, *for* 1·4855 *read* 1·4155.

On a New Solid Eye-piece. By the Rev. J. B. Reade, *F.R.S.*

The author stated that he had been able to get rid of the two well-known defects of the common negative eye-piece, viz. a play of false light and the formation of a false image, or as it is generally termed, *a ghost* of a planet or star, by simply filling the eye-piece with water. The addition of the water causes the ray of light to pass to the eye without suffering any inner reflexions from the surfaces of the lenses of the eye-piece. It also makes the eye-piece positive instead of negative, while at the same time the magnifying power remains nearly the same, the magnitude and flatness of the field are preserved, and the achromatism is not disturbed. It is however desirable to make the inner surface of the field lens a little convex, as the ray now passes out of glass into water, and not into air. The Astronomer Royal of Scotland, after trying the eye-piece upon Saturn, double stars and clusters, expressed a very decided opinion as to its admirable performance generally, as well as the increased blackness of the field, owing to the absence of all false light. To avoid some little trouble arising from the use of water, the author proposes to substitute glass or rock-crystal for the water, and to cement the surfaces together with Canada balsam; but in this case the inner surfaces of the eye and field lens must have a diminished radius of curvature. It was added, that the use of an eye-hole, exactly as in the eye-piece of a Gregorian telescope, is not only desirable, but for large object-glasses indispensable. Without it, the aperture of an object-glass must be reduced to three or four inches when turned upon the sun, or the dark glasses will infallibly be cracked; but with it, all injurious heat is stopped out, and the full aperture can be used as in the case of a Gregorian of seven or eight inches in diameter. This arises from the different refrangibility of the rays of light and heat. In the ordinary use of a prism, it is well known that the rays of heat are less refrangible than the rays of light, and are in fact at a maximum beyond the red rays of the spectrum; but when the sun's rays are brought to a focus by means of an achromatic object-glass, the author finds that the point of most intense heat is within the focus of the compound lens. In a direct experiment with a six-inch object-glass of Tulley's, he found that black glazed paper was not burnt, but only smoked, when held two inches beyond the focus; at one inch it took fire in thirty-nine seconds, at half an inch in twenty-seven seconds, at the focus in twenty-four seconds, at a quarter of an inch *within the focus* in eleven seconds, at half an inch within in fourteen seconds, and at one inch within in nineteen seconds. Hence it follows, from the different position of the principal foci of light and heat, that the eye-piece which makes the image rays parallel, leaves the hot rays divergent and passing to some extent on the outside of the illuminating rays, and the eye-hole becomes essentially important, not only for the general purpose of stopping out false light, but particularly for stopping out all injurious heat during the examination of the sun with large telescopes.

On the Expansion of Solids by Heat. By RICHARD ROBERTS.

The author stated, that having some years since added the manufacture of clocks to his business of machinist, he, in order to be able to construct a good and cheap compensation pendulum, consulted tables of the expansion of solids published by many eminent men of science, but found them to differ very considerably; he therefore determined to make a series of experiments upon the various metals specified in the annexed tables, in which the rods were all thirteen feet long; the metal and glass rods were three-quarters of an inch in diameter, whilst those of wood had a cross section of an inch by one and five-eighths. The metal rods were wrapped in listing to prevent, as far as possible, any change of temperature during their removal from the stove to the measuring apparatus. The first experiment was made about 6 A.M., summer and winter, the rod being at the temperature of the atmosphere, through having lain all night in a shed open at one side. The second experiment was made about noon, the rods and thermometer having previously been three or four hours in a stove over a steam-engine boiler. To ensure uniformity of expansion throughout their length, the rods, whilst in the stove, were placed in a box, which was suspended at different heights from the boiler, according to the degree of heat required. The rods were taken out of the stove separately and measured, which operation, as the apparatus was only a few yards from the stove, occupied only forty seconds. The third experiment was made three or four hours later in the day, the rods having again been stoved. The apparatus used for measuring was as follows: on the outer side of a fire-proof brick building is a flight of steps, the hand-rail of which is fastened to the wall (27 inches thick) at an angle of 40° to the horizon, a little beyond the lower end of the hand-rail a piece of planed cast-iron is wedged securely into the walls, and to it is fastened an angular piece of iron, likewise planed, whose higher edge coincides with the middle of the first-mentioned piece, and is at right angles to the wall and hand-rail. A little beyond the upper end of the hand-rail another piece of cast-iron is wedged into the wall, upon which piece are two carriers, through which a micrometer-screw having ten threads to the inch passes. On the screw, between the carriers, is a brass nut 3½ inches in diameter, whose periphery is divided into a hundred equal parts, therefore the screw (being prevented from turning by a pin projecting into a groove in the piece supporting the carriers) will advance through a space equal to $\frac{1}{1000}$ of an inch for each division through which the nut shall be turned. Pieces of wood are placed on the hand-rail to support the rod, in a direct line with the apparatus. The expansion has been ascertained in each case from experiments made on the same day; consequently the apparatus could not have altered materially between the compared experiments. The tables exhibited show the average expansion of the substances enumerated, deduced from numerous experiments made at temperatures between 30° and 150° Fahr., but as none of the materials expand in a uniform degree by equal increments of temperature (in some of them the expansion is very anomalous), the author purposes extending his experiments, with a view of ascertaining the amount of expansion due to every 10° of temperature, from 30° to 130°, or 140°.

Table I.—Linear expansion for 1° (Fahr.) of the undermentioned materials, obtained at temperatures between 30° and 150°. Average of 60 experiments.

Zinc, cast	·21385	Bagnall's common iron	·08503
Zinc, tube	·17714	Daw's best ditto	·08481
Block tin, tube	·19384	Low moor	·08452
Block tin, cast	·16280	Eglinton, Clyde, and Glenarnock	·08108
Muntz's metal	·13737	Steel, cast	·07746
Brass, drawn	·13200	Steel, shear	·07674
Brass, watch	·12585	Langloan (CI. No. 3)	·07581
Gun-metal	·12738	Langloan, ditto	·07499
Copper, drawn	·12132	Glass, solid	·05392
Copper, cast	·12111	Glass, tube	·05144

Table II.

	Gen. Roy.	Dulong and Petit.	Troughton.	Smeaton.	Lavoisier.	R. Roberts.
Glass, flint	·04311	·04788	....	·04629	·04509	·05268
Steel	·06359	....	·06610	·06805	·05993	·07710
Iron, cast	·06170	·06566	....	·06988	....	·07729
Iron, wrought	....	....	·08000	....	·06865	·08478
Copper	....	·09545	·10660	·09444	·09569	·12121
Brass	....	....	·10660	·10416	·10370	·12892
Tin	....	....	....	....	·12072	·17832
Zinc	....	....	....	....	....	·19549

Table III.—Amount of expansion and contraction for 1° (Fahr.) of the wooden rods, obtained at temperatures between 54° and 90°.

Pine, St. John's.		Pine, varnished.		Cedar.		Cedar, varnished.		Baywood.		Baywood, varn.		
Expan.	Contrac.	Expan.	Contrac.	Expan.	Contrac.	Expan.	Contrac.	Expan.	Contrac.	Expan.	Contrac.	
....	·03788	....	·01836	....	·06773	....	·03444	....	·06429	....	·02525	Fine.
....	·00366	·01465	....	·01343	....	·01343	....	....	·00366	·02442	....	Fine.
....	·01612	·02357	....	....	·01612	·00992	....	....	·01116	·01861	....	Cloudy.
·00809	....	·01214	....	....	·00506	·01417	....	....	·00809	·02125	....	Fine.
....	·01895	....	·00111	....	·02898	....	·00111	....	·02786	·00334	....	Fine & cloudy.
....	·02497	·00000	....	....	·02996	....	·01098	....	·03096	....	·00998	Ditto.
....	·02591	....	·00585	....	·03927	....	·00919	....	·03428	·00585	....	Ditto.
·00809	·12749	·05036	·02532	·01343	·18712	·03752	·05572	....	·18030	·07347	·03523	
·00809	·02124	·01259	·00844	·01343	·03118	·01250	·01393	....	·02575	·01469	·01761	

The figures in all these Tables require four ciphers to be prefixed to them.

The first five columns in Table II. show the linear expansion for 1° (Fahr.) of seven metals, at temperatures between 32° and 212°, extracted from the works of the author, named at the head of each. The last column contains the average linear expansion from a series of experiments between 30° and 150°.

TABLE IV.

Amount of expansion and contraction for 1° (Fahr.) of the wooden rods, obtained at temperatures between 44° and 80°.

Pine, St. John's.		Pine, varnished.		Cedar.		Cedar, varnished.		Baywood.		Baywood, varnd.		
Expan.	Contrac.	Expan.	Contrac.	Expan.	Contrac.	Expan.	Contrac.	Expan.	Contrac.	Expan.	Contrac.	
·02036	....	·02036	....	·01583	....	....	....	·02262	....	·02941	....	Fine.
·00932	....	·00466	....	·00932	....	·00466	....	·01165	....	·01165	....	Dry.
·00357	....	·01431	....	·00178	....	·02772	....	·00983	....	·02146	....	Dull.
·00281	....	·01031	....	·00469	....	·01594	....	·00562	....	·02251	....	Cloudy.
·03606	....	·04964	....	·03162	....	·04832	....	·04972	....	·08503	....	
·00901	....	·01241	....	·00790	....	·01610	....	·01243	....	·02125	....	

TABLE V.

Amount of expansion and contraction for 1° (Fahr.) of the wooden rods, obtained at temperatures between 44° and 144°.

Pine, St. John's.		Pine, varnished.		Cedar.		Cedar, varnished.		Baywood.		Baywood, varnd.		
Expan.	Contrac.	Expan.	Contrac.	Expan.	Contrac.	Expan.	Contrac.	Expan.	Contrac.	Expan.	Contrac.	
....	·00930	·00500	....	....	·03291	....	....	....	·01359	....	·00071	Rain.
·00575	....	·01110	....	·00123	....	....	....	·01316	....	·02385	....	Clear.
....	·00538	....	·00153	....	·03461	....	....	....	·01230	·00153	....	Wet.
....	·00911	·00079	....	....	·02696	....	·01070	....	·01030	·00000	......	Dull & moist.
·00575	·02379	·01689	·00153	·00123	·09448	....	·01070	·01316	·03619	·02538	·00071	
·00575	·00793	·00563	·00153	·00123	·03149	....	·01070	·01316	·01206	·00846	·00071	

TABLE VI.

Amount of expansion and contraction for 1° (Fahr.) of the wooden rods, obtained at temperatures between 34° and 134°.

Pine, St. John's.		Pine, varnished.		Cedar.		Cedar, varnished.		Baywood.		Baywood, varnd.		
Expan.	Contrac.	Expan.	Contrac.	Expan.	Contrac.	Expan.	Contrac.	Expan.	Contrac.	Expan.	Contrac.	
·01040	....	·01226	....	·00222	....	·01114	....	·01114	....	·01709	....	Fine.
·01171	....	·01405	....	·00390	....	·02108	....	·01171	....	·02030	....	Fine.
·00966	....	·00966	....	·00074	....	·00966	....	·00966	....	·01709	....	Fine.
·03177	....	·03597	....	·00686	....	·04188	....	·03251	....	·05448		
·01059	....	·01199	....	·00228	....	·01396	....	·01083	....	·01816		

On the mode of Disappearance of Newton's Rings in passing the angle of total Internal Reflexion. By Professor Stokes, *M.A.*

When Newton's rings are formed between the under surface of a prism and the upper surface of a lens, there is no difficulty in increasing the angle of incidence so as to pass through the angle of total internal reflexion. When the rings are observed with the naked eye in the ordinary way, they appear to break in the upper part on approaching the angle of total internal reflexion, and pass nearly into semicircles when that angle is reached, the upper edges of the semicircles, which are in all cases indistinct, being slightly turned outwards when the curvature of the lens is small.

The cause of the indistinctness will be evident from the following considerations. The *order* of the ring (a term here used to denote a number not necessarily integral) to which a ray reflected at a given obliquity from a given point of the thin plate of air belongs, depends partly on the obliquity and partly on the thickness of the plate at that point. When the angle of incidence is small, or even moderately large, the rings would not be seen, or at most would be seen very indistinctly, if the glasses were held near the eye, and the eye were adapted to distinct vision of distant objects, because in that case the rays brought to a focus at a given point of the retina would correspond to a pencil reflected at a given obliquity from an area of the plate of air, the size of which would correspond to the pupil of the eye; and the order of the rays reflected from this area would vary so much in passing from the point of contact outwards that the rings would be altogether confused. When, however, as in the usual mode of observation, the eye is adapted to distinct vision of an object at the distance of the plate of air, the rings are seen distinctly, because in this case the rays proceeding from a given point of the plate of air, and entering the pupil of the eye, are brought to a focus on the retina, and the variation in the obliquity of the rays forming this pencil is so small that it may be neglected.

When, however, the angle of incidence becomes nearly equal to that of total internal reflexion, a small change of obliquity produces a great change in the order of the ring to which the reflected ray belongs, and therefore the rings are indistinct to an eye adapted to distinct vision of the surfaces of the glass. They are also indistinct, for the same reason as before, if the eye be adapted to distinct vision of distant objects.

To see distinctly the rings in the neighbourhood of the angle of total internal reflexion, the author used a piece of blackened paper in which a small hole was pierced with the point of a needle. When the rings were viewed through the needle-hole, in the light of a spirit-lamp, the appearance was very remarkable. The first dark band seen within the bright portion of the field of view where the light suffered total internal reflexion was somewhat bow-shaped towards the point of contact, the next still more so, and so on, until at last one of the bands made a great bend and passed under the point of contact and the rings which surrounded it, the next band passing under it, and so on. As the incidence was gradually increased, the outermost ring united with the bow-shaped band next above it, forming for an instant a curve with a loop and two infinite branches, or at least branches which ran out of the field of view: then the loop broke, and the curve passed into a bulging band similar to that which had previously surrounded the rings. In this manner the rings, one after another, joined the corresponding bands till all had disappeared, and nothing was left but a system of bands which had passed completely below the point of contact, and the central black spot which remained isolated in the bright field where the light suffered total internal reflexion. Corresponding appearances were seen with daylight or candlelight, but in these cases the bands were of course coloured, and not near so many could be seen at a time.

On Metallic Reflexion. By Professor Stokes, *M.A.*

The effect which is produced on plane-polarized light by reflexion at the surface of a metal, shows that if the incident light be supposed to be decomposed into two streams, polarized in and perpendicularly to the plane of reflexion respectively, the *phases* as well as the intensities of the two streams are differently affected by the reflexion. It remains a question whether the phase of vibration of the stream polarized in the plane of reflexion is accelerated or retarded relatively to that of the stream polarized perpendicularly to the plane of reflexion. This question was first decided by the Astronomer Royal, by means of a phænomenon relating to Newton's rings when formed between a speculum and a glass plate. Mr. Airy's paper is published in the Cambridge Philosophical Transactions. M. Jamin has since been led to the same result, apparently by a method similar in principle to that of Mr. Airy. In repeating Mr. Airy's experiment, the author experienced considerable difficulty in observing the phænomenon. The object of the present communication was to point out an extremely easy mode of deciding the question experimentally. Light polarized at an azimuth of about 45° to the plane of reflexion at the surface of the metal was transmitted, after reflexion, through a plate of Iceland spar, cut perpendicular to the axis, and analysed by a Nicol's prism. When the angle of incidence was the smallest with which the observation was practicable, on turning the Nicol's prism properly the dark cross was formed almost perfectly; but on increasing the angle of incidence it passed into a pair of hyperbolic brushes. This modification of the rings is very well known, having been described and figured by Sir D. Brewster in the Philosophical Transactions for 1830. Now the question at issue may be immediately decided by observing in which pair of opposite quadrants it is that the brushes are formed, an observation which does not present the slightest difficulty. In this way the author was led to Mr. Airy's result, namely that as the angle of incidence increases from zero, the phase of vibration of light polarized in the plane of incidence is *accelerated* relatively to that of light polarized in a plane perpendicular to the plane of incidence.

On a Fictitious Displacement of Fringes of Interference. By Professor Stokes, *M.A.*

The author remarked that the mode of determining the refractive index of a plate by means of the displacement of a system of interference fringes, is subject to a theoretical error depending upon the dispersive power of the plate. It is an extremely simple consequence (as the author showed) of the circumstance that the bands are broader for the less refrangible colours, that the point of symmetry, or nearest approach to symmetry, in the system of displaced fringes, is situated *in advance* of the position calculated in the ordinary way for rays of mean refrangibility. Since an observer has no other guide than the symmetry of the bands in fixing on the centre of the system, he would thus be led to attribute to the plate a refractive index which is slightly too great.

The author has illustrated this subject by the following experiment. A set of fringes, produced in the ordinary way by a flat prism, were viewed through an eye-piece, and bisected by its cross wires. On viewing the whole through a prism of moderate angle, held in front of the eye-piece with its edge parallel to the fringes, an indistinct prismatic image of the wires was seen, together with a *distinct* set of fringes which lay *quite at one side* of the cross wires, the dispersion produced by the prism having thus occasioned an *apparent* displacement of the fringes in the direction of the general deviation.

In conclusion, the author suggested that it might have been the fictitious displacement due to the dispersion accompanying eccentrical refraction, which caused some philosophers to assert that the central band was black, whereas, according to theory, it ought to be white. A fictitious displacement of half an order, which might readily be produced by eccentrical refraction through the lens or eye-piece with which the fringes were viewed, would suffice to cause one of the two black bands of the first order to be the band with respect to which the system was symmetrical.

On Haidinger's *Brushes. By* Professor Stokes, *M.A.*

It is now several years since these brushes were discovered, and they have since been observed by various philosophers, but the author has not met with any observations made with a view of investigating the action of different colours in producing them. The author's attention was first called to the subject, by observing that a green tourmaline, which polarized light very imperfectly, enabled him to see the brushes very distinctly, while he was unable to make them out with a brown tourmaline which transmitted a much smaller quantity of unpolarized light. He then tried the effect of combining various coloured glasses with a Nicol's prism. A red glass gave no trace of brushes. A brownish yellow glass, which absorbed only a small quantity of light, rendered the brushes very indistinct. A green glass enabled the author to see the brushes rather more distinctly than they were seen in the light of the clouds viewed without a coloured glass. A deep blue glass gave brushes of remarkable intensity, notwithstanding the large quantity of light absorbed. With the green and blue glasses, the brushes were not coloured, but simply darker than the rest of the field.

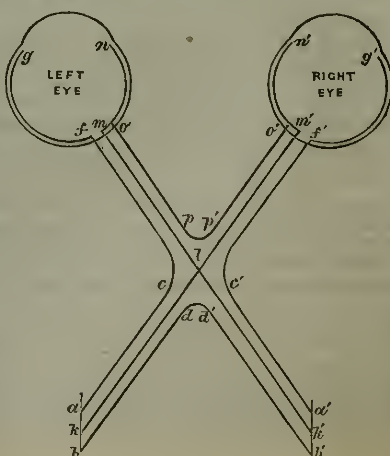
To examine still further the office of the different colours in producing the brushes seen with ordinary daylight, the author used a telescope and prism mounted for showing the fixed lines of the spectrum. The sun's light having been introduced into a darkened room through a narrow slit, it was easy, by throwing the eye-piece a little out of focus, to form a pure spectrum on a screen of white paper, placed a foot or two in front of the eye-piece. On examining this spectrum with a Nicol's prism, which was suddenly turned round from time to time through about a right angle, the author found that the red and yellow did not present the least trace of brushes. The brushes began to be visible in the green, about the fixed line E of Fraunhofer. They became more distinct on passing into the blue, and were particularly strong about the line F. The author was able to trace them about as far as the line G; and when they were no longer visible, the cause appeared to be merely the feebleness of the light, not the incapacity of the greater part of the violet to produce them. With homogeneous light, the brushes, when they were formed at all, were simply darker than the rest of the field, and, as might have been expected, did not appear of a different tint. In the blue, where the brushes were most distinct, it appeared to the author that they were somewhat shorter than usual. The contrast between the more and less refrangible portions of the spectrum, in regard to their capability of producing brushes, was most striking. The most brilliant part of the spectrum gave no brushes; and the intensity of the orange and more refrangible portion of the red, where not the slightest trace of brushes was discoverable, was much greater than that of the more refrangible portion of the blue, where the brushes were formed with great distinctness, although *cæteris paribus* a considerable degree of intensity is favourable to the exhibition of the brushes.

These observations account at once for the colour of the brushes seen with ordinary daylight. Inasmuch as no brushes are seen with the less refrangible colours, and the brushes seen with the more refrangible colours consist in the removal of a certain quantity of light, the tint of the brushes ought to be made up of red, yellow, and perhaps a little green, the yellow predominating, on account of its greater brightness in the solar spectrum. The mixture would give an impure yellow, which is the colour observed. The blueness of the side patches may be merely the effect of contrast, or the cause may be more deeply seated. If the total illumination perceived be independent of the brushes, the light withdrawn from the brushes must be found at their sides, which would account, independently of contrast, both for the comparative brightness and for the blue tint of the side patches.

The observations with homogeneous light account likewise for a circumstance with which the author had been struck, namely, that the brushes were not visible by candlelight, which is explained by the comparative poverty of candlelight in the more refrangible rays. The brushes ought to be rendered visible by absorbing a certain quantity of the less refrangible rays, and accordingly the author found that a blue glass, combined with a Nicol' sprism, enabled him to see the brushes very distinctly when looking at the flame of a candle. The specimen of blue glass which showed them best, which was of a tolerably deep colour, gave brushes which were decidedly red, and were only comparatively dark, so that the difference of tint between the brushes and side patches was far more conspicuous than the difference of intensity. This is accounted for by the large quantity of extreme red rays which such a glass transmits. That the same glass gave red brushes with candlelight, and dark brushes with daylight, is accounted for by the circumstance, that the ratio which the intensity of the transmitted red rays bears to the intensity of the transmitted blue rays is far larger with candlelight than with daylight.

An Attempt to explain the occasional distinct Vision of Rapidly Revolving Coloured Sectors. By Prof. Stevelly, *LL.D.*

The author exhibited an instrument for whirling cards with coloured sectors on them, devised by Mr. Grattan of Belfast, to teach his children the effect of combining colours. He had shown this at the Natural History Society with an application for enabling painters to determine, experimentally, the mixture of any number of colours, and their relative proportions to produce the exact effect which they required. This apparatus he had lent to Prof. Stevelly to show his class; and while doing so he was surprised to observe, that while the cards were revolving rapidly, if he suddenly turned away his head he caught a distinct view of the individual coloured sectors at the instant he was losing sight of them by a side view. A few weeks before this he had attended the lectures of Prof. Carlile, of Queen's College, Belfast, on the anatomy of the eye and of the ear; and had then become aware of a circumstance connected with the arrangement of the optic nerves and their relation to the retina, which seemed to him to afford an explanation of this curious fact. The optic filaments which originated in the right side of the brain and crossed over to the left eye, on entering that eyeball, only expanded into that part of the retina which spread over the portion of the eyeball next the nose; and the similar portion of the retlna of the right eye was supplied by optic filaments which sprang from the left side of the brain. These nerves, however, were united in their action by commissural fibres, which stretched in an arch from the one to the other. The other and larger portion of the retina of each eye, and that on which the images of objects as usually seen were depicted, was formed by filaments which sprang from the brain in each case on the side next the eye to which they went; these, after accompanying the optic filaments of the other eye to the place where they crossed the optic nerve going to its own eye, turned round with a bend and accompanied the latter in its passage into the eyeball. These portions of the retina of the different eyes were also united into one nervous action by the commissure of the retina; so that the retina of each eye was divided into two portions,—the portion next the nose, and the outer and larger portion; and these two portions of each eye were supplied by filaments springing from opposite sides of the brain, and not united in their action by any commissure or connecting nerve. Now, the consequence of the sudden turn of the head was, to throw the image from its usual place on to the portion of the retina next the nose, affecting a new and fresh part of the retina for an instant only, for the motion of the head instantly interposed the socket of the eye and shut off the object. The sectors therefore became distinct at that instant, for a similar reason that in the beautiful experiment of Prof. Wheatstone the electric spark showed them distinct, viz. the instantaneousness of the impression on a nervous expansion coming from the opposite side of the brain, and having an entirely distinct action. Prof. Stevelly hazarded a conjecture, that one use of this arrangement might be to arrest the attention of the owner of the eye, and direct it from objects in the direction of the optic axes to those moving objects on the side from which danger might arise. The use of this to man in his less civilized state, as well as to the lower animals, is obvious. The accompanying diagram from Mayo, was kindly furnished by Prof. Carlile, and will render the above descriptions more perspicuous.



abdc, *a'b'd'c'*, optic tracts; *cfop*, *c'f'o'p'*, optic nerves; *cpp'c'd'd*, commissure of optic nerves.

acf, *a'c'f'*, external filaments of the optic tracts and optic nerves, which are expanded into the portions of the retinæ; *fg*, *f'g'*, most distant from the nose.

klm', *k'lm*, central filaments of the optic tracts and optic nerves, which are expanded into the portions of the retinæ, *m'n'*, *mn*, nearest to the nose.

bdd'b', internal filaments of the optic tracts, which join those tracts together; *opp'o'*, internal filaments of the optic nerves conjoining the inner portions of the retinæ, *mn*, *m'n'*.

On the Theory of Magnetic Induction in Crystalline Substances. *By* Prof. W. Thomson.

Plücker's admirable discovery of the directive action experienced by crystals in a magnetic field, renders it an object of the highest interest to establish a theory of magnetic induction in crystalline substances. A theory founded on Poisson's original suggestion regarding the possible magnetic structure of crystalline matter, which has exclusive reference to the hypothesis, now universally rejected, of "magnetic elements," each containing "northern and southern magnetic fluids" in equal quantities, could not be received in the present state of science. The author of this communication stated two principles, involving no physical hypothesis regarding the ultimate nature of magnetization, which he considered to be a sufficient foundation for a complete mathematical theory of magnetic induction. One of these, which he calls the superposition of magnetic inductions, cannot be considered as fully established by experiment; but it is probably true, or approximately true, in a great variety of actual cases, especially those in which the capacity for magnetic induction is very feeble. On the other hand, it is not probable that it is even approximately applicable to soft iron in a state of intense magnetization (such as may be produced by electro-magnetic means), since it is hardly to be conceived that iron in such a state could be as open to additional magnetization from another magnet as non-magnetized soft iron. The theory indicates with clearness and precision how any deviations from this principle, which experiment may point out, are to be taken account of. The author proceeded to indicate some of the conclusions which may be drawn by mathematical reasoning, from the two principles which he had stated, and gave the steps of a demonstration of the existence of three axes at right angles to one another in every crystalline substance, possessing certain symmetrical properties with reference to inductive magnetization, in virtue of which they may be called "principal axes of magnetic induction."

In conclusion the author remarked, that, although on first reading a paper "on the Magneto-optic Properties of Crystals" by Messrs. John Tyndall and Hermann Knoblauch, recently published in the Philosophical Magazine (July), he considered that there would be some difficulty in reconciling the views of these writers with his theory; yet the opportunity the British Association had afforded him of discussing personally with Mr. Tyndall some of the points of difference, gave him reason for hoping that a complete agreement would ultimately be established.

On the Magneto-Optical Properties of Crystals. *By* John Tyndall.

Astronomy, Meteors, Waves.

On a Sidereal Clock for showing the Arc of Right Ascension directly. *By* Prof. Chevallier, *F.R.S.*

On the alleged evidence for a Physical Connexion between Stars forming Binary or Multiple Groups, deduced from the Doctrine of Chances. *By* James D. Forbes, *F.R.S., Corr. Member of the Institute of France, &c.*

An opinion has long obtained amongst astronomers that the great number of cases which occur in the heavens of two or more stars being apparently very close to one another (constituting what have been called double, triple or multiple stars), constitutes of itself an argument for a more than *apparent* connexion between the members of those groups.

It is evident that two stars may constitute an *apparently* double star without any real proximity between them, merely because a line passing through the eye of the spectator and the nearer star may, if prolonged into space (no matter how far), pass somewhere near a second star, whose position would therefore seem almost to coincide with the first, although the distance which separates them might be indefinitely great. Such stars are sometimes said to be "optically" double. On the other hand, it may happen that the two stars are really as well as seemingly near, and may act upon one another by their mutual attractions, after the manner of sun and planet. Such stars are called "physically" double.

Nearly a century ago the Rev. John Mitchell attempted to deduce from the theory of probabilities, the chances against the fortuitous approximation of two or more stars, supposing the stars generally to be "scattered by mere chance as it might happen." He concludes that there is a probability of 80 to 1 that the two stars β Capricorni are physically connected, and above 500,000 to 1 that the stars of the Pleiades are so. These results have been implicitly adopted by most subsequent writers on probabilities and on astronomy.

The author denies *in toto* the legitimacy of the influences and the possibility of putting a numerical value upon such evidences of physical relation. As *inductive presumptions* of such a connexion, he admits that they have a certain evidence in their favour; but one not more expressible by numbers than that of any physical theory, such as that of gravity. The author endeavours to show that Mitchell has confounded the mere *expectation* of an event which may or may not occur, with the inherent probability that a particular event which *has* occurred, should happen rather than any other possible event. He also shows that Mitchell's mathematical expression of the result of random scattering leads to absurd results, and must therefore be erroneous and delusive.

The following were stated to the meeting as the results at which the author had at that time arrived:—

(1.) The fundamental principle of Mitchell is erroneous. The probability expressed by it is an altogether different probability from what he asserts. His calculations are also apparently inaccurate, in some instances at least.

(2.) All the *numerical* deductions of his successors are equally baseless.

(3.) Were Mitchell's principle just, a perfectly uniform and symmetrical disposition of the stars over the sky would (if possible) be that which could alone afford no evidence of causation, or any interference with the laws of "random;"—a result palpably absurd.

(4.) Special collocations, whether (α) distinguished by their symmetry, or (β) distinguished by an excessive crowding together of stars, or the reverse, inevitably force on the reasoning mind a more or less vague impression of causation;—an impression necessarily vague, having nothing absolute, but depending on the previous knowledge and habits of thought of the individual, therefore incapable of being made the subject of exact (*i. e.* mathematical) reasoning.

On the Distribution of Shooting Stars in the Interplanetary Spaces. By Henry Hennessy.

The attention of the writer having been excited by the periodical return and other remarkable circumstances connected with falls of shooting stars, he proceeded to examine from the data already obtained, the laws of distribution of these bodies in space. Adopting the opinion that these masses circulate either in rings or cloud-like bodies around the sun, the possibility that their distribution may be also dependent on their mean distances from the sun, is brought under consideration. The position of the orbits of the known groups of aërolites, and also the comparative numbers expressing the amount falling at different parts of the earth's orbit, would assist in determining this point. Astronomers appear in general to agree that these groups circulate within the earth's orbit, and from a calculation made by Kaemtz, quoted by Dove*, it seems that the greater proportion of aërolites fall during that half of the year when the earth is near its perihelion. It follows therefore that shooting stars increase in number in going towards the sun. If this conclusion be combined with the views of Colonel Portlock respecting fossil aërolites, as stated at the Swansea meeting of the British Association, it would follow that the earth's mean distance from the sun has been undergoing a secular diminution since the earlier geological epochs. An interplanetary resisting medium would account for this secular inequality, but as observation has not as yet detected it, the truth of the fore-

* Repertorium der Physik, 1841.

going results would require that the periods of geological time should be immense compared to those of history. It is also evident that the explanation of the former high temperature at the earth's surface would more than ever require the hypothesis of its having been once in a state of fusion.

On the Structure of the Lunar Surface and its relation to that of the Earth. By James Nasmyth.

The subject was illustrated by a series of drawings which the author has executed by the aid of a powerful telescope, which he has made for himself for the express purpose of following up his investigations on the subject in question. These appear, from the drawings exhibited and the description given by Mr. Nasmyth, to afford striking illustrations of the nature and action of some of those agencies which in remote periods of the earth's geological history has given to its surface many of its most remarkable features; namely, as to the causes of volcanic action, the protrusion of igneous rocks, the upheaving of mountain ranges, as well as the submersion of extensive portions of the earth's surface, all of which vast geological phænomena Mr. Nasmyth appears to assign to a few grand and simple prime causes, resulting from the consolidation and alternate contraction of the crust and interior of the earth or moon, both of which planets appear to have originally been in a molten condition.

After drawing attention to the vast number and magnitude of crater-formed mountains with which every portion of the moon's surface appears to be covered, Mr. Nasmyth proceeded to give the reasons for the conclusion that these crater-formed mountains are really the craters of extinct lunar volcanos; pointing out the frequent occurrence of the central cone, the result of the last eruptive efforts of an expiring volcano, a feature familiar to all those who have observed volcanic craters on the earth's surface. This central cone Mr. Nasmyth showed to exist in the majority of the lunar craters, and thereby drew the conclusion that they were the result of the same kind of action which has produced craters on the volcanos of the earth.

The cause of the vast numbers of such volcanic mountains with which the lunar surface is bespattered was next considered, and traced to the rapid consolidation and contraction of the crust of the moon, whose mass or bulk being only $\frac{1}{64}$th of that of the earth, while its surface is the $\frac{1}{16}$th, has in consequence of these proportions a radiating or heat-dispensing surface four times greater than that of the earth in relation to its bulk. From this simple geometrical consideration Mr. Nasmyth explained how it was that, by the rapid cooling and collapse of the crust of the moon on its molten interior, the fluid matter under the solid crust was by this "hide-binding" action forced to find an escape through the superincumbent solid crust and come forth in the great volcanic actions which in some remote period of time have covered its surface with those myriads of craters and volcanic features that give to its surface its remarkable character.

The cause of the vast magnitude of the lunar craters was next alluded to, and assigned, as in the former case, to the rapid and energetic collapse of the moon's crust on its yet molten interior. The action as regards *the wide dispersion* of the ejected matter was enhanced by the *lightness* of the erupted matter, the force of gravity which gives the quality of *weight* to matter on the moon as on the earth being very much less on the surface of the moon than on the earth, so that the collapse action had to operate on material probably not half the weight of cork bulk for bulk.

The causes of those vast ranges of mountains seen on the moon's surface were next touched on; and Mr. Nasmyth endeavoured to explain them by the continued progress of the collapse action of the solid crust of the moon crushing down or following the contracting molten interior, which by the gradual dispersion of its heat would retreat from contact with the interior of the solid crust, and permit that to crush down and so force that portion of the original surface *out of the way*, and in consequence of this action assume the form and arrangement of mountain ranges. Mr. Nasmyth, in illustration of this important action, adduced the familiar case of the wrinkling of the surface of an apple, by reason of the contraction of the interior, and the inability of the *surface* to accommodate itself to the change otherwise. The mountain ranges in question Mr. Nasmyth considers to be nothing more or less than the material which in the original expanded globe formed the comparatively level crust of the moon.

The fall of the unsupported crust on the retreating nucleus was described to yield a very probable explanation of the appearance of granitic and igneous centres of certain mountain ranges, as well as the injection of igneous rocks in the form of trap dykes and basaltic formations, which appear to have come forth in this manner from below the crust of the earth, and to have overlaid formations of comparatively very recent formation.

The partial and *gradual* retreat of the molten interior or nucleus from the solidified crust was in like manner suggested as the most probable cause of the submersion of large portions of what had previously been dry land, causing when on a comparatively small scale " Bason formations," and when on a vast scale, and with more sudden action, occasioning the influx of the ocean over the submerged continent, the waters hurling along with them fragments of rock, denuding the surface of the submerged land, and scattering its surface with the wreck in the form of *boulders, gravel, sand* and *clay*.

Mr. Nasmyth suggests the above contracting theory to the most earnest and careful attention of geologists, as the most probable and satisfactory explanation of the cause of those vast torrents, of which the boulder and gravel-covered surface of extensive districts of the earth yield the most striking evidence. Thus have we then, in this grand but simple action of the progressive collapse of the crust of the earth following down after the retreat of the contracting interior, the cause of those tremendous earthquakes, the evidence of which is so clearly indicated by faults and dislocated strata.

The origin or cause of those bright lines which radiate from certain volcanic centres on the moon's surface (Tycho for instance) is alluded to, and illustrated by a very striking experiment of causing the surface of a globe of glass filled with water to collapse on the fluid interior by rapidly contracting the surface while the water has no means of escape. The result was the splitting or cracking up of the surface of the globe in a multitude of radiating cracks, which bear the most remarkable similarity to those on the moon. Mr. Nasmyth further illustrated this subject by reference to the manner in which the surface of a frozen pond may be made to crack by pressure from beneath, so yielding radiating cracks from the centre of divergence where the chief discharge of water will take place, while simultaneously all along the lines of radiating cracks the water will make its appearance; thus explaining how it is that the molten material, which had in like manner been under the surface of the moon during that period of its history, came forth simultaneously up through the cracks, and appeared on the surface as basaltic or igneous overflow, irrespective of surface inequalities. Mr. Nasmyth concluded his address by an earnest appeal to his geological hearers to test the correctness of what he had advanced, by a careful inspection of those vast natural records of the changes which the earth's surface has undergone, of which our mountains, hills and valleys are the mighty monuments, and which shadow forth in characters which science can trace, past events of the most surpassing interest and grandeur, inasmuch as they are the evidences of the handiwork of the all-wise Creator when preparing the earth for the advent of man,

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On Atlantic Waves, their Magnitude, Velocity, and Phænomena. By W. Scoresby, *D.D., F.R.S. L. & E., Member of the Institute of France, American Institute, Philadelphia, &c.*

During *two* passages across the Atlantic in 1847–48, I had opportunities for investigating certain elements respecting deep-sea waves, more favourable than had ever before occurred within my experience in navigation. These opportunities being made available for investigation on every occasion presenting any matter of interest within the time occupied by the steam-ships in which I sailed, I now give the results as a small contribution towards this branch of natural science—the phænomena of *great waves*.

These observations, it should be noted in the outset, and the results deduced from them, were entirely uninfluenced by, and separate from, theory. They form but a contribution, as I have said, to this interesting branch of natural phænomena, but I offer them to the Section the more readily from the circumstance of their entire independency and speciality; and because of the testing which they may derive from Mr. Scott Russell, now present, whose laborious and valuable researches on WAVES have contributed so much to our information.

On my outward passage from Liverpool to Boston, United States, in October 1847, we had a rather hard gale a-head, or nearly a-head, against which, however, notwithstanding the high sea, we were always enabled to make a surprising degree of progress. On this occasion we had a somewhat heavy sea. In the most elevated position which I attained, the height of the eye being about 22 feet above the line of flotation of the ship (the Cambria), the greater proportion of the waves did not rise so high as to intercept the horizon; the average height, consequently, (reckoning from the hollow to the ridge,) was not so much as the elevation of my position. A minor proportion, however, of the waves, comprising about one in four or five, rose so high, in an extended range, as completely to conceal the horizon. These I estimated at 4 or 6 feet above the horizon, giving 26 or 28 feet for their elevation. And this, I apprehend, except in the case of incidental elevations in "topping" or crossing waves, was the highest. But the mean elevation, during this really turbulent sea, must have been very much less; I should suppose scarcely reaching 18 or 20 feet.

It was on our return voyage from America, however, that the highest seas occurred, when the circumstances adapted for interesting observations were singularly favourable; for, whilst the magnitude and the peculiar construction of the upper works of the ship, the Hibernia, afforded various platforms of determinate elevation above the line of flotation for observations on the HEIGHT OF THE WAVES, the direction of the ship's course, with respect to that of waves, was generally so nearly similar as to yield the most advantageous agreement or accordance for observations on their width and velocity. These observations I shall extract, in their order, from my journal kept during the homeward passage.

My first observation, worth recording, is under the date of March 5, 1848, when the ship was in latitude about 51°, and longitude (at noon) 38° 50′ W.; the wind then being about W.S.W., and the ship's course, true N. 52° E. At sunset of the 4th the wind blew a *hard gale*, which, with heavy squalls, had continued during the night, so that all sail was taken in but storm-stay-sail forward. The barometer stood at 29·50 at 8 P.M.; but fell so rapidly as to be at 28·30 by 10 the next morning.

In the afternoon of this day I stood some time on the saloon deck or cuddy roof, a height, with the addition of that of the eye, of 23 ft. 3 in. above the line of flotation of the ship, watching the sublime spectacle presented by the turbulent waters. I am not aware that I ever saw the sea more terribly magnificent. I was anxious to ascertain the height of these mighty waves; but found almost every wave rising so much above the level of the eye, as indicated by the intercepting of the horizon of the sea in the direction in which they approached us, as to yield only the *minimum* elevation, and to show that the great majority of these rolling masses of water possessed a height of considerably *more* than 24 feet (including depression as well as altitude), or, reckoning from the mean level of the sea, of *more* than 12 feet.

Exposed as the situation was, I then adventured to the port paddle-box, which was about 7 feet higher, where the level (as ascertained afterwards at Liverpool, allowance being made for the alteration in the draught of water of the ship) was 24 feet 9 inches above the sea. This position, with 5 feet 6 inches, the height of my eye, gave an elevation altogether of 30 feet 3 inches for the level of the view then obtained; a level, it should be remarked, which was very satisfactorily maintained during the instants of observation, because of the whole of the ship's length being occupied within the clear "*trough* of the sea," and in an even and upright position, whilst the nearest approaching wave had its maximum altitude.

Here, also, I found at least *one-half* of the waves which overtook and passed the ship were far above the level of my eye. Frequently I observed long *ranges* (not acuminated peaks) extending 100 yards, perhaps, on one or both sides of the ship; the sea then coming nearly right aft, which rose so high above the visible horizon as to form an angle estimated at 2 to 3 degrees (say $2\frac{1}{2}°$), when the distance of the wave summit was about 100 yards from the observer; this would add near 13 feet to the level of the eye. And this measure of elevation was by no means uncommon, occurring, I should think, at least once in half-a-dozen waves. Sometimes peaks of crossing or crests of *breaking* seas would shoot upward at least 10 or 15 feet higher.

The *average wave* was, I believe, fully equal to that of my sight on the paddle-box, or more, that is $\frac{30}{2}=15$ feet, or upward; and the *mean highest waves*, not including the broken or acuminated crests, about 43 feet above the level of the hollow occupied at the moment by the ship.

Illuminated as the general expanse not unfrequently was, by the transient sunbeam breaking through the heavy masses of the storm-cloud, and, contrasting its silvery light with the prevalent gloom, yielding a wild and partial glare,—the mighty hills of waters rolling and foaming as they pursued us, whilst the gallant and buoyant ship—a charming "sea-boat"—rose abaft as by intelligent anticipation of their attack, as she scudded along, so that their irresistible strength and fierce momentum were harmlessly spent beneath her and on her outward sides,—the storm falling fiercely on the scanty and almost denuded spars and steam-chimney raised aloft, still indicating its vast, but as to us, innoxious, power in deafening roarings,—altogether this presented as grand a storm-scene as I ever witnessed, and a magnificent example of "the works of the Lord," specially exhibited to sea-going men, "and His wonders in the deep."

In the afternoon of the same day the gale again increased, blowing, especially during the continuance of a much-protracted hail-shower, terrifically, roaring like thunder, whilst we scudded before it, causing the ship to vibrate as by a sympathetic tremor, and the tops of rolling waves, too tardy, rapid as was their actual progress, for the speed of the assailing influence, to be carried off and borne along on the aërial wings in a perfect drift of spray! But during the period of these most vehement operations of nature I was fortunately enabled, from familiarity with sea enterprise, to pursue my observations with entire satisfaction.

The next day, March 6th, added to the interest of these investigations, by developing the character of the Atlantic waves under a long and fiercely continued influence of a little varying wind. It had blown a heavy gale, violent in the showers, from the north-westward, from Saturday evening the 4th to the evening of Sunday, from twenty-six to thirty hours; during the night, too, of Sunday it had again blown hard (abating towards the morning of Monday), and making a total continuance of the storm, in *its violence*, of about thirty-six hours*.

I renewed my observations on the waves at 10 A.M., the storm having been then subdued for several hours, and the height of the waves having perceptibly subsided. Still, I observed, when standing on the saloon-deck, that ten waves, in one case, came in succession, which all rose above the apparent horizon, consequently they must have been more than 23 feet; probably the *average* might be about 26 feet from ridge to hollow. At this period I also found that occasionally (that is, once in about four or five minutes) three or four waves in succession, as seen from the paddle-box, rose *above* the visible horizon; hence they must, like those of the preceding day, have been 30-feet waves. But one important *difference* should be noted, viz. that they were of no *great* extent on the ridge, presenting, though more than mere conical peaks, but a moderate elongation.

Another subject of consideration and investigation, on this occasion, was the period of the regular waves overtaking the ship, and the determination, proximately, of the actual width or intervals, and their velocity.

1. The ship was then going *nine* knots only, the free action of the engines being greatly interfered with by the heavy sea running; and the lines of direction of the waves and the ship's course differed about 22½ degrees, the sea being two points on the larboard quarter; in other words, the true course of the ship was east; the direction *from* whence the sea came was W.N.W.

* The *barometer* on Saturday at 8 P.M. was at 29·50; at 6 A.M. of Sunday it had fallen to 28·30, being 1·2 inch in ten hours; at 6 P.M. of the latter day it had risen to 30·00 inches.

2. The periods of regular waves, in incidental series, overtaking the ship, were observed as follows:—

Waves.		Min.	Sec.	Mean.
20	occupied	5	30	=16″·5
10	„	2	35	=15 ·5
10	„	2	50	=17 ·0
10	„	2	45	=16 ·5
8	„	2	16	=17 ·0
General average............				16 ·5

3. The length of the ship was stated to be 220 feet. The time taken by a regular wave to pass from stern to stem, appeared, on a mean of several observations, to be about *six* seconds.

Hence 6″ : 220 ft. (the width passed over in that time) : : 16·5 to 605 feet (the width passed over betwixt crest and crest). But this extent, by reason of the obliquity of the direction of the waves to the course of the ship, is found to be elongated about 45 feet, reducing the probable mean distance of the waves to 559 feet.

Independently of this process, I had previously estimated the distance of the wave-crests ahead and astern, when the ship was in the hollow, as I stood near the centre of the ship's length on the paddle-box, at 300 feet each way, by comparing the intervals betwixt my position and the place of the wave-crest with the known length of the ship. This comparison, frequently reconsidered and repeated subsequently, yielded, in much accordance with the former, a total width, in the line of the ship's course, of about 600 feet.

4. But the total distance betwixt the crests of two waves, thus reckoned at 559 feet, a distance passed by the wave in 16·5 seconds of time, by no means indicates, it is obvious, the real velocity of the wave, as the ship meanwhile was advancing nearly in the same direction at the rate of nine knots, that is nine geographical miles, or (6075·6 feet ×9=) 54680·4 feet per hour, or 15·2 feet per second. During the time, therefore, of a wave passing the ship=16″·5, the ship would have advanced on its course 16·5×15·2=250·6 feet. Reducing this for the obliquity of two points, we have 231·5 feet to be added to the former measure, 559 feet, which gives 790·5 feet for the actual distance traversed by the wave in 16·5 seconds of time, being at the rate of $\left(\frac{3600'' \times 790{\cdot}5}{16{\cdot}5}\right)$=17251·7 feet, or 32·67 English statute miles per hour.

To know how far this result is but proximate, it should be considered that, of the several elements employed in the calculation, all but one might be deemed accurate. The interval of time occupied by the transit of a wave with respect to the position of the ship, the *direction* of the ship's motion with relation to that of the waves, and the speed of the ship through the water, may all be received as, essentially, accurate. The element in doubt is that of the average distance, from summit to summit, of the waves. This distance, it has been seen, was, by a twofold process of observation or comparison, accordantly assumed. The value of the judgement derived from rapid comparison of measures by an eye accustomed to such estimations, is, it should be observed, far higher than might be generally considered. The practical military commander or engineer officer is able to make, by mere inspection of the ground before him, remarkably close estimates of spaces and distances. When engaged in the Arctic whale-fishery, I was enabled, from habit and comparison of immeasured spaces with known magnitudes, to estimate certain distances with all but perfect accuracy. Thus, as to a circumstance in which we were most deeply interested, the near approach of a boat to a whale, I found it quite practicable, whenever the pursuing boat approached within twice or thrice its length (except when the position was near end on), to estimate the distance to less than a yard.

Now the means of comparison, by the eye, as to the estimation of the breadth of the Atlantic waves, was that of the ship's length of 220 feet. When the ship was fairly in the middle of the depression betwixt two waves, it was assumed, with reference to this known measure, that something obviously less, but not greatly so, than the ship's length was the distance of each of the two waves then contemplated, giving a total width of about 600 feet. But the comparison of the time required by a wave to pass from stern to stem, with the average time of transit of an entire wave, yielded a much better result; and, on much consideration of the subject, I am inclined to believe that the estimate is a literally close approximation to the truth.

It should be observed, too, that the headway of the ship, in the direction of the course of the wave, being a known quantity, was favourable to the accuracy of the estimate. For, assuming an error in the width of the waves to have occurred, say to the amount of one-twelfth of the whole, or 49 feet, the effect upon the calculated *velocity* of the wave would have been only about a sixteenth, or 2·16 miles per hour*.

The form and character of these deep-sea waves became, at the same time, interesting subjects of observation and consideration. In respect to form, we have perpetual modifications and varieties from the circumstance of the inequality of operation of the *power* by which the waves are formed. Were the wind perfectly uniform in direction and force, and of sufficient continuance, we might have, in wide and deep seas, waves of perfectly regular formation. But no such equality in the wind ever exists. It is perpetually changing its direction, within certain limits, and its force, too, both in the same place and in proximate quarters. Innumerable disturbing influences are therefore in operation, generating the varieties more or less observable in natural sea-waves.

In regard to my own observations of the actual forms of waves, nothing particularly new, indeed, could be expected from an inquiry of this kind, in regard to phænomena falling within the perpetual observation of sea-going persons; yet, at the risk of stating what might be deemed common, I will venture to transcribe from my notes made with the phænomena before me, the leading characteristics which engaged my attention.

During the height of the gale (March 6th) the *form* of the waves was less regular than after the wind had for some time begun to subside. Though in many cases, when the sea was highest, the succession of the primary waves was perfectly distinct, it was rather difficult to trace an identical ridge for more than a quarter to the third of a mile. The grand elevation, in such cases, sometimes extended by a straight ridge, or was sometimes bent as of a crescent form, with the central mass of water higher than the rest, and not unfrequently with two or three semi-elliptical mounds in diminishing series, on either side of the highest peak.

These principal waves, too, it should be noted, were not continuously regular, but had embodied in their general mass many minor, secondary and inferior waves. Neither did the great waves go very prevalently in long parallel series like those retarded by shallow water on approaching the shore, but every now and then changed into a bent cuneiform crest with breaking accumulating peaks.

On the following morning, March 7, after a second stormy night, wind S.S.W. (true), we had a heavy and somewhat cross sea (from the change of wind from W.S.W. to S.S.W.). But almost unabated magnitude of the more westerly waves indicated a continuance of the original wind at some distance astern of us. The gale had moderated at daylight, and the weather became fine; but as the sea still kept high, its undulation became more obvious and easily analysed. At three in the afternoon, when about a third part of the greater undulations averaged about 24 feet from crest to hollow in height, these higher waves could be traced, right and left, as they approached the ship to the extent of a quarter of a mile on an average, more or less. Traced through their extent the ridge was an irregular round-backed hill, precipitous often on the leeward side, of waters. The undulations, indeed, as to primary waves, consisted mainly of these round-backed masses, broken into or modified by innumerable secondary and smaller waves within their general body.

The time in which these waves passed the ship was now, on an average, about fifteen seconds, the ship's speed being increased from nine to eleven knots, and the obliquity of the ship's course to the direction pursued by the waves was three points.

On the 9th, two days after the above condition of the waves, whilst the sea yet ran high, few waves could be traced, continuously, above 300 to 400 yards in extent along the same ridge. The crests often curled over, but none so as to reach the height of a 30-feet wave, and broke for a wide space, estimated at 50 to 100 yards in continuity.

* To show the effect of an extreme case, we shall assume an error in the estimated width of the wave of one-half, calling it 279·5 instead of 559 feet. The resulting velocity of the wave would still be 21·14 miles; the error of one-half the width producing an error only of one-third in the velocity.

The mode adopted in these researches of finding the *height* of waves, is, I believe, quite satisfactory, and, observed with care and with relation to numbers or proportion of waves, as accurate as need be. The depression of the horizon in respect to the elevation of the observer is too small to form even a correction. As the horizon from the paddle-box, $\frac{30}{2}=15$ feet, had only a depression of 3′ 49″, the distance of the visible horizon, as seen from this elevation, would be 4·45 statute miles, and the actual depression in feet due to the distance of the summit of the wave when the ship was in the midst of the hollow, could only be 0·18 foot or 2·16 inches.

Other modes of determining the width of a wave, or the extent betwixt summit and summit, much preferable to that described (the only available one I could devise), might easily be adopted where the management of the ship was in the hands of the observer. In steam ships, the simplest mode for high seas, perhaps, would be altering the speed of the ship when going in the direction of the wave or against the wave; the ratios of the times of transit of wave-crests under different rates of sailing of the ship might yield very close results to the truth.

In moderate-sized waves, the plan adopted by Captain Stanley, whose observations I did not meet with before this meeting, seems satisfactory. But in calms or moderate weather, after a storm, that is for the determination of the velocities of less elevated waves, a variety of processes might be available.

The author referred, in conclusion, to the waves near shore, the effect of shallow water — waves entering narrow channels betwixt smooth shelving shores, different from waves entering betwixt rocky (pointed) sides, such as Brassa Sound.

On Cometary Physics. By Prof. Smyth, *F.R.S.E.*

Account of the Edinburgh Observatory. By Prof. Smyth, *F.R.S.E.*

Meteorology.

On the Attempts to resolve the Pressure of the Atmosphere into two parts, that of Vapour and Dry Air. By J. A. Broun, *F.R.S.E.*

On some extraordinary Electrical Appearances observed at Manchester on the 16*th of July* 1850. *By* Peter Clare, *F.R.A.S. &c.*

About four o'clock p.m., on the 16th of July, the weather having been fine and warm for four days, the wind blowing from the north-east, and the clouds constantly moving from the east, some dense clouds appeared in the east, north, and also to the west, when one or two peals of thunder were heard at a distance. About this time a violent storm of thunder, lightning and very heavy rain commenced at Bolton, twelve miles N.N.W. of Manchester, extending westward and to the W.S.W. for many miles, and continued for two or three hours.

Afterwards the clouds extended to the south-west and south, and distant thunder was heard over a considerable extent of country to the south-west of Manchester, for several hours.

About nine o'clock, the clouds being very dark to the west and south-west of Manchester, but not so dense to the south and south-east, very frequent flashes of sheet lightning were observed, whilst for a period of nearly half an hour there were frequent coruscations of lightning observed between the south and south-west, all moving in a direction from south-west towards south, at an elevation of from 14° to 20° above the horizon; sometimes the appearances were like the roots of a tree, and occasionally with bright balls at the termination of all or some of the branches. On several occasions, immediately after a stream of light seemed to pass from near the south-west towards the south, through a space of 10° or 12°, a luminous ball of considerable size suddenly appeared and moved along the line of the stream with a velocity so slow that its progress was easily observed, and this was repeated several times near the same place.

Although these luminous appearances were frequently repeated, it was difficult to ascertain from whence they originated, as the clouds were much divided in that direction, and the lights became obscured without seeming to go behind the clouds, but had the appearance of being dissipated in the air. The author had been an attentive observer of thunder-storms for more than half a century, but had never witnessed similar appearances.

Remarkable Thermometrical Maxima at or near the Moon's First Quarter during the twelve years 1839–1850. *By* Richard Edmonds, Jun., *Penzance.*

In the British Association Report for 1845 (Sections, p. 20), the author has noticed a series of nine days, separated from one another by intervals of about four lunations each, and distinguished by earthquakes, extraordinary oscillations of the sea, or very remarkable states of the atmosphere. The series extended to the 13th of June 1845. On the 8th of October following, when another period of four lunations was completed, the barometer at Penzance, near the close of a very violent storm of wind and rain from S.S.W., reached a minimum of 28·75, lower than for at least six months before and above a hundred days afterwards. Here the series, with intervals of four lunations, terminates.

On the 6th of November 1845 (exactly one lunation afterwards), the barometer at Penzance, on the close of another violent storm of wind and rain from about south, was at nearly the same minimum as on the 8th of October.

Each of the phænomena alluded to occurred within forty-eight hours of the moon's first quarter. The following remarkable maxima of temperature, during the last twelve years, were also nearer to the moon's first quarter than to any other, except that of the 5th of July, 1846; but the great thunder-storm of that day commenced the preceding evening, when the moon was nearer her first quarter than any other. These maxima (assuming that *that* for 1850 has already occurred) include the annual maxima of the twelve years, except 1839, when the annual maximum was one degree higher; and except 1847, which last, however, would scarcely be regarded as an exception, if allowance were made for the early time of the year in which the remarkable maximum occurred. Most of the maxima were accompanied by thunder-storms or extraordinary oscillations of the sea.

Dates and Moon's age at 2 o'clock p.m.	Max. of therm. at Chiswick.	Remarks.
1839, June 18 (7 days 1 hour).	84°	This was higher than on any other day of the year, except the 3rd of August, when it was 85°. On the 20th of May (one lunation before) it was 73°, the maximum for the month. On the 17th of July (one lunation after) it was 80°, the maximum for that month, except one day, when it reached 81°.
1840, August 3 (5 days 17 hours).	87	The maximum of the year.
1841, May 27 (6 days 14 hours).	82	In Dumfriesshire and Chiswick this was the hottest day of the year, except the 12th of September, when at the latter place it was 84°. At Chiswick, on the day in the margin, there was much "sheet lightning at night with occasionally some of the zigzag and forked kind, with thunder and abrupt showers in large drops." In Truro, Cornwall, "on the evening of the 26th, a very remarkable series of electrical explosions commenced, the discharges continuing through the whole night with very little intermission, embracing a large portion of the central districts of the county, and repeatedly presenting a most brilliant appearance from the

Dates and Moon's age at 2 o'clock p.m.	Max. of therm. at Chiswick.	Remarks.
1841, May 27 (6 days 14 hours).	82°	flashes bursting simultaneously from almost the whole circuit of the heavens." On the 29th of April (nearly a lunation before) the thermometer at Pencarrow in Cornwall was 80°, the maximum for the year there.
1842, June 13 (4 days 16 hours).	90	The maximum for the year. At Boston in Lincolnshire, the 14th was the hottest day of the hottest June since 1826*.
1843, July 5 (7 days 19 hours).	88	The thermometer in Brighton as well as Chiswick, was at its maximum for the year. Extraordinary oscillations of the sea and great thunder-storms in different parts of Britain.
1844, July 25 (10 days).	92	On the 23rd of the preceding month (the day of the moon's first quarter) the thermometer at Chiswick was at 91°, the maximum for the year, except that in the margin; and in the evening an unusually severe thunder-storm was felt in Cornwall and Dumfriesshire, and the following morning at Boston and Liverpool. On the 23rd of July (one lunation afterwards) it became very dark at Penzance, as if another thunder-storm were approaching, and the barometer fell to a considerable minimum, on which day there was another thunder-storm in Dumfriesshire.
1845, June 12 (7 days 13 hours).	85	At Penzance, as well as Chiswick, this was the hottest day of the year (77°), except the 9th and 10th of September (three lunations afterwards), when it was one degree higher (77° and 78°). On the 13th of June an extraordinary oscillation of the sea occurred at Folkstone, and a "terrific" thunder-storm at Chatham.
1846, July 5 (11 days 20 hours).	95	At Boston in Lincolnshire, this was the hottest day since the 31st of July 1826. A great thunder-storm passed through Britain, having commenced in Mountsbay in the evening of the 4th. On the 1st of August (nearly a lunation afterwards) London was visited with a hail and thunder-storm more destructive than any there since the 18th of May 1809. On each of these days (5th of July and 1st of August) there was an extraordinary agitation of the sea in Mountsbay.
1847, May 23 (8 days 23 hours).	89	The highest temperature for many years at so early a time of the year. Extraordinary agitation of the sea along the coasts of Cornwall and Devon.
1848, July 6 (5 days 16 hours).	88	Mr. Glaisher, of the Greenwich Observatory, remarks, that this was the hottest day of the year throughout the country. Extraordinary oscillations of the sea on the following day at Lyme, Dartmouth, &c. On the 11th of May (nearly two lunations previously), and almost exactly twelve lunations after the 23rd of May 1847 above mentioned, the thermometer at Chiswick was 84°; and it is remarkable that the temperatures on the two last-mentioned days were not only the highest for those years up to such times, but higher than for exactly fifty days afterwards in each case, except that on the fourth day afterwards in the one case, and the fifth day in the other, it was one or two degrees higher.

* This day, and almost every subsequent day mentioned in the present communication, to the end of 1845, have been before noticed by the author in his paper above referred to. The days in 1846, 1847 and 1848, have been also noticed by him in the Report for 1848 of the Royal Institution of Cornwall, p. 53.

Dates and Moon's age at 2 o'clock p.m.	Max. of therm. at Chiswick.	Remarks.
1849, June 24 (4 days).	89°	Maximum for the year. On the 26th of July (a little more than a lunation afterwards) London was visited with another thunder and hail-storm more violent than any that had occurred there for many years, although not so destructive of property as that of the 1st of August 1846.
1850, July 16 (7 days).	89	Maximum for the year at Chiswick and Greenwich. The thermometer at Brighton was 80° on the 15th, and very high also on the 16th and 17th. At Penzance it was remarkably sultry on the 15th, and the clouds, a little before noon, gathered there from the south, as if a thunder-storm were approaching, and it rained most of the afternoon. Bristol, that afternoon, was visited by a terrific thunder-storm. On the following day (16th*) equally fearful thunder-storms occurred in Lancashire, and at Chatham and Rochester; and "several houses in Orleans were nearly destroyed by a waterspout." On the 17th similar thunder-storms were felt at Brighton, Reading, Guildford, and New Galloway, at which last place there was at the same time a waterspout (described with a woodcut in the 'Illustrated London News' of the 27th of July). On the night of the 18th a terrific storm of wind and rain from the east was felt on the Atlantic shores of the United States, greater than any there for half a century. During all these thunder-storms, which have proved unusually severe and fatal, the rain is described as of almost unexampled violence and descending like waterspouts. On the 19th of *May* (two lunations before) the thermometer at Chiswick was at 72°—higher than it had been previously for the year, and it did not exceed that elevation for ten days afterwards. On the 18th of *April* (the day before the moon's first quarter) the thunder and hail-storm at Dublin was the severest remembered there. This was a warmer day in Mountsbay than any previously for the year, and for twenty-three days after, the atmosphere in the evening being in a highly electrical state. In London, for the week ending the 19th of April, the thermometer on every day was higher than the average of the same day for the last seven years, and the mean temperature of the week was 48°·9, being 3° beyond the average. In Scotland the air was equally sultry on the 18th, 19th and 20th. On the 20th, 10,000 trees were rooted up by a storm at Strathspey in Invernesshire, and on the same day was a dreadful thunder and hail-storm at Dorking in Surrey.

On the Causes of the Rise of the Isothermal Lines (as represented on Professor Dove's *Maps) in the Winters of the Northern Hemisphere. By* THOMAS HOPKINS.

In the winter of the northern hemisphere, when the continents of America and Europe are cooled down to a low temperature, as shown by the isothermals for the

* See, in this Report, Mr. P. Clarke's account of "some extraordinary electrical appearances at Manchester on the 16th of July, 1850."

month of January, the temperature is comparatively high over the sea in that part of the Atlantic ocean that lies between these continents. But does this difference correspond with the relative extents of land and water in such a way as to indicate that they have the relation to each other of cause and effect? The northern Pacific ocean is about twice as broad as the northern Atlantic, up to the latitude of above 50°, but the former is not proportionately warmer than the latter. It is, on the contrary, colder, as may be seen from the isothermal lines over the two seas and adjoining parts, the temperature that is found at about 58° of latitude in the Pacific being carried as high as about 70° in the Atlantic.

If the breadth of the sea produced the effect under consideration, the isothermal lines would be at the same height in the same latitudes over the land on each side of the sea; but it is well known that they are not. It is true the isothermals rise in the winter from Siberia to the middle of the Pacific ocean, showing that the water is there warmer than the land; but they rise still higher as they approach the American coast, and attain the greatest height in that part near to or over the land in America; thus exhibiting the land in America, during the winter season, in the same latitude, much warmer than it is in Asia. In the Atlantic too the same isothermal, that on the American side is in the latitude of 42 or 44 degrees near Newfoundland, reaches 70 degrees on the European side near Norway; and that island is actually colder than Iceland, which touches the arctic circle in 66° of latitude.

Professor Dove speaks of the Gulf-stream of the northern Atlantic as materially affecting the temperature of that locality up to a high latitude; but it is not shown to be the cause of the phænomenon under consideration. It is well known that the Gulf-stream is turned from its northern direction off Newfoundland across the Atlantic towards Ireland and the Bay of Biscay, and is even thrown back on the coast of Africa. The frequent appearance of icebergs, far to the south in this ocean, indicates that an oceanic current sets in here, not towards the north, but southward. It is known too, from attempts that have been made to approach the north pole, that a current sets from the Polar sea near Spitsbergen to the south. It appears, therefore, that the assumption that the Gulf-stream flows into a high latitude in this part, and warms it, is not merely unwarranted, but at variance with known facts.

But if neither the proportional extent of the surface of the sea, as compared with the land, nor the flow of a warm current of water carries high temperature to these northern latitudes, what is the cause of such temperature being found there? The answer to this question has been substantially given where I have pointed out the cause of all the great local heatings and winds that prevail over the globe. But a reply is prepared by Professor Dove himself, where, in his remarks, he says, "This surface," meaning the surface of the globe, "being a highly varied one, the sun's influence on it is also constantly varying, for the impinging solar heat is employed in raising the temperature of substances which do not change their condition of aggregation; but when engaged in causing the melting of ice, or the evaporation of water, it becomes latent. When therefore the sun returning from its northern declination enters the southern signs, the increasing proportions of liquid surface upon which it shines causes a corresponding part of its heat to become latent, and hence arises the great periodical variation in the temperature of the globe which has been noticed above," meaning the difference of temperature of the northern and southern hemispheres.

Why suppose that this effect of the evaporation of water is experienced only in the relative temperatures of the northern and southern hemispheres? And why not trace the effects of *condensation* of vapour, as well as of the *evaporation* of water? It is evident that heat is absorbed and made latent wherever vapour is produced, and it is equally clear that that heat is given out and made active wherever the vapour is condensed.

It does not appear from the atmospheric currents which prevail that any portion of the vapour of the southern hemisphere passes into the northern to be condensed within or near to the basin of the Pacific, and there is no reason to suppose that it does; but in the basin of the Atlantic it is sufficiently evident that vapour does not so pass. The vapour which passes over the northern Atlantic, and is condensed beyond the British Islands and Norway, is supplied from the tropical and other seas north of the equator. The West Indies constitute the principal point of departure of this vapour, and in the month of January it is carried by south-western and western winds to those localities where the isothermal lines advance furthest towards the pole. It is accordingly to the condensation of this vapour, and not to the neighbourhood of the Atlantic ocean, in the latitude, that we are to attribute the high temperature of this part of the world in the winter. The Atlantic ocean is as near to Labrador as to Norway, but there is little condensation on the coast of the former, whilst there is much about the latter. Indeed, as far as we know, condensation of vapour is the only influence that operates exclusively on the eastern coasts of the two oceans, the Pacific and the Atlantic, and therefore to it we may attribute the warming of the localities, particularly in the Arctic ocean, as indicated by the isothermal lines. Condensation we know furnishes a constant and abundant supply of heat, not like diffusion by contact, nor radiation from surfaces nearly equal in temperature, but by the energetic chemical action which converts an aëriform substance into a liquid, and consequently changes the heat from a latent to an active state.

The greatest irregular rise in the isothermal lines is found in the winter of the northern hemisphere, just at the time that the condensation of vapour produces the greatest effect on the temperature of the air. And the temperature rises the most along that line or stripe where the largest amount of condensation takes place; and in that locality the same temperature reaches the highest latitude, showing that condensation of vapour is the cause of the rise of the isothermal lines in the parts.

On the means of computing the Quantities of Aqueous Vapour in the Atmosphere at various places and heights. By THOMAS HOPKINS.

The author stated that meteorologists usually estimated the total amount of vapour in a vertical column of the atmosphere from the dew-point at its base, from which they inferred its tension, and thence the total quantity. This he asserted was an erroneous method, as it neglected the effort of the vapour expanding and forcing itself upwards through the air, a colder medium than would exist in each successive foot if nothing but the vapour itself were present. This opinion he illustrated by diagrams.

On the Daily Formation of Clouds at Makerstoun. By THOMAS HOPKINS.

The author went into an examination of the meteorological registers kept at Makerstoun for the year 1844, to prove that the facts registered were in harmony with and tended to establish the theory he had advanced, that the horary fluctuations of the barometer were attributable to the daily vaporization of water by the sun, and the daily condensation of a portion of that vapour into cloud; the great difficulty being to account for the fall of the barometer from ten in the morning till four in the afternoon. At Makerstoun, the state of the atmosphere as to cloud was registered by noting an overcast sky by 10, a cloudless sky by 0, and intermediate states by intermediate numbers. The state of the wet- and dry-bulb thermometers was also regularly noted, showing both the activity of vaporization and the tension of vapour.

On Meteorological Observations made at Kaafjord, near Alten, in Western Finmark, and at Christiania in Norway. By JOHN LEE, *LL.D., F.R.S., of Hartwell, Bucks.*

Alten.—Dr. Lee presented to the Association the meteorological observations which had been lately received by him from Mr. J. H. Grewe at the Alten Copper Mines in Norway.

These observations are for twelve months, viz. from October 1848 inclusive to September 1849 inclusive; and although they form a continuation of previous observations extending over a series of eleven years, yet in consequence of the alteration of the hours of observation, as also an additional number of daily observations (there being five daily observations, viz. at 7 and 11 A.M., 3, 7 and 10 P.M., instead of three, as formerly, at the hours of 9 A.M., 3 and 9 P.M.), they may be considered as constituting a new series. These alterations have been made agreeably with the suggestion of Professor Hansteen of the Observatory at Christiania and Mr. Grewe, who, since the departure from Alten of his former colleague, Mr. J. F. Cole, had continued the observations alone, and has been kindly assisted in this new series by Mr. Ole Brochgrevink, a brother officer in the Company's service. As will easily be seen on reference to these observations, it has required extra exertion on the part of the meritorious observers, who have to baffle with a very ungenial climate for making meteorological observations, and more especially as their instruments are all placed in a small building about 100 yards distant from any dwelling-house.

Three tables of results accompany these observations, namely—

1st. The monthly and quarterly means of the barometer at all the hours of observation, as well as the monthly and quarterly results.

2nd. The monthly and quarterly means of the thermometer, also at the hours of observation, together with the monthly and quarterly results.

3rd. The highest and lowest observed points of the barometer, as also the maximum and minimum of the thermometer, with the range of each; a comparison of the monthly means of the thermometer with the means as deduced from the maximum and minimum, and the monthly quantity of rain or melted snow.

Christiania.—Dr. Lee also presented a series of meteorological observations for the year 1849, made at Christiania, and which he had received from J. R. Crowe, Esq., Her Britannic Majesty's Consul-General of Norway. This series is a continuation of former observations presented to the Association, and consists of observations on the Barometer taken in Norwegian inches, and on the Thermometer according to the Reaumur scale, as also the quantity of rain with the direction of the wind. The hours of observation are 7 and 9 A.M., 2, 4 and 10 P.M. Some useful and interesting comparisons may hereafter be made between these observations and those now in course of being taken at Alten.

London, July 27, 1850.

SIR,—Agreeably with your request I have examined the Meteorological Observations made at the Alten Copper Works for the year ending the 30th September 1849, as also the three Tables of results drawn up from these observations by Mr. Grewe, which Tables I have reduced into English scales, for the better comparing them with results obtained by other meteorologists with English instruments, or that may have been reduced to English measures; and I have now the pleasure of sending you herein enclosed copies of the Tables I have framed accordingly, and beg to add a few remarks on their contents.

One important feature in these observations, and which will at once strike the eye on looking through them, is that no blanks occur; and as they form the commencement of a new series, the results may be therefore taken as faithfully representing the various phænomena at the hours of observation, which I may mention have been changed from 9 A.M., 3 and 9 P.M. to 7 and 11 A.M., 3, 7 and 10 P.M., in conformity with the suggestion of Professon Hansteen of Christiania, thus giving five daily observations instead of three as formerly.

Barometer.—The results of the year's observations on this instrument show that

It rises from 7 A.M. to 11 A.M.	0·00268 inch.
And falls from 11 A.M. to 3 P.M.	0·00386 ,,
And rises from 3 P.M. to 7 P.M..........	0·00571 ,,
And also rises from 7 P.M. to 10 P.M. .	0·00417 ,,

The means for the year of the 7 and 11 A.M. observations are below the mean of the year, while the 3, 7 and 10 P.M. are above.

The mean for the year of the 11 A.M. observations comes nearest the mean of the year, differing only by 0·00028 inch, and of the monthly means that for March approaches nearest the mean of the year (as is the case in the former series of observations, embracing a period of eleven years), differing by an increase of 0·00161 inch above the mean of the year.

The mean of the month of April, reaching 29·94907 inches, is the highest monthly mean of the year, while that for February, reaching only 29·23510, is the lowest. The highest monthly mean for the eleven years previous (see British Association Report, 1849, Transactions of the Sections, p. 19) was in the month of May; but as will be seen in the present series, the means of the months of April and May differ by only 0·00811 inch.

Of the seasons in this new series, the mean for Spring is the highest and Winter the lowest, while Autumn and Summer are nearly equal. The quarterly results show that

The barometer rises from Winter to Spring	0·39657 inch.
And falls from Spring to Summer............	0·13838 ...
Also falls from Summer to Autumn.........	0·00528 ...
And again falls from Autumn to Winter ...	0·25291 ...

In the series referred to for eleven years, Spring gives the highest mean and Autumn the lowest.

Of the monthly observations in the new series, the greatest range takes place in March, being 1·92086 inch, whilst the least oscillation occurs in September, being 0·71378 inch.

The highest observed point for the year is 1848, December 19th, at 11 A.M., being	30·58419 inch.
And the lowest observed point is 1849, January 18th, 7 P.M.	28·45585 ...
The difference between these two points is	2·12834 ...

which is therefore the greatest observed oscillation of the barometer for the year.

The difference between the mean of the year and the highest observed point for the same period is 0·92086 inch, and the difference between the mean of the year and the lowest observed point also for the same period is 1·20748 inch.

The result of the eleven previous years' observations on the barometer gives a yearly mean of 29·75490, this year it only reaches 29·66333.

Thermometer.—The results of the observations on the thermometer in this new series present a very peculiar feature, the mean for the year of the 11 A.M. observations being actually the highest, and differing from the 3 P.M. by 0°·156 Fahr.

The yearly means show that the thermometer rises from 7 A.M. to 11 A.M.	2°·831 F.
And falls from 11 A.M. to 3 P.M.	0·156 ...
Also falls from 3 P.M. to 7 P.M.	2·682 ...
And again falls from 7 P.M. to 10 P.M.	1·876 ...

The 7 A.M. and 7 P.M. means for the year differ from one another by only 0°·007 Fahr., the 7 A.M. being that much the highest. The means for these hours, viz. 7 A.M. and 7 P.M., are nearest the mean of the year; and of the monthly means, those for October and April come nearest the mean of the year.

The mean for July being 59°·707 is the highest monthly mean, while that for January being 7°·268 is the lowest.

The quarterly means rise from Winter to Spring ...	22°·981 Fahr.
And rise from Spring to Summer	13·746 ...
Then fall from Summer to Autumn	31·138 ...
And again fall from Autumn to Winter	5·589 ...

The result of the eleven previous years' observations on the thermometer gives a yearly mean of 34°·273 Fahr., but the mean this year only reaches 32°·932 Fahr., showing it to have been somewhat colder.

The maximum for the year was registered 1849, July 17th, at 3 P.M.	86°·90 Fahr.
And the minimum, 1849, January 14th, at 3 P.M.	—20·20 ...
Making a total range for the year of	107·10 ...

The difference between the mean of the year and the maximum for the same period is 532°·968 Fahr., and between the mean of the year and the minimum 53°·132 Fahr.

With reference to the thermometer falling to —20°·20 Fahr., as has just been remarked, allow me to state, that I well remember at such low temperatures the instruments almost sticking to my gloves from the cold, as also the peculiar crackling sound when walking over the snow, and the beautifully clear and bespangled sky.

I remain, Sir, your most obedient Servant,

John Lee, Esq., LL.D. &c. &c. J. F. COLE.

TABLE I.—Results of the Observations on the Barometer made from the 1st October 1848 to the 30th September 1849, both inclusive, at the Alten Copper Works, Kaafjord, West Finmark, in Norway. Latitude 69° 57′, longitude 23° 2′ E. of Greenwich. The observations are corrected for capillarity, error of the scale, and reduced to 0° centigrade, as also to the level of the sea.

Years.	Months.	Monthly Means. 7 A.M. No. of observ.	7 A.M. Barometer.	11 A.M. No. of observ.	11 A.M. Barometer.	3 P.M. No. of observ.	3 P.M. Barometer.	7 P.M. No. of observ.	7 P.M. Barometer.	10 P.M. No. of observ.	10 P.M. Barometer.	Monthly Means. No. of observ.	Monthly Means. Barometer.
			in.		in.		in.		in.		in.		in.
1848	October	31	29·84931	31	29·86073	31	29·86258	31	29·86675	31	29·84348	155	29·85655
...	November	30	29·32872	30	29·33852	30	29·33053	30	29·32848	30	29·33608	150	29·33246
...	December	31	29·86522	31	29·87502	31	29·87833	31	29·88388	31	29·89222	155	29·87892
1849	January	31	29·41136	31	29·41226	31	29·41313	31	29·40148	31	29·40730	155	29·40911
...	February	28	29·24797	28	29·25089	28	29·22537	28	29·22132	28	29·23006	140	29·23510
...	March	31	29·64470	31	29·67104	31	29·66230	31	29·67514	31	29·67163	155	29·66494
...	April	30	29·94884	30	29·94750	30	29·94167	30	29·95258	30	29·95474	150	29·94907
...	May	31	29·94470	31	29·94518	31	29·94423	31	29·93431	31	29·93636	155	29·94096
...	June	30	29·60730	30	29·59955	30	29·59841	30	29·61459	30	29·62482	150	29·60892
...	July	31	29·70553	31	29·70667	31	29·70943	31	29·71970	31	29·72856	155	29·71396
...	August	31	29·59116	31	29·58285	31	29·58096	31	29·60018	31	29·61313	155	29·59364
...	September	30	29·77978	30	29·76636	30	29·76344	30	29·78045	30	29·79069	150	29·77612
Means of the year		365	29·66037	365	29·66305	365	29·65919	365	29·66490	365	29·66907	1825	29·66333

Years.	Seasons.	Quarterly Means. 7 A.M. No. of observ.	7 A.M. Barometer.	11 A.M. No. of observ.	11 A.M. Barometer.	3 P.M. No. of observ.	3 P.M. Barometer.	7 P.M. No. of observ.	7 P.M. Barometer.	10 P.M. No. of observ.	10 P.M. Barometer.	Quarterly Means. No. of observ.	Quarterly Means. Barometer.
			in.		in.		in.		in.		in.		in.
1848.	Autumn	92	29·68108	92	29·69140	92	29·69049	92	29·69305	92	29·69061	460	29·68931
1849.	Winter	90	29·43467	90	29·44470	90	29·43360	90	29·43266	90	29·43632	450	29·43640
...	Spring	91	29·83360	91	29·83073	91	29·82809	91	29·83384	91	29·83864	455	29·83297
...	Summer	92	29·69215	92	29·68529	92	29·68463	92	29·70010	92	29·71077	460	29·69459
Means of the year		365	29·66037	365	29·66305	365	29·65919	365	29·66490	365	29·66907	1825	29·66333

Observers—Messrs. J. H. Grewe and Ole Borchgrevink. Reduced from millimètres to English inches by Mr. J. F. Cole.

Table II.—Results of Observations on the Thermometer in the open air at the Alten Copper Works in Norway, made by Messrs. J. H. Grewe and Ole Borchgrevink, and reduced from the centigrade to the Fahrenheit scale by Mr. J. F. Cole.

Years.	Months.	Monthly Means. 7 A.M. No. of observ.	7 A.M. Thermometer.	11 A.M. No. of observ.	11 A.M. Thermometer.	3 P.M. No. of observ.	3 P.M. Thermometer.	7 P.M. No. of observ.	7 P.M. Thermometer.	10 P.M. No. of observ.	10 P.M. Thermometer.	Monthly Means. No. of observ.	Monthly Means. Thermometer.
1848.	October	31	31·008	31	33·226	31	32·796	31	30·164	31	30·223	155	31·483
...	November	30	16·268	30	16·869	30	17·037	30	17·271	30	16·862	150	16·862
...	December	31	18·401	31	18·390	31	18·414	31	17·670	31	18·349	155	18·244
1849.	January	31	6·962	31	7·950	31	6·975	31	7·236	31	7·218	155	7·268
...	February	28	19·355	28	20·950	28	21·097	28	20·673	28	20·365	140	20·487
...	March	31	19·249	31	26·478	31	25·293	31	20·637	31	18·698	155	22·071
...	April	30	31·316	30	36·788	30	35·600	30	29·377	30	26·402	150	31·897
...	May	31	40·176	31	43·241	31	43·623	31	39·450	31	34·815	155	40·260
...	June	30	47·732	30	49·005	30	48·727	30	45·279	30	42·309	150	46·611
...	July	31	59·767	31	61·927	31	62·942	31	58·878	31	55·022	155	59·707
...	August	31	51·213	31	55·935	31	56·597	31	53·571	31	50·198	155	53·503
...	September	30	45·055	30	49·735	30	49·501	30	46·220	30	43·459	150	46·794
Means of the year		365	32·209	365	35·040	365	34·884	365	32·202	365	30·326	1825	32·932
Years.	**Seasons.**	**Quarterly Means. 7 A.M. No. of observ.**	**7 A.M. Thermometer.**	**11 A.M. No. of observ.**	**11 A.M. Thermometer.**	**3 P.M. No. of observ.**	**3 P.M. Thermometer.**	**7 P.M. No. of observ.**	**7 P.M. Thermometer.**	**10 P.M. No. of observ.**	**10 P.M. Thermometer.**	**Quarterly Means. No. of observ.**	**Quarterly Means. Thermometer.**
1848.	Autumn	92	21·893	92	22·829	92	22·750	92	21·702	92	21·812	460	22·197
1849.	Winter	90	15·188	90	18·459	90	17·789	90	16·182	90	15·427	450	16·608
...	Spring	91	39·742	91	43·011	91	42·651	91	38·035	91	34·509	455	39·589
...	Summer	92	52·012	92	55·866	92	56·347	92	52·889	92	49·559	460	53·335
Means of the year		365	32·209	365	35·040	365	34·884	365	32·202	365	30·326	1825	32·932

TABLE III.—Highest and lowest observed points of the Barometer; Maxima and Minima of Thermometer, with Date, Time and Range. Monthly Means of Thermometer compared with Means as deduced from Maxima and Minima; and total quantity of Rain.

Years.	Months.	Barometer (reduced to inches).					Thermometer (reduced to Fahrenheit).					Monthly thermometrical means compared with the monthly means as deduced from the maxima and minima.		Monthly fall of rain in English inches.
		Date and time of.	Highest.	Date and time of.	Lowest.	Range.	Date when registered.	Maximum.	Date when registered.	Minimum.	Range.	Monthly means.	Mean of maxima and minima.	
1848	October ...	3, 10 P.M.	30·39285	16, 7 A.M.	29·18813	1·20472	6	58°·10	29	6°·80	54°·30	31°·483	31°·921	2·244
...	November	26, 3 P.M.	29·91726	21, 11 A.M.	28·61097	1·30629	6	35·60	19	−10·30	45·90	16·862	16·349	1·957
...	December	19, 11 A.M.	30·58419	7, 7 A.M.	29·08931	1·49488	23	44·24	18	− 9·40	53·64	18·244	18·244	2·008
1849	January ...	7, 11 A.M.	30·00112	18, 7 P.M.	28·45585	1·54527	8	30·20	14	−20·20	50·40	7·268	6·730	0·945
...	February...	12, 3 P.M.	30·09640	8, 10 P.M.	28·58813	1·50827	9	37·40	28	2·30	35·10	20·487	20·736	0·886
...	March......	31, 10 P.M.	30·47789	7, 7 A.M.	28·55703	1·92086	{16, 23}	44·60	3	−17·32	61·92	22·071	22·518	0·630
...	April	1, 11 A.M.	30·52395	10, 7 A.M.	29·39404	1·12991	27	51·80	13	− 0·40	52·20	31·897	31·465	0·559
...	May	4, 7 P.M.	30·33104	21, 7 A.M.	29·42593	0·90511	27	62·60	6	19·40	43·20	40·260	40·476	1·854
...	June	16, 11 A.M.	29·87789	30, 10 P.M.	29·11333	0·76456	{22, 29}	63·50	{10, 11}	35·60	27·90	46·611	47·010	1·102
...	July	12, 7 A.M.	30·28931	6, 11 A.M.	29·23380	1·05551	17	86·90	12	45·50	41·40	59·707	60·256	1·280
...	August ...	28, 7 A.M.	30·03577	23, 11 A.M.	29·03104	1·00473	3	83·30	31	39·20	44·10	53·503	53·676	2·441
...	September	26, 7 A.M.	30·16648	13, 7 A.M.	29·45270	0·71378	3	63·50	30	24·80	38·70	46·794	46·526	1·280
												Mean of the year. 32·932	Mean of the year. 32·988	Total. 17·186

Observers—Messrs. J. H. Grewe and Ole Borchgrevink. Reduced to English scales by Mr. J. F. Cole.

On the British Meteorological Society. By Dr. Lee.

Dr. Lee presented to the British Association an address of the British Meteorological Society, explanatory of its formation and the objects which it has in view :—

The collection of correct manuscript observations.

The publication of Tables.

The Reduction of Observations to useful results.

The distribution of Meteorological Papers.

The examination and correction of Meteorological Instruments.

The encouragement and promotion of Meteorological Science.

The formation of a Library.

The payment of Computers to reduce observations, &c.

He stated that the Society at present consisted of 121 Members, and that the Society was anxious to obtain the patronage of the British Association of Science, and to act in connection with it and to promote its views.

On some Phænomena of Mirage on the East Coast of Forfarshire. By the Rev. C. F. Lyon.

Mr. Lyon had noticed the Red Head at Montrose, distant twenty-five miles from St. Andrews, assume a square form, then notched, then double-notched. The outlines of the sea had risen up with angular corners, and portions of the sea seemed raised up as if seen through unequal glass. (Diagrams illustrated the communication.)

On Meteorological Phænomena at Huggate, Yorkshire, for 1849. *By the* Rev. T. Rankin.

The results may be thus abstracted :—Thermometer, coldest day, January 3, night thermometer, 19°; hottest day, July 12, thermometer, 71°; lowest range (or change), June 11 and December 13, viz. 1°; greatest range, May 12, viz. 26°. Barometer, lowest point, 28·20 in., January 10; highest, 30·42 in., October 29; lowest range, 0·01, January 17 and February 8; greatest range, 0·66 in., February 14. Hygrometer, wet bulb, minus dry, lowest, 0°·5, March 23, June 5, October 25; greatest depression of wet bulb, 8·5, June 27; during heavy rain and intense frost both are nearly equal. The author found the cold water in the tube to affect by radiation the dry bulb; but a sheet of paper interposed got rid of this source of error. Rain, total, 29·770 in., being 12·855 in. less than in 1848; least rain in February, 0·720 in.; most in July, 4·750 in. November Atmospheric Wave, edge of anterior trough, 29·95 in., barometer, on November 10, gentle breeze S.; bottom of trough, 29·17 in., on November 15, wind W.; crest of wave, 30·00 in. on the 17th, wind W.; bottom of posterior trough, 28·95 in., on the 24th, wind W.; height of the edge, 29·87 in., on the 27th, wind N.W.; seventeen days passing, same as in 1848. Aurora on August 12, resembling a fan; on the 28th, perpendicular beams; December 23, sky dappled in shape of a dome. Halo, a beautiful one, about 8° around the moon, December 26, between 9 and 10 P.M., moon nearly full, wind W. Hurricane, night of December 26, about twelve o'clock, barometer fell from 29·80 to 29·11 in.; thermometer, 34°; a hurricane from W. followed; previously large masses of cirro-cumulus had been floating about. Winds, E., 6; W., 44; N., 2; S., 15; N.E., 31; N.W., 22; S.E., 15; S.W., 26. Thunder, April 28; June 14; July 18, 21, 30; August 17, 18. Weather, 129 days clear, 66 days occasional rain, 22 days frost, 15 days occasional snow, 226 days wholly or partially dull: in 1848 there were 229 days wholly or partially dull.

On the Passage of Storms across the British Islands. By R. Russell, *Kilwhiss, Cupar, Fife.*

Mr. Russell stated that there appeared to be two distinct classes of storms which occurred in the British islands, but in both there were two currents in the atmosphere blowing in different directions :—1st, those in which the wind below veered from S.W. to N.W. or N., the upper current being generally from the N.W. or N.; 2nd, those in which the wind was easterly below, with a S.W. upper current; the latter were more particularly the rainy form of storms, and he confined his observations to this class. He pointed out an anomaly in the barometer, that while it attained its highest range with easterly winds, its greatest depressions often occurred during their prevalence; but in the latter instance this was due to the presence of a S.W. current above; a stormy easterly wind very rarely occurs unless a S.W. wind overlies it, which was the Atlantic fountain from whence the east winds derived their moisture, as they were always relatively dry during the first stages of the storm. When dry easterly winds prevailed in summer their saturation from this source is often the work of days, the moist south-west upper currents are often driven back and evaporated in their passage over the island. The barometer may fall over the whole extent of Britain, and the winds go through the rainy form, but precipitations only occur at such points where the two contending winds are saturated. It is under these conditions that rainy weather in summer often travels so slowly northwards; the north-western edges of the moist currents above become evaporated in crossing by the dry winds that oppose them; thus rain very often falls many days in the south of England before it reaches Scotland. No doubt in many instances the storm bursts over the island at once, but it is not the common mode. In Scotland it is a prevailing opinion, founded on observation, that we may expect rain in course of eight or ten days after it has fallen in the south of England: there must be a point to the north in every storm where precipitations do not take place; he had often occasion to remark this limit both to the north and to the south.

The author exemplified these remarks by reference to the weather observed at many points in Great Britain during the early part of October 1849, and traced the particular phænomena occasioned by the conflict of the two aërial currents.

On Hourly Meteorological Observations made in Thibet at an elevation of 18,400 feet. By Lieut. STRACHEY, *R.E.*

On Indian Hail-Storms. By Lieut.-Col. SYKES, *F.R.S.*

The following instances of remarkable Indian hail-storms were selected from a long list which had been placed in Colonel Sykes's hands, the result of the usual zealous research of Dr. Buist, LL.D., of Bombay. More or less lengthened descriptions are given in the list of sixty-one hail-storms, going back as far as the 9th of November 1781, and terminating on the 28th of May 1850, but with a gap between 1781 and 1822. Biblical accounts teach us that hail in ancient times had been destructive to man and beast (Exodus ix. v. 25.), but in climates not bordering on the tropics the inhabitants have rarely witnessed such disastrous effects. In India, however, the biblical accounts appear to be but too frequently verified in the sacrifice of life and in the vast destruction of property from the extraordinary magnitude of the hailstones or masses of ice which fall, in two instances said by Dr. Buist to have exceeded a hundred-weight. The occult operations of nature in the formation of such masses of frozen water in the atmosphere, are not less matters for the speculative inquiry of the physicist than the formation of meteorolites.

Dr. Buist says there is no account of the occurrence of hail within 1000 feet of the level of the sea south of latitude 20°, though just to the north of this hail-storms are very abundant, and they occur very frequently within the tropics at altitudes of 1700 feet and upwards. From the list the hail-storms appear to have occurred 21 times in the month of April, 13 in March, 8 in February, 3 in January, 6 in May, 3 in June, 2 in September, 2 in November, and 2 in December. A few instances will suffice to show their character, and these are given from European testimony. On the 10th of April 1822, at Bangalore, a hail-storm killed many cattle, the hail-stones being represented by the natives as large as pumpkins. *Three days after the storm* the gentleman who gives an account of it says, "I went to the spot and found the carcases of 27 bullocks lacerated by hail-stones; also dead birds. In a tank 300 yards in circumference, half of the surface was covered with floating masses of hailstones which had been carried down the ravines two days before; some of the masses were five and a half inches in thickness; the hailstones were angular and oval, and some measured three inches in diameter*."

At Kamptee, on the 3rd of June 1823, an officer writes, "the hailstones without exaggeration were as large as pullets' eggs."

At Bopalpoor, on the 9th of February 1825, an officer writes, "the hailstones were the largest and most extraordinary ever seen, some of them being as large and as heavy as goose-eggs, which they resembled."

At Serampoor in Bengal, on the 30th of March 1827, the European writer says, "each of the hailstones was equal to the size of a goose's egg."

At Kotah, on the 5th of March 1827, the hailstones were as large as a man's fist, and the next day remained unmelted of the size of pigeons' eggs. Men, animals and birds were killed; in the village of Nauda alone six persons were killed and seven others dangerously bruised.

At Calcutta, on the 20th of April 1829, the editor of the Bengal Chronicle says, "one of the hailstones brought to us was larger than a ducks' egg:" many of them were angular fragments of ice, and several natives were killed.

At Serampore the hailstones were as large as hens' eggs, and consisted of coats like an onion; the nucleus was whiter than the exterior.

At Sylhet, on the 19th of February 1830, the hailstones were the size of the largest potatoes†. Sheep and goats were killed. At Jubbalpoor, on the 9th of April 1831, the hailstones were the size of guinea fowls' eggs. On the 10th of April 1831, at Kamptee, some of the hailstones measured from ten to twelve inches in circumference; few or none were smaller than a hen's egg; five persons were killed in the neighbourhood. At Alhahabad, on the 5th of May 1833, a hailstone weighed 6¾ ounces troy, and measured ten inches in circumference. At Chunar, on the same day, the gentleman writes, "blocks of ice fell; I am really speaking within bounds when I say a goose's egg was a trifle compared to some of the stones that fell; one measured 11½ inches in circumference." "I am informed," he adds, "one hailstone in the bazaar weighed *two pounds*." On the 16th of March 1834, at Raneegunge, a gentleman travelling in a palkee writes, "my palkee top yesterday was broke through in three places by hailstones and one of my bearers knocked down by them." At Pubna, on the 12th of April 1834, one of the hailstones measured a foot in circumference, and another weighed eleven ounces. At Benares, in February 1836, some of the masses of ice weighed two pounds. At Secunderabad, on the 30th of March 1837, some of the hailstones were two inches in diameter. At Dum Dum, the artillery cantonment in Bengal, on the 8th of April 1838, two hailstones were picked up which measured sixteen inches in circumference and better than five inches in diameter. At Jaulna, on the 14th of January 1849, the hailstones were as large as billiard-balls. On the 5th of February 1850, at Gwalior, pieces of ice fell nearly two pounds weight, and animals and some men were killed. At Condwiel, near Sattarah, on the 7th of April 1850, some hailstones were as large as cocoa-nuts; the writer says, "I am within the mark when I say they were as large as cocoa-nuts."

To the above, Dr. Buist adds Dr. Spilsburg's personal notes of hail-storms consisting of thirty instances. He speaks of goats and sheep being killed, and on one occasion of hailstones being as large as hens' eggs, and he mentions the unexampled fact of a hail-storm in *July* in the midst of the monsoon. The above notices afford ample and unimpeachable testimony to the extraordinary magnitude of the masses of ice that fall in India in hail-storms. Colonel Sykes adds, that in a paper in the Philosophical Transactions for 1835, he had spoken of the fall of masses of clear ice exceeding an inch in diameter in hail-storms; and on one occasion globular masses of clear ice fell inclosing a central star of many points of diaphanous ice like ground glass, of which he made drawings. Colonel Sykes suggested that the operations of nature producing such instantaneous and intense cold in the atmosphere, whether by electrical or other causes, and the singular aggregation of the drops of rain or particles of water to constitute masses of ice in the air, had not received that attention from physicists which the remarkable character of the phænomena seemed to demand.

* This was on the third day after the fall in the scorching month of April.

† Potatoes in general are not much larger than hens' eggs in India.

Observations on the Climate of the Valley of the Nile. *By* T. Spencer Wells, *F.R.C.S., Surgeon Royal Navy.* (*Presented by the* Marquis of Northampton.)

The following observations are only to be regarded as an attempt to determine in some degree the nature of the climatal influences to which an invalid is subjected during a winter voyage up the Nile.

The observations extend from the 6th of December 1849 to the 16th of March 1850. The instruments were kept in a cabin in the boat of an invalid. The cabin was 6 feet high, 12 feet broad, and 10 feet deep. Its floor was from 1 to 2 feet above the level of the river. The dry- and wet-bulb thermometer, and the barometer were fixed to a beam in the centre of the cabin, where they were not exposed either to the direct or reflected rays of the sun. There were six glass windows to the cabin, provided with open blinds. Some of these windows were always open during the day, so that the morning and afternoon observations may be considered to represent the temperature of the open air in the shade. Sometimes a window was open until after the evening observation; but more frequently this was not the case, and to this is ascribed the fact that the mean of the evening observations is above that of the morning. A register night thermometer was fixed outside one of the windows, and the lowest temperature observed each day is recorded. The barometer used was an aneroid, corrected by a standard instrument at Cairo. Three daily observations were made at the hours of 9 a.m., 3 p.m., and 11 p.m. The following Table is an abstract of these daily observations:—

Date.	North latitude.	East longitude.	Maximum, dry-bulb thermometer.	Minimum, dry-bulb thermometer.	Minimum, register thermometer in open air.	Mean of three daily observations.	Mean of minima by register thermometer.	Mean temperature of evaporation.	Greatest difference between dry- and moist-bulb thermometers.	Smallest difference.	Mean difference.	Extreme range of dry-bulb thermometer in shade.	Extreme range, including observations of register thermometer.	Mean daily range of dry-bulb thermometer in shade.	Mean reading of the barometer.	Extreme range of barometer.	Number of days on which rain fell.
Dec. 6 to 31.	31° 25′ to 28 50	30° to 31	69°	52°	40°	61°	45°	57°	8°	2°	4°	17°	29°	8°30	in. 30·13	in. 0·47	5
Jan. ...	28 50 to 24 10	31 to 33	77	48	37	60	45	54	14	3	6	29	40	10·02	29·86	0·55	
Feb. ...	24 20 to 26 50	33 to 31	74	50	35	61	44	54	16	4	7	22	39	10·03	29·94	0·80	
Mar. 1 to 16.	26 50	31...	76	54	38	62	45	55	12	4	7	22	38	10·31	30·06	0·38	2

In order to judge of the advantage to be gained by an English invalid by passing a winter in Egypt, a comparison will be made between the results recorded in the above table, and those published in the returns of the Registrar-General from Mr. Glaisher's reports, premising that the winter in Egypt was universally acknowledged by the natives to be the most severe they had suffered for many years. The laws of diurnal variation for England having been ascertained, the means published by Mr. Glaisher must be accepted as correct, but this law for Egypt is not yet known. It is probable, however, that the means, according to my mode of calculation, are rather too high, perhaps from 1 to 2 degrees of the dry-bulb thermometer, and from half a degree to a degree of the temperature of the dew-point. The recorded atmospheric pressure is also probably about 0·003 too great. These allowances being made, a close approximation to the truth will be arrived at.

The *mean temperature of the air* for the period of my observations at Greenwich was 39° 3′; on the Nile it was 61°.

The *mean temperature of evaporation* at Greenwich was 37°·4; in Egypt 55°.

The *mean temperature of the dew-point* at Greenwich was 34° 1′; in Egypt 50°·8.

The *mean elastic force of vapour* in Egypt was 0·384; at Greenwich 0·214.

The mean weight of water in a cubic foot of air in England was 3 grains; in Egypt $4\frac{8}{10}$ grains; but still, owing to the higher temperature, the air was much drier in Egypt. At Greenwich the mean additional weight of water required to saturate a cubic foot of air was only $\frac{4}{10}$ of a grain, while on the Nile it was $1\frac{3}{4}$ grain. If we represent air completely deprived of moisture by zero, and air completely saturated as unity, the *mean degree of humidity* on the Nile was 75 per cent., while at Greenwich it was 85 per cent.

The mean readings of the barometer in the two countries very nearly approach each other; in Egypt being 29·99, at Greenwich 29·87. A glance at the Table, however, will show how very small the extreme range of the instrument was on the Nile.

The *average weight of a cubic foot of air* at Greenwich was 549 grains; in Egypt 527 grains.

Rain fell in various districts of England on averages from thirty-one to sixty-one days; while in Egypt it only fell on five days, and on three of these a shower was of but a few minutes' duration. On two days rain fell heavily at Cairo for several hours.

The mean daily range of the temperature of the air at Greenwich was 11·37; in Egypt 10·31; but while the mean extreme range in Egypt was 38, at Greenwich it was but 29, the mean extreme range in the cabin being only 7 degrees below that on the grass at Greenwich in the open air.

Fog was occasionally but rarely observed. It was general in the Delta in the early morning, but above Cairo it was only observed on three occasions.

On the Six Climates of France. *By* Dr. C. Martins.

The author stated that France partook of the climates both of continental and sea-girt countries. He wished at present to consider six climatal subdivisions, viz.—1. the north-east or Vosgian; 2. the north-west or Séquanian; 3. that of the west or Armorican; 4. the south-west or Girondin; 5. the south-east or Rhodanian; 6, and finally, the Mediterranean or Provençal climate. Upon each of these subdivisions he enlarged, detailing the features of the country, the rivers, mountain-ranges, sea-coasts, geological structure, differences of level, and state of cultivation in each case, with the prevailing and most important features in the actual climate of each. Dr. Martins exhibited a map of France with these six regions distinguished. He stated that hitherto the labours of the meteorologists of France had no channel of publicity at their command, but that a journal devoted exclusively to meteorology was about to be established.

Mr. Follett Osler exhibited Papers containing Registers from his new Integrating Anemometer. A sheet of *plain paper* placed in the instrument under a registering pencil is moved forward by rotating hemispherical fans, at the rate of one inch for every ten miles of air that passes; this same pencil, having a lateral motion given to it by a vane, records the point of the compass from which the wind blows; and a clock hammer descending every hour, strikes its mark on the margin of the paper to express the time. Thus, in a *single line*, are given,—1st, the length of the current; 2ndly, the direction of it; and 3rdly, the time occupied in passing a given station marked hourly, or at any shorter interval that may be desired.

CHEMISTRY.

On the Action of Oxidizing Agents on certain Organic Bases. *By* T. ANDERSON, *M.D., F.R.S.E.*

THE author commenced by remarking, that the past year had formed an important epoch in the history of the organic bases, and had been distinguished by a variety of researches which had gone far towards the establishment of the true constitution of the artificial volatile bases. The extreme complexity of the natural fixed bases, and the slender success attending their investigation, had hitherto prevented chemists paying much attention to the action of different reagents upon that class of bases, although there could be no doubt as to the importance of the results to be obtained. The recent investigations of the volatile bases had however removed many of the difficulties besetting that of the more complex class; and we might now with justice expect the speedy determination of their constitution also.

In the course of some experiments, made with another object, the author had had occasion to observe some remarkable facts, which had led to an extended examination of the general action of oxidizing agents on the organic alkalies, and seemed likely to throw some light upon their constitution.

When codeine is treated with very dilute nitric acid, a substitution base, *nitrocodeine*, is obtained, which the author had described in a paper which would be published in the next part of the Transactions of the Royal Society of Edinburgh; but when the acid is of moderate strength, very violent action takes place, with the evolution of nitrous fumes and the production of an orange solution, from which water throws down a resinous acid, sparingly soluble in water, readily in alcohol. The analysis of this substance had not yet been fully completed; but the results obtained indicate a formula derived from that of codeine by the substitution of more than one equivalent of NO_4 and the addition of several equivalents of oxygen. When mixed with water, and dilute solution of potash added, it dissolves with a dark red colour; and by boiling the solution, a *volatile base*, possessing a strong peculiar odour, is evolved, and by distillation obtained dissolved in the water in the receiver. The fluid which distils is strongly alkaline; and when saturated with hydrochloric acid and evaporated on the water-bath, yields a highly crystalline salt, which dissolves readily in absolute alcohol, and gives, with bichloride of platinum, a fine yellow salt, insoluble in alcohol, but soluble in water. The salt so obtained gave on analysis results corresponding to the formula $C_2\,H_5\,N\,HCl\,PtCl_2$; and the base is consequently the *methylamine* of Wurtz, the formation of which by the action of a mixture of lime and potash on codeine had been determined in the paper already referred to. Methylamine however appears to be the sole product of the action of potash upon the yellow resin; but when potash-lime acts upon codeine, it is accompanied by *propylamine*, $C_6\,H_9\,N$, and ammonia.

Narcotine gives with nitric acid a variety of products, depending upon the concentration of the mixture. If the acid is dilute and the temperature employed low, derivative bases are obtained, which have not yet been examined in detail; but with stronger acid a yellow resinous acid is obtained, which by treatment with potash yields a volatile base, the platinum salt of which also gives results corresponding to methylamine.

Morphia and *strychnia*, by similar treatment, both give volatile bases.

Piperine, when treated with nitric acid, is rapidly acted on, with the evolution of nitrous fumes, accompanied by an odour resembling that of oil of bitter almonds. A brown resin is obtained as the result of the action, which dissolves in potash with a magnificent blood-red colour, and on ebullition evolves a volatile base with a peculiar and somewhat aromatic odour. This base gives with hydrochloric acid a beautiful salt, crystallizing readily from alcohol in needles nearly an inch long; and with bichloride of platinum, a salt in beautiful orange prisms, which on analysis yielded results corresponding to the formula $C_{10}\,H_{11}\,N\,HCl\,PtCl^2$, that is, to a base differing from valeramine by H_2.

Nicotine undergoes very violent decomposition with moderately strong nitric acid, and red fumes are given off in large quantity. When dilute acid is employed, however, and the temperature is kept just below the boiling-point, no nitrous acid is obtained, but the distilled fluid contains a large quantity of hydrocyanic acid. A volatile base is obtained by supersaturating with potash the residue in the retort, but in so small a quantity that it has been as yet impossible to ascertain whether or not it may not be a small quantity of unchanged nicotine, although the experiments made render that improbable.

On a Compound of Iodine and Codeine. By THOMAS ANDERSON, *M.D., F.R.S.E.*

The author commenced his paper by referring to the constitution of codeine which he had determined by his previous investigations, and referred in detail to the compounds and products of decomposition which had enabled him to fix its formula as $C_{36}\ H_{21}\ NO_6$.

The compound of iodine and codeine which formed the special subject of his communication is obtained by mixing together alcoholic solutions of equal quantities of codeine and iodine, and leaving the mixture to spontaneous evaporation, when the new compound is deposited in crystals. The compound is insoluble in water, sparingly soluble in cold alcohol but readily in boiling, and it is again deposited in small triangular plates as the solution cools. Its crystalline form has been determined by Prof. Haidinger of Vienna, who finds it to belong to the doubly oblique system. The crystals have a fine diamond lustre and a deep purple colour by reflected, and ruby-red by transmitted light. In powder its colour is cinnamon-brown.

The analysis of this substance had been attended with considerable difficulty from the very large amount of iodine it contains, but the author had been enabled to determine its formula to be $C_{36}\ H_{21}\ NO_6\ I_3$.

Its alcoholic solution is decomposed by sulphuretted hydrogen, and the solution contains hydriodate of codeine. Nitrate of silver poured upon the pulverized substance immediately produces iodide of silver; but in this way the author found that the whole iodine could not be separated, but that the iodide of silver obtained was variable in different experiments, and always fell 13 or 14 per cent. short of the calculated quantity.

The optical properties of this substance have been examined by Prof. Haidinger of Vienna. When examined with the dichroscopic lens by transmitted light, the ordinary image is seen of a colour varying according to the thickness of the crystal from honey-yellow to blood-red, while the extraordinary image begins with blood-red and soon becomes black as the thickness of the crystal increases. By reflected light the one image presents a brilliant ultramarine-blue, the other a ruby-red. The former of these however varies with the angle of incidence, and passes into violet, and with very high angles of incidence into bronze yellow.

Remarks on some Chemical Facts connected with the Tessellated Pavements discovered at Cirencester. By Prof. BUCKMAN, *F.L.S., F.G.S.*

In this paper it was shown that the materials of which pavements are composed are of two kinds:—the first, derived from rocks of the district, and termed natural; the second, composed of clay, fictilia and glass, artificial tessellæ. The natural tessellæ, many of which are so altered by chemical manipulation as to cause them to be referred to foreign rocks, consisting of bits of stone from the chalk, oolite, lias, and red sandstone formations, were clearly referred to their origin, and the processes by which they were prepared for pavements was pointed out. Thus, a gray colour was produced from a cream-coloured oolite, the change of colour being caused by a process of roasting. This is dependent upon the fact, that the oolite bed of which they are made contains iron and organic matter, the latter of which prevented the iron peroxidizing, and thus the gray was due to a protoxide of that metal.

The artificial tessellæ from pottery consist of shades of red and black; the reds all being due to a peroxidation of the iron in the clays from which they were made, whilst the blacks were the result of baking in "smother furnaces," as long since pointed out by Mr. Artis, so that the carbonaceous matter of the fuel with which the baking was effected was prevented from escaping; and, as he would lead us to infer, the black smoke penetrates the clay, and thus blackens it. The author however showed that this smoke acted chemically, by preventing the oxidation of the iron; and thus the change from the dark colour of the clay to red, which usually occurs in burning pottery and bricks, was prevented.

Reference was then made to a medallion of the pavement representing Flora, in the first drawing of which the head-dress and flowers held in the hand were coloured verdigris-green, the hue these objects presented on being exhumed; but as this was unsatisfactory in chromatic arrangement, the author suspected some subsequent chemical change; and on scraping away the green from the surfaces of the tessellæ in question, a beautiful ruby glass presented itself. New drawings (which were also exhibited) were then made, with ruby instead of green colour; the result of which was, that what was before inharmonious in colour and grouping, at once assumed harmony in these respects, and became perfectly intelligible. An analysis of the glass, made by Professor Voelcker, showed the cause of change from ruby to green to have been due to the fact, that the antique ruby glass had derived its colour from peroxide of copper, and that the tessellæ had become covered with carbonate of copper from a decomposition of their surfaces.

On the Action of the Soap-test upon Water containing a Salt of Magnesia only, and likewise upon Water containing a Salt of Magnesia and a Salt of Lime. By DUGALD CAMPBELL, *F.C.S.*

Experiments were first made upon water containing a salt of magnesia alone in different proportions, in order to ascertain if the soap-test acted throughout with magnesian solutions as it does with lime. For this purpose, 19·2 grains pure dry sulphate of magnesia (MgO, SO^3), the equivalent quantity of that salt to 16 grains carbonate of lime, were dissolved in a gallon of distilled water. This solution was considered as a standard of magnesia of 16° hardness. Fifteen other standards were prepared from this by proportional dilution with distilled water, in the same way as the standards of lime are recommended to be prepared by Professor Clark in the specification of a patent printed in the 'Repertory of Patent Inventions' for 1841.

The action of the soap-test in producing perfect lathers with these standards coincides, or nearly so, with the action of the soap-test upon like standards of lime up to the sixth degree; but from that point the magnesian standards begin not to require so much soap-test as the lime; and as the standards increase, this difference in soap-test increases till the magnesian standard of 16° requires only 19·6 soap-tests, whilst the lime standard of 16° requires 32.

Standard solutions were prepared containing 16°, 12°, 8°, 6°, 4°, 2° lime in a gallon plus 1°, 2°, 3°, 4° magnesia, and so on up to 16°.

Less soap-test is requisite to cause a perfect lather in most of these solutions than is requisite for the standard of lime alone contained in them; or, in other words, the magnesia appears to soften the lime standards, and this peculiarity increases as the magnesia increases; for example, a standard of lime of 16° takes 32 test measures; a standard of lime of 16°+1° magnesia takes 31·6, and a standard of lime of 16°+16° magnesia, 27·9.

As the standards of lime decrease, the action of a few of the lower degrees of magnesia in softening is modified, till solutions of the standard of lime of 2°, plus the first 4° of magnesia, take nearly as many soap-test measures as if they were entirely lime solutions.

In a number of these standard solutions, when a perfect lather had been produced by a minimum quantity of soap-test, the addition of a small quantity more reduced the lather to a curd; great agitation produced the lather again, and stronger than it was before the last addition of soap-test. If beyond a certain amount of soap-test however had been added, a new action showed itself, which was that the lather cannot be restored properly again until a certain amount of soap-test had been added. The additional quantities of soap-test were in every case noted when this peculiarity was observed.

The inferences drawn from the experiments are as follows:—1. That water containing sulphate of magnesia alone acts towards the soap-test in producing with it a perfect lather, similarly or nearly so, as does water containing a lime salt alone, but only when the equivalent of magnesia salt does not exceed 6 grains of carbonate of lime in a gallon of water.

2. That the degrees of hardness of an ordinary water cannot be inferred by the rule,—"compute the grains of lime, magnesia, oxides of iron, alumina, in a gallon of water, each into its equivalent of chalk. The sum of these equivalents will be the hardness of the water."

3. That the degrees of hardness of a water containing magnesia and lime salts, as shown by the soap-test as it is now applied, cannot, in almost every case, be taken as representing the amount of these salts in the water; nor, in nearly every instance, can it be considered as giving the amount of lime in a water when magnesia is present.

4. That water might show by the soap-test a small degree of hardness in comparison to the considerable quantities of salts of magnesia and of lime it might contain; and trusting to this method of analysis alone, when selecting water for ordinary use and for steam purposes, might lead to a water being selected which might not be conducive to the general health, and which would leave considerable deposit in vessels in which it was boiled—a great deterioration to its use in steam generating.

Remarks on the Isomorphous Relations of Silica and Alumina. *By* Prof. Chapman, *Univ. Coll., London.*

In this paper the author endeavours first to disprove the hypothesis, adopted by certain chemists, that 3 atoms of alumina are isomorphous with 2 atoms of silica. He shows, that, on this supposition, the formula RO, R^2O^3, which represents the highly-natural group of aluminates, ferrites, chromites, and their isomorphs,—comprising the well-established monometric or regular forms, spinel, gannite, magnetic iron ore, chromic iron, &c.,—should be isomorphous with 3RO, $2SiO^3$, the formula of a remarkable division of monoclinic or oblique prismatic silicates, including augites, Wollastonite, and other kindred forms. The minerals of these respective groups, however, do not bear the slightest analogy to each other.

The author then proceeds to examine the opinion which makes alumina isomorphous with silica atom for atom. He shows, that, according to this view, the above formula, RO, R^2O^3, of the spinels, magnetic iron ore, &c., should be equivalent to 3RO, $SiO^3+Al^2O^3$, SiO^3, the formula of the garnets. Here the included minerals belong equally to the monometric system; and although the spinel group affects octahedral forms, whilst the garnets usually crystallize in rhombic dodecahedrons, yet certain members of the series offer transitions from one to the other; magnetic iron ore, for instance, which occurs both in octahedrons and in rhombic dodecahedrons.

Allusion is then made to the statement of Berzelius, that he had analysed specimens of magnetic iron ore united crystallographically, as it were, to specimens of garnet, the two constituting a single crystal; also to the fact, that the author had seen rhombic dodecahedrons of garnet in which each of the three-sided angles—the positions of octahedral faces—consisted of magnetic iron ore. These facts, tending in a manner to confirm the second hypothesis, are met by the circumstance, that unions of a somewhat similar kind between minerals of dissimilar crystallization are not unknown, as in the familiar disthene-staurolite crystals from St. Gotthardt; although, in this latter case, the two crystals might be referred to the same group, by considering monoclinic forms as hemihedrons of the trimetric system, according to the views of Professor Weiss.

The angles of the principal monometric forms, however, being necessarily constant, no matter what the nature of the substance may be to which these crystals belong, the isomorphism of the two formulæ cannot be absolutely proved from the spinel and garnet minerals. The author therefore relies more particularly, in confirmation of this view, upon the crystallographic relations exhibited by two other minerals allied by their composition to the above. These minerals are the *Hausmannite* and the *Idocrase*,—the first having the composition MnO, Mn^2O^3, and consequently belonging to the spinel series; and the second having the general composition of the garnets. Both crystallize in the dimetric or square prismatic system, the Hausmannite occurring in only three forms, square-based octahedrons. Taking the more frequent of these to represent the protaxial form, and designating it by the symbol X, to avoid employing any particular system of notation, we obtain the axial ratios of the three forms as given in the following Table:—

	Considered as a diaxial pyramid.	Considered as a triaxial pyramid.
X	1 : 1·661	1 : 1·175
$\frac{1}{2}$X	1 : 0·830	1 : 0·587
$\frac{1}{3}$X	1 : 0·554	1 : 0·392

The idocrase is exceedingly rich in pyramidal planes, but any one may be selected for the basis of the notation of the variable forms. Taking for this purpose a plane of common occurrence, and which makes with the basal planes of the crystals an angle of 151° 51′, we obtain the axial proportions—

1 : 0·5351, or 1 : 0·3783 (triax.).

These, compared to the axial proportions exhibited by the Hausmannite, show that $\frac{1}{3}$X in that substance is equivalent to the present form of the idocrase, the slight difference being due to the isomorphic dissimilarity in the composition of the minerals, or to unavoidable errors in the measurement of the angles.

Having thus demonstrated the apparent isomorphism of silica and alumina, the author points out certain objections to the theory. In the first place, the natural forms of these compounds, quartz and corundum, are not exactly alike. Both crystallize in the same system, but differ in their axial proportions in the ratio of 4 silica to 5 alumina*, or according to the number of atoms present in each substance.

The second objection arises from the fact, that, by the adoption of the hypothesis, a peculiar and scarcely probable theoretic composition would result to many of the silicates; the proportions of oxygen in the base, for instance, would in several cases be 15, 24, or even 33 times less than in the acid.

The question therefore remains entirely undecided; and the author, in calling attention to the subject, and showing its important bearings on the general philosophy of the science, points out the serious want that must continue to be felt, from this state of uncertainty, in numerous mineralogical investigations. No satisfactory classification of the silicates can well be framed, neither can we account for the anomalous composition presented by certain of these bodies, by the staurolite for example, which consists of silica and alumina in inconstant proportions, whilst its external characters and crystallization remain unchanged.

On the Incrustation which forms in the Boilers of Steam-Engines, in a Letter addressed to Dr. George Wilson, *F.R.S.E.* *By* John Davy, *M.D., F.R.S., Inspector-General of Army Hospitals.*

On entering upon this inquiry, which I did after my return from the West Indies in December 1848, and after communicating a short paper to the Royal Society on Carbonate of Lime in Sea-water, it appeared to me desirable to collect as many specimens as possible of incrustation from the boilers of steam-vessels, now so widely employed in home and distant navigation. By application to companies and to friends in our seaports, as Dundee, Hull, Southampton, Hayle, Liverpool, Whitehaven, I have succeeded in procuring specimens of incrustation, formed by deposition, in voyages from port to port in the British and Irish Channels and the North Sea; between Southampton and Gibraltar; in the Mediterranean and the Black Sea; and in the Atlantic Ocean between Liverpool and North America, and between Southampton

* In the quartz rhombohedron the axes are as 1 : 1·095, in corundum as 1 : 1·362. One of these forms might however be considered, in the language of the French crystallographers, to be the "inverse" of the other, as in some of the calc-spar rhombohedrons; for the calculated plane angles of the corundum rhombohedron do not differ more than two minutes from the measured dihedral angles of the quartz form.

and the West Indies. I am promised specimens from the Red Sea and the Indian Ocean, but these I have not yet received.

The character and composition of the incrustation, whether formed from deposition, from water of narrow seas, or of the ocean, I have found very similar, with few exceptions crystalline in structure, and, without any exception, composed chiefly of sulphate of lime, so much so, indeed, that unless chemically viewed, the other ingredients may be held to be of little moment, and rarely amounting to five per cent. of the whole.

From two specimens of incrustation from the boilers of steamers crossing the Atlantic, one of which you sent me, in which you had detected a notable portion of fluorine, judging from its etching effect on glass, I also procured it; it was in combination with silica; and I procured it also so combined from two obtained from steamers navigating our own seas, one between Dundee and London, the other between Whitehaven and Liverpool. Of this I had proof by covering with a portion of glass or platina-foil a leaden vessel charged with about 200 grs. of the incrustation mixed with sulphuric acid, and by keeping the glass cool by evaporation of water from its surface, and by supplying moisture for the condensation of the silicated gas by a wet band round the mouth of the vessel. After about twenty-four hours under this process, a slight but distinct deposition was found to have taken place, corresponding to the margin of the vessel—a deposition such as that produced by silicated fluoric acid gas under the same circumstances; thus it was not dissipated by heat nor dissolved by water, and yet admitted of removal by abrasion, either entirely or in great part; the former in the instance of the platina-foil, the latter in that of the glass. Besides the ingredients above-mentioned, I may add that in many instances oxide of iron, the black magnetic oxide, was found to form a part of the incrusting deposit, collected in one or more thin layers; and further, that in some, especially of steamers navigating the narrower and least clear part of the British Channel, the deposition presented a brownish discoloration, produced by the admixture of a small quantity of muddy sediment: incrustations so discoloured, I may remark, are reported to be most difficult to detach.

I have said that the incrustations, with few exceptions, were similar in their structure, and that that was crystalline; it was not unlike the fibrous variety of gypsum of the mineralogists. The specimens received, as might be expected, varied very much in thickness, viz. from one line and less to half an inch. I have endeavoured, by a set of queries which I had distributed, to obtain information respecting the exact time in which the incrustations were formed, and under what circumstances, but with partial success only, owing, it may be inferred, to a want of exact observation. In one instance, that of the North American mail steam-ship "Europa," which arrived at Liverpool on the 15th of November, at 4 P.M., having left Boston on the 7th of the same month, at 9 A.M., an incrustation was found in her boiler of about one-fiftieth of an inch in thickness; and it is stated that an incrustation of about the same thickness was formed on her outward voyage. This example may aid in giving some idea of the degree of rapidity with which the incrustation is produced, at least in the Atlantic, with the precaution of "blowing off" every three hours, and with the "brine-pumps" kept in constant work. In other seas, especially contiguous to shores, and more especially of shores formed by volcanic eruption, it is probable that, *cæteris paribus*, the rate of the deposition of the incrusting sulphate of lime will be more rapid. The results of the trials of several portions of sea-water taken up on the voyage from the West Indies to England, noticed in the paper of mine already referred to, are in favour of this conclusion.

To endeavour to prevent the deposition of the incrusting matter, or to mitigate the evil, various methods it would appear have been had recourse to,—some of a chemical kind, as the addition of muriate of ammonia and sulphate of ammonia to the water in the boiler,—without success, as might be expected; others, of a mechanical kind, with partial success,—as the introduction of a certain quantity of sawdust into the boiler, or the application of tallow, or of a mixture of tallow and plumbago to its inside, to prevent close adhesion and the more easy separation of the incrusting matter, either by percussion, using a chisel-like hammer, or by contraction and unequal expansion by means of flame kindled with oakum after emptying the boiler and drying it. Of all the methods hitherto used, that of "blowing off," that is, the discharging by an inferior stopcock a certain quantity of the concentrated water of the boiler by the pressure of steam, after the admission above of an equivalent quantity of sea-water of ordinary density, appears to be, from the reports made, the most easy in practice, the least unsuccessful, and the most to be relied on. But, as in the instance given of the North American steamer, it can be viewed only as a palliative.

Considering the composition of the incrusting matter, and the properties of its principal ingredient, the sulphate of lime, a compound soluble in water and in sea-water, and deposited only when the water containing it is concentrated to a certain degree, there appears to be no difficulty theoretically in naming a preventive. The certain preventive would be the substitution of distilled or rain-water in the boiler for sea-water; of this we have proof in the efficacy of Hall's condenser, which returns the water used as steam, condensed, after having been so used: but, unfortunately for its practical success, the apparatus is described as being too complicated and expensive for common adoption. Further proof is afforded in the fact that the boilers of steamers navigating lakes and rivers, in the waters of which there is little or no sulphate of lime, month after month in continued use, remain free from incrustation. This I am assured is the case with the steamers that have been plying several summers successively on the lake of Windermere. And, it may be inferred, that in sea-going steamers, in which sea-water is used in the boiler, or indeed any water containing sulphate of lime, the prevention of deposition may be effected with no less certainty by keeping the water at that degree of dilution at which the sulphate of lime is not separated from the water in which it was dissolved. From the few trials I have made, I may remark, that sulphate of lime appears to be hardly less soluble, if at all less, in water saturated with common salt than in perfectly fresh water. This seems to be a fortunate circumstance in relation to the inquiry as to the means of prevention, and likely to simplify the problem.

If these principles be sound, their application under different circumstances, with knowledge and judgement on the part of the directing engineer, will probably not be difficult. His great object will be, in sea-going steamers, to economize the escape of water in the form of steam, and thereby also economize heat and fuel; also, when fresh water is available, to use it as much as possible; and further, to avoid using sea-water as much as possible near coasts and in parts of seas where sulphate of lime is most abundant.

From the incrustation on the boilers of sea-going steamers, the attention can hardly fail to be directed to that which often forms, to their no small detriment, in the boilers of locomotive railway engines, and of engines employed in mines, and in the multifarious works to which steam-power is now applied.

These incrustations will of necessity be very variable, both in quantity and quality, according to the kind of ingredients held in solution in the water used for generating the steam. Hitherto I have examined two specimens only of incrustations from the boilers of locomotive engines, and a single one only from the boiler of a steam-engine employed in a mine—a mine in the west of Cornwall. The latter was fibrous, about half an inch thick, and consisted chiefly of sulphate of lime with a little silica and peroxide of iron, and a trace of fluorine. The former were from one-tenth of an inch in thickness to an inch. They were laminated, of a gray colour, and had much the appearance of volcanic tufa; they consisted principally of carbonate and sulphate of lime with a little magnesia, protoxide of iron, silica, and carbonaceous matter; the two last, the silica and carbonaceous matter, probably chiefly derived from the smoke of the engine and the dust in the air. From the engineer's report, it would appear that the thinnest, the incrustation of about one-tenth of an inch, had formed in about a week, during which time the locomotive had run about 436 miles, and consumed about 10,900 gallons of water.

On a peculiar Form produced in a Diamond when under the Influence of the Voltaic Arc. By J. P. Gassiot, *F.R.S.*

M. Jacquelin was the first to show that when the diamond is submitted to the high temperature and influence of the voltaic arc, it quickly becomes converted into a black carbonaceous matter, having all the appearance of coke. The diamond, when in a native state, is an insulator or non-conductor of electricity, but when thus changed into coke it becomes an excellent conductor.

At the Chemical Section of the British Association, held at Oxford in 1847, Dr. Faraday exhibited some specimens of the diamond coke which had been forwarded to him by M. Jacquelin; and subsequently, on the 16th of June 1848, he publicly showed the experiments in London in the theatre of the Royal Institution.

On repeating the experiments a short time since before a few private friends, I obtained a product so totally different from that of M. Jacquelin, that I am induced to bring the subject before this Section, in the anticipation that it may tend to elicit some observations on a phænomenon which at the time attracted the attention of many electricians.

The apparatus I used in this experiment consisted of forty series of the usual size of Grove's nitric acid battery; the terminals were made from two pieces of well-burnt boxwood-charcoal, that attached to the positive or platinum end of the battery, being formed in the shape of a small cup or crucible, in which the diamond was placed; to the negative or zinc end of the battery a piece of the same charcoal (but pointed) was attached.

The experiment was then made in the same form as described by M. Jacquelin, by first making contact with the two charcoal terminals, then bringing the flame in such a position as to cause it to *surround* the diamond; in less than one minute the diamond as well as the electrode became in a state of intense ignition; the diamond gradually increased in size, rolling about in the heated crucible, when it *suddenly expanded*, forcing itself upwards on the negative terminal, at which moment I separated the electrodes.

The diamond, which was in a state of intense ignition, remained attached to the negative terminal. When cool, it exhibited the same state as it now presents; it was expanded to eight or ten times its original bulk. Instead of becoming a black carbonaceous substance and a good conductor, it has a *vitreous, white, opake* appearance, and remains a non-conductor. It has also a deep circular cavity on that portion which was opposite and nearest to the positive electrode, that part which was in contact with the negative electrode being clearly discernible by a small portion of the boxwood-charcoal remaining attached to it. The centre of the cavity appears to be still brilliant, as if that portion of the diamond had not been in a complete state of fusion.

In one or two other experiments the diamond disintegrated, the fragments remaining in a carbonaceous state; since which I have not had the opportunity of repeating the experiment.

Observations on the Growth of Plants in Abnormal Atmospheres. *By* Dr. J. H. Gladstone *and* Mr. G. Gladstone.

Though oxygen is the most important constituent of the atmosphere, so far as animal life is concerned, it is upon the carbonic acid, ammonia and aqueous vapour that the vegetable world is mainly dependent.

The question arises, Do the oxygen and nitrogen of the air play no important part in the process of vegetation? The following preliminary experiments, with a view to the solution of this and similar inquiries, were detailed by the authors:—

A pansy lived for the length of twenty-four days in an atmosphere of hydrogen containing 5 per cent. of carbonic acid; one similarly placed in an atmosphere of common air remained healthy for a longer period.

Five onions, just commencing to sprout, were severally placed in carbonic acid, carbonic oxide, coal-gas, air containing 8 per cent. of light carburetted hydrogen, and ordinary atmospheric air. The germination of the two first was entirely stopped, while the hydrocarbons appeared considerably to accelerate the growth of the vegetable. The plants in each instance lost weight.

A pansy in flower, a young stock and a grass plant were placed in pure nitrogen gas. The two former soon died, but the grass was left growing a month after the commencement of the experiment.

Another pansy was placed in a mixture of oxygen and hydrogen gases in the proportion requisite to form water. In order to imitate the balance that obtains in nature between animal and vegetable life, some flies were introduced, along with some sugar, to serve as their food. The experiment was commenced a fortnight since; and the plant, when last observed, was in good condition. Owing to the low specific gravity of the mixed gases, the flies were unable to mount on the wing, or make the usual buzzing noise; but the substitution of hydrogen for nitrogen in the atmosphere had no marked effect upon their breathing; thus confirming the observations of M. Regnault by an instance drawn from the Articulata.

On the Sulphite of Lead.
By William Gregory, *M.D., Professor of Chemistry.*

In Dr. Scoffern's process for purifying and extracting sugar, the albuminous matters are precipitated by acetate of lead, and the lead remaining in solution is thrown down by sulphurous acid gas as insoluble sulphite.

In the event of lead being found in the sugar thus prepared, and it appears that a minute trace may thus be found, owing to imperfect filtration, it must be in the form of sulphite; and I thought it most desirable to examine the properties of this salt. The sulphite of lead is one of the most insoluble salts known, far more insoluble than the sulphate; indeed it may be called absolutely insoluble. As the sulphate has always been considered inert, and indeed sulphuric acid is used as an antidote to poisoning by lead on this account, it appeared most probable that the sulphite would likewise prove inert. To test this up to a certain point, I prepared a quantity of pure sulphite of lead, and gave it, in the moist state, to rabbits and dogs with their food. The animals all took it readily and throve upon it, although large doses were daily given for periods varying from three to six weeks. The rabbits, being well-fed, became very fat, and continued quite healthy.

It is well known that very minute doses of carbonate of lead, when long continued, produce poisonous effects. I had not the opportunity of testing the effect of very minute doses of the sulphite for very long periods; but I think it reasonable to conclude, that as the large doses, continued for six weeks, had *no deleterious action whatever*, the sulphite of lead is essentially inert and innocuous. Besides its insolubility, it is remarkable for stability; and so strong is the action of sulphurous acid on the salts of lead, that it changes the black sulphuret into a white powder. In presence therefore of an excess of sulphurous acid, no lead can be left in solution.

In conclusion, sugar prepared by Dr. Scoffern's process, and probably containing as much lead as was found in the samples analysed by the Commission, has been used for months by families without any bad results. As long then as no such results have been observed, and my experiments tend to show that they are not to be expected, it would be wrong to reject the very great improvement of Dr. S. merely because a trace of lead (and that, not as carbonate, the truly poisonous compound) has been found in the sugar prepared by his process. It may also confidently be expected, that, by improved means of filtration, even the minute trace of sulphite of lead, hitherto found, will be entirely got rid of.

On some Amalgams. By J. P. Joule, *F.R.S.*

The author had procured an amalgam of iron by precipitating it on mercury by the electrotype process. He had subsequently pursued the research with a view to form definite amalgams by a simple chemical or mechanical process. When mercury was made negative under a solution of sulphate of copper, an amalgam of copper was formed, which, when fully saturated with copper, was found to be represented by the formula Cu+Hg.

The author also exhibited a small apparatus whereby amalgams could be made to endure a pressure of 60 tons per square inch of surface. The superfluous mercury was thus expelled through the openings in the sides of the press, leaving an amalgam of definite chemical composition. In this way he had procured the following compounds:—

Pt+2Hg
Ag+2Hg
Cu+ Hg
Fe+ Hg
2Zn+ Hg
2Pb+ Hg
7Sn+ Hg.

New Researches on the Conductibility of the Earth. By Prof. MATTEUCCI.

Although the good conducting power of the earth is at present generally admitted, and is advantageously applied to the construction of electrical telegraphs, it must be confessed that nothing has been hitherto known of the laws and theory of this singular phænomenon. In England, Germany and Russia, it has been found advisable, for several years past, to form the telegraphic circuit partly with the earth and partly with a metallic wire, instead of forming the whole circuit with metal wire only. I was, I believe, the first to show by exact experiments made in 1844 at Pisa, and by others performed according to my propositions at the Scientific Congress of Milan, that *the resistance of the earth* to the passage of the electrical current, which is sensible in short distances, ceases to increase, and remains constant when the distance between the electrodes plunged in the earth has attained a certain length. Having latterly renewed my studies on this subject, I have confirmed and extended, in a complete and general manner, the conclusions drawn from my former researches; I have also demonstrated the principal result, given above, by different experimental processes. I have compared the resistance of a mixed telegraphic circuit with that of an entirely metallic circuit, containing a length of wire twice as great as that employed in a mixed circuit. I have also formed metallic circuits of very fine brass wires, having the same resistance as the metallic portion of a very long mixed telegraphic circuit; and finally, by making use of long metal wires covered with gutta percha, I have been able to compare the resistance of an entirely metallic circuit with that of a mixed circuit, in which the metallic portion remained constantly the same, and to which were added different lengths of earth. The following are the principal conclusions drawn from experiments which have occupeid me for about a year:—

The resistance of a layer of earth to the passage of the electrical current varies according to the quantity of water contained in the earth of which it is composed; according to the specific gravity of that earth; according to its depth beneath the surface; and according to the nature of the electrodes and extent of their surface.

This resistance does not increase with the increased length of the layer of earth; on the contrary, beyond a certain limit of length, which varies according to the different circumstances just indicated, but which in all cases is of little extent, the resistance of a layer of earth *remains constant, whatever be its length.* It is unnecessary to say, that I could not prove this fact by experiment on circuits exceeding eighty miles in length, such being the average of the telegraphic circuits in Tuscany.

In making the experiment near the surface of the soil, it is difficult to plunge the electrodes in earth of exactly the same conducting power; different portions of the surface of soil possessing either better or worse conductibility than that on which we begin to operate, it follows that in increasing the distance between the electrodes, we may find either an increase or diminution in the resistance of the earth. Likewise, in operating on a long mixed telegraphic circuit, which is not perfectly isolated, owing to the effect of the different derived circuits formed between the posts and the earth, the electric current is stronger near the pile than at a distance, and stronger than in a circuit which is formed only of metal wire equal in length to that which enters into the mixed circuit. This explains the results which I had obtained from my former uncompleted experiments. The resistance of a layer of earth appears to diminish, as its length increases, only in case we meet with other layers of better conducting power.

In every layer of earth of a certain *constant* conducting power, the resistance, which at first increases very feebly with the increased length of the layer, becomes very soon constant, and continues the same for all the subsequent lengths, however great, on which experiments have been made. Now it is evident, that, as the increase of resistance in a long metallic circuit is scarcely perceptible when we add to the circuit, by means of two large electrodes, a thin stratum of water, so we ought to find in the long mixed telegraphic circuits, that the resistance of the earth is null, or nearly so, since it is equal to that of a thin stratum of water of a very large section.

The law of the conducting power of the earth being established, it remains to give the theory of this phænomenon. The opinion of the scientific world is divided on this point. Some explain the good conducting power of the earth by the almost infinite section of the earth compared with the distance of the electrodes; others again suppose that the electricities at the two extremities of the pile are dissipated in the earth in the same manner as the electricity of the conductor of an electrical machine.

This second explanation will not bear the slightest examination, nor can it be made to tally with the results of the most elementary experiments relative to the conducting power of the earth. In fact, one cannot on this supposition explain why the resistance of the earth increases at first with the length of the layer; why it varies with the depth and the degree of moisture of that layer; why it changes if the mass of earth interposed between the two electrodes happens to decrease, or to be wanting, as I have proved by experiments made in mountainous districts; why the interposition of a portion of earth of a different conducting power produces a variation in the resistance of the entire mass; why the resistance becomes infinitely greater when we keep this layer in a wooden trough separate from the earth, but in communication with it by means of large metallic plates. According to this explanation, the resistance of the metallic part of a mixed circuit ought to disappear, a thing which never happens.

I think that I may be able to give a satisfactory explanation of the good conducting power of the earth, founding my assertions on very simple experiments, and on theoretical views already known. As long ago as 1837, I proved, in a memoir published in the 'Annales de Physique et de Chimie,' that in operating on a certain liquid mass, very considerable compared with the distance of the electrodes plunged in it, *the length of the intermediate liquid stratum has no sensible influence on the intensity of the current.*

I have recently verified this result on a very large scale. I had a wooden case made, 7 *metres* in the side; I keep this case isolated from the earth, and filled with water. Operating on this mass of water, we find that the resistance of a certain stratum of water, variable within certain limits, is independent of its length. In like manner, in studying the conducting power of spherical masses of water varying in diameter from 2 centimetres to 30 or 40 centimetres, I have found that the resistance of these spherical masses of water was the same, and independent of their diameter.

I have already said, that this result may be deduced from the theory, and this is done as follows. From the same differential equations, given first of all by Fourier in his celebrated theory of heat, and which Ohm has applied to electricity, suppressing in the latter case the terms which expressed the dispersion of heat in the air, are deduced in the case of the sphere, the results which I have obtained by experiments on the propagation of electricity in the earth. Although we are as yet ignorant of the physical value of that *variable* U which figures in the fundamental equation of Ohm in three partial differentials, which is the same as that of Fourier in the propagation of heat, and although that equation would really be more applicable to the case of the metallic wire, which communicates at one extremity with the conductor of an electrical machine in action, and at the other extremity with the earth, than to the case of the electrical current *defined* by its electro-chemical and electro-magnetical action, it is no less true, that a certain number of the phænomena of the electrical circuit are explained by representing the propagation of the electrical current by the same equation given by Fourier in his theory of heat. Among these phænomena may be placed, the fundamental law of the propagation of electricity in metallic wires according to their section and length; and the other more general cases of the propagation of the electrical current, and of derivation, in large metallic plates, or in spherical masses, and in the earth, such as they have been found by MM. Kirchhoff and Smaasen in Germany, and in Italy by my friends Ridolfi and Felici.

On the presence of Carbonates in Blood. By Prof. G. I. Mulder, *of Utrecht.*

In this paper Prof. Mulder proves experimentally that blood contains carbonic acid, not merely in solution, but also in chemical combination with bases and organic substances, as globulin, albumin, &c. When blood is mixed with water, boiled, filtered, and the clear liquid evaporated to dryness, and the residue redissolved in a little water, it will be found that acetic acid does not disengage any appreciable quantity of carbonic acid, though carbonates are present in the blood. This circumstance, which led several chemists to infer that blood contains no carbonates, finds its explanation in the fact, that the presence of organic substances in the blood gives rise to the decomposition of the carbonates. In order to prove this experimentally, Prof. Mulder treated blood in the manner described, with the addition of carbonate of soda, but he could nevertheless not detect any appreciable quantity of carbonic acid; addition of acetic acid to the residue left on evaporation of the blood serum.

Another source of error in determining the quantity of carbonic acid in blood, is found in the greater power of absorbing carbonic acid which acetic acid possesses in comparison with that of water. According to Mulder, 100 vol. of acetic acid of a specific gravity of 1·070 absorbs 350 vol. of carbonic acid.

Acetic acid of	1·064	,,	300	,,
,,	1·053	,,	130	,,
,,	1·028	,,	110	,,

The author disagrees with Liebig, who, as it is well-known, explains the fact that blood absorbs much carbonic acid by the presence of the tribasic phosphate of soda in blood, with which salt, according to him, carbonic acid enters into chemical combination, and mentions some experiments, which are intended to prove that no chemical change takes place when carbonic acid is passed through a solution of tribasic phosphate of soda; on this occasion Mulder found that tribasic phosphate of soda simply possesses a greater power of absorbing carbonic acid than water. This however he found to be the case with other salts likewise; phosphate of lime particularly is mentioned by the author as a salt which absorbs half more of carbonic acid than water. For these reasons Prof. Mulder considers it illogical to ascribe solely to phosphate of soda, a function in blood which it shares with several other combinations, both organic and inorganic, which are found in blood.

On a new and ready Process for the Quantitative Determination of Iron. By Dr. FREDERICK PENNY, *Professor of Chemistry in the Andersonian Institution, Glasgow.*

In this paper the author recommends the employment of the chromate and bichromate of potash for the estimation of iron in the common ores of the metal, and especially for the analysis of the clay-band and black-band ironstone of this country. He was led to the application of these salts in the course of certain investigations upon the materials and products of the manufacture of alum from alum-shale, in which he was much retarded by the want of a ready method for estimating the oxides of iron. After trying various modes, and also Marguerite's process with the permanganate of potash, he decided on the chromates of potash, which give very exact results, and possess the great advantage that a much larger quantity of material may be operated upon than can be conveniently treated by the usual methods. For practical purposes, he says, the bichromate is to be preferred. The process requires no other apparatus than that commonly used for Centigrade testing, which is familiar to all persons engaged in chemical pursuits. It may be easily and rapidly executed, occupying only a fraction of the time required for the process of estimating iron by precipitation as the sesquioxide; and it is not interfered with by the presence of alumina and phosphates, which usually exist in the ore. The method is based upon the well-known reciprocal action of chromic acid and protoxide of iron, whereby a transference of oxygen takes place, the protoxide of iron becoming converted into sesquioxide, and the chromic acid into sesquioxide of chromium. The following equation will serve to exhibit the general nature of this reaction:—

$$2CrO_3+6FeO=Cr\ O+3Fe^2O\ .$$

The following is an outline of the mode of operating in the case of clay-band and black-band ironstone. The test solution of bichromate of potash is first prepared by putting into a common alkalimeter 44·4 grains of the salt in fine powder, filling to zero with tepid distilled water, and agitating until the salt is dissolved and the solution is of uniform density throughout. 100 grains of the ironstone, previously pulverized, are dissolved in hydrochloric acid, and the solution diluted with water, and filtered in the usual manner. To this filtered solution the test-liquor in the alkalimeter is now added, until, on testing a portion of the mixture with red prussiate of potash, a blue colour is no longer produced, but a reddish tinge communicated. The operation is then finished, the number of divisions of test-liquor consumed carefully read off, and this number divided by two gives the amount per cent. of metallic iron in the ore. Dr. Penny gave the results of numerous experiments made with pure metallic iron, and with protosulphate of iron, for the purpose of ascertaining the exact quantity of bichromate of potash corresponding to a certain weight of iron. The mean of all his experiments gives 100 of iron to 88·75 of bichromate. In the analysis of those varieties of ironstone which contain an admixture of peroxide of iron, Dr. Penny recommends the employment of sulphite of soda, by which the peroxide is speedily reduced to the minimum state of oxidation, and then the bichromate may be applied as before indicated. The only precaution to be observed is to use the sulphite of soda in sufficient quantity, and to take care to expel the excess of sulphurous acid by brisk ebullition. Dr. Penny likewise noticed several objections, which appear to militate against the accuracy of this method of analysis. He showed that no error could arise, during the performance of the experiment, from the oxidation of the protocompound of iron in the hydrochloric acid solution by the oxygen of the air, as no appreciable change can be detected even after the lapse of several hours. And he also satisfied himself that hydrochloric acid exerts very little influence upon dilute solutions of the chromates, so that no inaccuracy could be produced by this action.

In conclusion, Dr. Penny remarked, that his paper might be much extended by showing the application of this process to the analysis of other ores of iron, as well as its availability for the examination of alum liquors and copperas liquors, and other products of the arts; but such applications can easily be made by any one ordinarily acquainted with practical chemistry.

Phophorescence of Potassium. *By* William Petrie.

It was not accident that led Mr. Petrie to observe the fact of the phosphorescence of potassium, but while speculating on the consequences of the dynamical theory of heat he was led to the conclusion that cold potassium ought to be found *luminous*, and further, that it ought to be only about a tenth part as luminous as phosphorus.

On testing this experimentally, as soon as opportunity allowed, with the precautions for sensitive vision which the anticipated feebleness of the light indicated to be necessary, the result was, that on dividing a bit of potassium (which was quite dry, being protected only by a coating of bees'-wax) the halves showed two *distinctly luminous sections*, the light being about a tenth of that from a similar surface of phosphorus. The light diminished naturally as a protecting coat of oxide was formed, but remained just perceptible to the most sensitive sight as long as half an hour.

The outline of the considerations which led theoretically to this fact may be worthy of a brief notice. Light from electricity or from combustion is due to the intense heat produced by the electricity or by the chemical combination; in other words, the transfer of electric power in the one case, or, in the other, the violent impulsion of the atoms of carbon and oxygen, by affinity, from their natural atomic distances towards each other, produces atomic motions, which (having nothing to absorb the dynamic force invested in them) must continue as a state of intense vibration, causing the phænomena of *heat*. *Some* of the vibrations communicated to the surrounding æther are of a transverse order, and *some of these* are of that intensity which affects the eye with the sensation of *light*.

But, such being the cause of light, how can phosphorus emit light when *not warm*? Because the few individual atoms which are at any moment in process of oxidation must necessarily be at the instant thrown into the full state of vibration due to the force of affinity acting during their transit onward from the distance ordinarily separating them from those of the oxygen, and this vibration must continue until it is gradually expended in imparting vibrations of radiant heat and light to the surrounding *æther*, besides gradually dividing its force into slighter vibrations in all the adjacent atoms of its own substance, that is, *raising* its temperature in a minute degree. The heat of so few atoms vibrating intensely is scarcely perceptible, while another substance may have *all* its atoms in a state of general vibration such as to be much hotter, and yet *not one of them* vibrating with sufficient intensity to produce *light*.

Now it is clear that the greater the number of vibrations which each of the few combining atoms can make and communicate to the surrounding æther, before the atom loses its motion, by gradually imparting it to all the surrounding atoms of the substance, so much the more light will each of the combining atoms have produced, on the whole.

In the case of phosphorus, a *large* portion of the motion of any vibrating oxidized atom becomes expended in producing radiant heat and light before the atom can divide its motion among the adjacent atoms of phosphorus, for they are so connected that they do but slowly and imperfectly communicate their vibrations to each other, which is the theoretical way of saying that the substance is a bad conductor of heat. The amount of light, therefore, produced by the oxidation of *a newly-exposed cold surface* of any substance having sufficient affinity for the surrounding gas will be less, as its conducting power is greater.

These considerations indicate that potassium (and of course sodium, calcium, &c.) must be phosphorescent, though less so than phosphorus itself, and experiment has fully confirmed these anticipations.

On the Condensation of Volume in highly hydrated Minerals. By Lyon Playfair, *Ph.D., F.R.S.*

Dr. Lyon Playfair has been for some time engaged in a series of investigations having particular reference to the atomic constitution of bodies. This communication was in continuation of this subject. It was shown that the water in hydrated minerals was, by some peculiar molecular force, subjected to extreme condensation; that it occupied only the space of the solid matter of the mass; and on dissolving any salts containing water of crystallization, it was found that they only increased the bulk of the water by the quantity of water they contain, the solid matter appearing to occupy no space.

Observations on Ropy Bread. By George Read.

During the summer and autumn of 1846, the bakers of London made many complaints repecting a disease in their bread termed ropiness. Having, at the request of many bakers, investigated the subject, the author offered the various statements which he had collected, and some results of personal observation, for the consideration of the Section. Among other facts, he mentions, that on examining some specimens of diseased bread with a powerful microscope, he found that the whole of the cellular portion of it was destroyed, and its appearance was that of a peculiarly white, luminous substance, somewhat resembling the granules of starch. One or two of the specimens which he examined were found to be completely covered with fungi.

On the Sugar Produce of the South of Spain, chiefly in connexion with the employment of Acetate of Lead and Sulphurous Acid as Purifying Agents. By Dr. Scoffern.

On the southern coast of Spain, in a region limited by Almeria on the east and Malaga on the west, bounded on the north by mountain ranges and on the south by the Mediterranean, is a tract of land which, so far as its climate and productions are concerned, may be aptly denominated tropical. In it the date, palm, indigo, cotton, and sugar-cane flourish with vigour, yielding products equal both in quantity and quality to those of the tropics themselves.

The sugar-cane, first introduced by the Arab conquerors, is not only consumed in large quantities as a dessert, but also gives rise to a considerable manufacture of raw and refined sugar, a circumstance which beyond Spain itself seems to be very little known.

There is perhaps no example on record of any operation involving a commercial result, attended with such an enormous destruction of material as the operation of extracting sugar from the cane. One portion of this loss is due to mechanical, another to chemical causes.

The sugar-cane has been stated by most writers who have found opportunities of practically examining the subject, to contain no more than 10 per cent. of solid non-saccharine matter, leaving 90 per cent. of juice to be extracted. Of this 90 per cent. most writers concur in testifying, that in practice scarcely 50 per cent. are actually obtained, at least in the British West India possessions. Cane-juice itself has usually been stated to contain from 17 to 23 per cent. of crystalline sugar, of which scarcely 7 per cent. in practice were actually extracted.

Considerable doubts having been expressed as to these statements of the amount of juice in the cane, and sugar in the juice, I have lately gone through a series of experiments having for their object the settlement of the doubt, and with the result of amply confirming the testimony of other experimenters. Having operated on canes from various parts of this district by slicing them, exhausting first by hot water, then by hot alcohol, and finally drying, I obtained as my mean result about 10 per cent. of woody or insoluble matter, whilst the sugar extracted and crystallized ranged from 17 to 23 per cent., as had previously been stated. It would consequently appear that 40 per cent. of juice is actually lost in the practice of our West India workings; and now arises as a most important consideration, the question as to what extent this loss is inevitable, and to what extent it might have been obviated by altered machinery or improved manipulation.

Instead of 50 per cent. of juice extracted, 70 per cent. is much nearer the average amount yielded by the sugar-mills of this coast, although occasionally the result is as high as 75 per cent., and this in some cases with mills of very inferior construction. The cane however is passed between the rollers of the mill four times, until the refuse or megass, as the pressed cane is called, has been reduced to a state of disaggregation resembling ground tan, whereas the West India cane refuse is represented to be in the form of long strings, a sufficient proof that the pressure applied has been very inadequate.

After the cane has finally left the mill, it is immediately, in the Spanish sugar regions, subjected to the operation of pressing, sometimes by the agency of a screw, but in many cases by hydrostatic force. By the latter method I have seen 13 per cent. of juice extracted from megass which had already yielded up 73 per cent. of juice to the mill, thus elevating the total quantity extracted to 86 per cent. out of the original 90, and consequently, as a manufacturing operation, leaving very little more to be desired. The hydrostatic press I consider to be an apparatus which is indispensable to the œconomy of every sugar estate: not only does it largely contribute to the amount of juice extracted, but what is most remarkable, the juice resulting from hydrostatic pressure of megass, is invariably, so far as my observations have gone, richer in sugar than juice yielded by the mill, a fact which seems to be only explicable on the supposition that the hydrostatic press, in virtue of its great power, is enabled to extrude those particles of sugar which microscopic examination demonstrates to exist in the cane in the solid and crystalline form.

The subsequent stages of the sugar manufacture, as carried on in Spain, do not materially differ from those in operation in Cuba and many other tropical countries. The juice is defecated or purified by lime, skimmed, evaporated to the requisite degree, and poured into earthenware moulds, the contents of which are finally exposed to the operation of claying. In one manufactory, however, witnessed by me, at Almunecar, lime is no longer used, on account of its well-known injurious effects on sugar, no other agent having been substituted in its stead, but sole reliance being placed on the coagulation by heat of albuminous matters present in the juice, and their final removal by skimming. Under this system of manufacture, the sugar produced is light-coloured but badly grained, and the unseparated albuminous matters are present in such quantity, that every 103 parts of the concentrated saccharine juice, as it comes from the teache or last evaporating pan, only yields 40 parts of crystallized sugar on cooling, the other 60 per cent. remaining in the condition of molasses, perfectly uncrystallizable until some adequate means for defecation be had recourse to.

The chief object of my residence in this sugar district was to superintend the erection of machinery for manufacturing sugar by means of my own process. The site of our operations is Motril, about forty-five miles south of Granada, in a manufactory furnished with apparatus of the rudest character. Up to this period (July 9th), our own vacuum apparatus has not been sufficiently advanced to enable us to pursue our operations by its aid; nevertheless, owing to the superior defecating power of the subacetate of lead, we have, even with the old and rude machinery, obtained a result of more than 16 instead of 7 per cent. of sugar. Our striking teaches or final evaporating pans we were under the necessity of removing, in order to afford the requisite space for our own machinery; hence we were reduced to the necessity of concluding our process of concentration in a brass pan of conical form and holding about 600 imperial gallons, thus materially increasing the difficulty of the evaporative process. Hitherto only one-sixth per cent., on the juice, of subacetate has been used, but I imagine the quantity may be advantageously increased. As filtration is indispensable to the conducting of this process, considerable fear was entertained lest fermentation might supervene. This fear, however, practice has demonstrated to be groundless, inasmuch as we possess in sulphurous acid an agent most antagonistic to fermentation. Another speculative fear was, lest danger might arise from the lead employed: this fear, too, practice demonstrates to be entirely without foundation, for not only is the sulphate of lead most easily removed, but even were it to remain, no injury could supervene, inasmuch as this agent is as harmless as chalk.

On the Tetramorphism of Carbon. By HENRY CLIFTON SORBY.

The object of this paper was to show that the great difference between the various states of carbon is produced by its existence in different crystalline forms and volumes.

First, we have diamond, crystallized in the regular system, its primary form being the regular octahedron, and having a specific gravity of 3·521; and graphite, crystallized in regular hexagonal prisms, with a specific gravity of 2·177 when in fine powder, due allowance being made for the ashes. But besides these, the author had found, by the microscopical examination of the fine powders of coke, anthracite and charcoal, that there are two other modifications which have not hitherto been distinguished. Coke is crystallized in the regular system, its primary form being a cube, and its density quite different from diamond, viz. 1·891; and its properties varying so much in other respects, that it is obviously a totally different modification of carbon. The specific gravity of coke and that of graphite are however related to one another in the ratio which mathematical calculation shows they ought to be, if they are supposed to consist of spherical atoms of precisely the same size, arranged in the different manners indicated by their respective crystalline forms. Their relations to heat and electricity also agree with that supposition.

Anthracite and charcoal have a form and volume differing from any of the others, being crystallized in the square prismatic system, the axes being to one another as 5, 5 and 3, and the specific gravity being 1·773, or one-half that of diamond; whereas its specific heat is double. Anthracite, lamp-black and charcoal belong to this form; and when their specific gravities are determined with proper precautions, they agree very closely, that of anthracite being 1·760, lamp-black 1·774, and charcoal 1·784.

The properties of this form are different in important particulars from those of any of the others, the most marked between it and coke being, that it is very much softer and a much worse conductor of electricity. By exposure to a low red heat, no change is produced in it; but when heated to a bright red or white heat, its change in properties shows that it is converted, as far as regards its ultimate atoms, into the coke form, but not in its crystalline structure or specific gravity, and it is therefore pseudomorphous.

On a direct Method of separating Arsenious from Arsenic Acid, and on its application to the estimation of Nitric Acid. By JAMES STEIN, *of Glasgow.*

Chemists have not as yet been supplied with a method for the direct separation of arsenious from arsenic acid. In the course of an investigation on the salts of arsenious acid, with which he was lately engaged in Prof. Liebig's laboratory, the author observed a fact which led him to a solution of this problem. He found, that, on adding arsenite of ammonia to a solution of sulphate of magnesia, no precipitate was formed in the presence of free ammonia or chloride of ammonium, provided these bodies were present in sufficient quantity; and further, that a previously-formed precipitate was redissolved by these reagents. Now Prof. H. Rose has given us a very exact method of estimating arsenic acid by precipitation as ammonio-arseniate of magnesia, similar to the process usually employed for the determination of phosphoric acid. M. Stein accordingly found that arsenic acid might be precipitated from a fluid containing arsenious acid, while the latter remained in solution and was easily filtered off. He did not think it necessary to make any quantitative separation of these acids, as he considered that if the arsenious acid were thoroughly washed out, the completeness of the separation would be apparent from Prof. Rose's paper. The evidence, however, that it was so, he has also indirectly supplied in testing the following process for the estimation of nitric acid, to which he soon perceived the above might be applied.

Owing to the fact that nitric acid forms no insoluble compound, its accurate determination has been accompanied with considerable difficulty, and its amount was at no distant period only determined by very uncertain and difficult processes. The author having referred to the processes employed for this purpose by M. Crum, M. Pelouze, and Prof. Penny, proposes the following process:—

The process is generally this:—nitric acid has the power of oxidizing arsenious acid, and it is from the amount of arsenic acid formed that I propose to calculate its amount.

It was however necessary to determine how much arsenious acid a certain quantity of nitric acid could oxidize. In experiments for this purpose, I found that I obtained one equivalent of arsenic acid for every equivalent of nitric acid used, showing that two atoms of oxygen had been transferred from the nitric to the arsenious acid.

After various trials, which I need not here describe, I fixed upon the following method as the best.

The nitrate to be analysed is mixed with three times its weight of pure arsenious acid, and concentrated hydrochloric acid is poured over it, in a small flask or basin. It is then cautiously heated and evaporated slowly, almost to dryness. When cool, water is added and the whole transferred to a beaker-glass. The fluid is now rendered alkaline by ammonia, and a considerable amount of chloride of ammonium is added, and subsequently sulphate of magnesia. The precipitate is allowed to subside, and is then collected on a weighed filter. It is washed on the filter with water containing ammonia and chloride of ammonium, till all traces of arsenious acid are removed, after which ammoniated water only is used, till all the chloride of ammonium is washed out. After this it is dried at 212° Fahr. till it ceases to lose weight.

I have also used a modification of the above process, as follows:—The dry nitrate was mixed with rather more than three times its weight of pure arsenious acid, and the mixture very cautiously heated in a covered porcelain crucible, till the nitrate began to melt, when copious red fumes were disengaged. The heat was continued till these had entirely ceased. Towards the end, the temperature was slightly elevated to ensure the thorough decomposition of the nitrate. This mode, however, required much caution, on account of the vapour of arsenious acid which was given off, and it could not of course be performed in the open laboratory, but under the hood of a chimney.

In experiments to test the accuracy of the process, I obtained the following results: ·436 grm. of nitrate of potash yielded ·813 grm. of ammonio-arseniate of magnesia, dried at 212° Fahr., and ·5745 grm. gave 1·071 grm. of that salt. The formula of the ammonio-arseniate of magnesia, dried at 212° Fahr., is $2MgO\ NH_4O, AsO_5, HO$, and these numbers consequently indicated respectively 52·995 and 52·985 per cent. of nitric acid in the saltpetre. This is slightly less than the theoretical amount.

It is evident that this process cannot be applied in the presence of phosphates or lime, as these bodies would also be precipitated, and would therefore require to be previously removed. I hope, however, to be able to apply to it a method of Centigrade testing which will get clear of this difficulty, and at the same time render it more expeditious.

On the Chemical Composition of the Rocks of the Coal Formation. *By* Henry Taylor.

On the Proportion of Phosphoric Acid in some Natural Waters. *By* Dr. A. Voelcker.

The object of this paper was to draw attention to a natural source from which many of our fields may be œconomically supplied with phosphoric acid. Prof. Fownes has shown that traces of phosphoric acid are met with in many rocks of igneous origin; but also in stratified rocks, particularly in limestone rocks, the presence of phosphoric acid has been indicated by several chemists. The author found the proportion of phosphoric acid in great oolite from the neighbourhood of Cirencester amounting to 0·124 per cent., equal to 0·260 of bone-earth, and in Stonesfield slate from the same locality amounting to 0·117, equal to 0·244 per cent. of bone-earth. As water charged with carbonic acid is capable of dissolving bone-earth, this important fertilizing substance is found in many natural waters, percolating rocks which contain phosphoric acid. Such waters therefore may be applied with advantage for irrigation. The advantages derived from this too-often neglected natural source are strikingly exhibited in the irrigated meadows in the neighbourhood of Cirencester; and it is the opinion of the author, that one of the chief causes of the beneficial effects which follow the application of the water for irrigation in this locality is to be found in the phosphate of lime it contains. In a tea-kettle incrustation, formed in a short period by this water, the proportion of phosphoric acid was found to amount to 1·25 per cent., showing a considerable quantity of this acid present in the water. A very hard water from Edinburgh was likewise proved to contain phosphoric acid; but its proportion was not so large as that in the Cirencester water, the quantity of phosphoric acid in a boiler-incrustation formed by this Edinburgh water being only 0·427 per cent. Sea-water also contains phosphoric acid, but the proportion of the latter amounts to mere traces. A quantitative determination of phosphoric acid in the boiler-deposit of a Canada steamer gave only 0·0306 per cent., and that in a boiler incrustation of a steamer plying between Dublin and Liverpool 0·0424, as the per-centage of phosphoric acid. In conclusion, the author recommended Svanberg's test, molybdate of ammonia, as a ready means for detecting the presence of phosphoric acid in natural waters.

On the Per-centage of Nitrogen as an Index to the Nutritive Value of Food. By Dr. A. Voelcker.

The object of this paper was to show, that the usual estimation of the nutritive qualities of an article of food is frequently attended with inaccuracies, which render it desirable to modify our present methods in this respect in many cases. A circumstance which leads to considerable errors, is the presence of ammoniacal salts in the juices of plants. Having examined several vegetables, and constantly found a considerable amount of ammoniacal salts in the sugary extracts of the juices of plants, from which all soluble proteine-compounds had been previously separated, the author inferred that the nutritive value of various vegetables had been overrated, as the amount of nitrogen they furnished on combustion with soda-lime was taken as the index to their nutritive value. If the whole amount of nitrogen in juicy vegetables is assumed to exist in the plant in the form of albuminous substances, and calculated accordingly, a considerable excess will be found in summing up the results of the analysis; which proves indirectly that the whole of the nitrogen in vegetables is not contained in them in a form in which it can be considered to add to the nutritiveness of the vegetable. In cauliflower, and in the leaves of the same plant, an excess of nearly 12 per cent. was experienced in the proximate analysis, by calculating the per-centage of proteine-compounds from the amount of nitrogen obtained by direct combustion.

In order to prove experimentally the presence of ammoniacal salts in larger quantities than hitherto suspected, and to avoid the objection that they might result from a partial decomposition of albuminous substances during the analysis, the author chose fungi for his experiments, which are rich in nitrogen, and known as being highly nutritious, and which, growing abundantly on the Cirencester College grounds, immediately adjoining the laboratory, could easily be got in the perfectly-fresh state. The species used was *Agaricus prunellus*, a species which is edible, and remarkable for forming most beautiful fairy-rings. After having separated all soluble proteine-compounds by means of basic acetate of lead, which reagent throws down these completely, the amount of nitrogen still present in the juice of these Agarics, in the form of ammoniacal salts, was found to be 0·204 per cent. for the fresh fungi, or 1·82 per cent. for the dry fungi.

The whole amount of nitrogen in the same Agarics, collected at the same time, determined by combustion with soda-lime, was found to be 0·74 per cent. for the fresh fungi, or 6·61 per cent. for the fungi dried at 212° F. Deducting from the last-stated numbers the quantity of nitrogen found to exist in the juice in the form of ammonia, we find that only 0·536 per cent. of nitrogen in the fresh, or 4·79 per cent. of nitrogen in the dry fungi, exists in the state of proteine-compounds, and that nearly one-third of the nitrogen obtained by direct combustion exists in the form of ammonia in the juice, or at all events in a form in which the nitrogen adds nothing to the nutritive value of the fungi. The nutritive value of fungi has thus been overrated considerably; and there can be little doubt that the same is the case with many vegetables, which, according to the author's experiments, contain sometimes considerable quantities of ammonia in the form of ammoniacal salts.

Results of a Research on Ætherification. By Prof. A. W. Williamson.

The process by which this remarkable transformation of the elements of alcohol is effected has been the subject of much discussion among chemists; of the two theories which have been devised to explain it, each counts among its supporters many first-rate chemists.

The facts upon which the contact theory lays peculiar stress are more physical than those to which the appropriately-designated chemical theory refers for its evidence. But there is one point upon which the two differ essentially, and that is the composition of alcohol; the one maintaining that the two products, æther and water, are made from 2 atoms of alcohol; the other, that they are both produced from 1 atom of double size. This is a difference of fact, and is therefore susceptible of being decided by experiment, as it requires nothing more than a direct evidence of the relative atomic weights of alcohol and æther.

An experiment was accordingly devised, of such a nature as to give a result according to the simple, differing from that according to the double atomic weight of alcohol. It consisted in making æther from alcohol by a new process, in which the various steps of which it consists were performed separately. One-sixth of the hydrogen of alcohol was first expelled by the action of potassium; this compound differs from æther by having half as much carburetted hydrogen as that body to an equivalent weight of potassium to the other half, or by doubling its atomic weight, may be supposed to contain æther and potash. By double decomposition with iodide of æthyle, this substance was converted into æther, and not into a body of double the atomic weight of æther, which would have been the case according to the chemical theory of ætherification. By acting upon the same potassium compound with other iodides, new æthers were obtained, which to 1 atom of oxygen contained two different carburetted hydrogen atoms, one of which was contained in the alcohol, the other occupied the place of the hydrogen of that body.

In the common process of ætherification, sulphovinic acid is known to be the immediate product of the action of the sulphuric acid upon the alcohol. Now this sulphovinic acid is strictly analogous to iodide of æthyle and iodide of hydrogen. To convert alcohol into æther, it has merely to exchange its æthyle for the hydrogen, which in the preceding experiment was expelled by potassium. It is thus reconverted into sulphuric acid, to recommence a similar circle.

The continuous action of the reagent sulphuric acid, of which a given quantity is known to be capable of converting an unlimited amount of alcohol into æther and water, is thus owing to an exchange of analogous molecules in alternately opposite directions, and is distinctly different from any effect of chemical affinity.

On the Influence of Sunlight over the Action of the Dry Gases on Organic Colours. By George Wilson, *M.D., F.R.S.E.*

The object of this communication is, to report the result of a series of experiments made this summer, on the effect of sunlight in modifying the chemical action of eight different dry gases, viz. chlorine, sulphurous acid, sulphuretted hydrogen, carbonic acid, a mixture of sulphurous and carbonic acid, oxygen, hydrogen and nitrogen on organic colouring matters. I had ascertained the action of the gases mentioned already, on vegetable colouring matters, so arranged, that both colouring matter and gas should be as dry as possible, the aim of the inquiry being to elucidate the theory of bleaching, by accounting for the inaction of dry chlorine upon dry colours. In the course of this inquiry, I ascertained that in darkness dry chlorine may be kept for three years in contact with colours without bleaching them, although when moist it destroys their tints in a few seconds, and I thought it desirable to ascertain whether dry chlorine was equally powerless as a bleacher when assisted by sunlight. The general result of the inquiry was, that a few weeks sufficed for the bleaching of a body by chlorine in sunlight, where months, and I may even say years, would not avail in darkness. I had not been able, however, to watch the stages of the actinic bleaching by chlorine, and I returned to the inquiry this summer, with a view to ascertain this, and subjected at the same time all the gases upon which I had previously experimented to the influence of sunlight. The results of this inquiry I shall now briefly state to the Section, and the method of procedure may be best illustrated by a special reference to the most important of the bleaching gases, chlorine. Four tubes were connected together so as to form a continuous canal, through which a current of gas could be sent. Each tube contained a small glass rod, on which seven pieces of differently coloured paper were spiked or impaled. Three of those papers were tinged with the colouring matter of the wallflower, which I expected to prove very sensitive to actinic action. This colouring matter, as extracted from the petals by diluted alcohol, colours paper of a grayish blue or slate colour; this formed one tint. The same colouring matter reddened by an acid, gives a bright crimson, much more vivid than the tint of reddened litmus; and when treated by ammonia, gives a pure bright green. Each of those wallflower-tinted papers was introduced into every tube, and, in addition, a piece of blue litmus paper, a piece of red litmus paper, a piece of alkaline or brown rhubarb paper, and a piece of yellow rhubarb paper. All the tubes thus contained seven different coloured papers, of different origins, and easily distinguished by the eye. They were arranged in the same order in each tube, and were prepared as nearly as possible of the same shade.

The papers were first dried in a current of desiccated air, passed over them for some hours, and a current of the gas to be experimented on was then passed through the tubes for five minutes, after which they were sealed hermetically, whilst full of the gas. One of the four tubes was placed aside in darkness, the other three were exposed to sunlight. This exposure was not commenced till the 1st of last June, when four tubes having been filled with each of the gases to be experimented on, three in each case were exposed to sunlight. Two of the tubes were hung up on the inner side of a window having a western exposure; the third tube was attached to a frame and exposed in the open air on a wall looking directly south. The exposed tubes were in this way subjected to the light of the sun, as well as to that of the other heavenly bodies, so far as they could influence them, from the 1st of June to the 27th of July, a period of eight weeks. I have now arranged the four tubes, which were filled with each gas, on one sheet of pasteboard; the upper tube was that left in darkness; the two middle tubes were placed in a western exposure behind glass, and the lowest was turned to the south in the open air.

I shall now describe the effect of sunlight in each of the gases. In the dark chlorine tube, the colours are very little altered, and would probably have been altered less, had the tube not been frequently exposed to light for the sake of examination. In the western tubes, the originally gray and green wallflower papers have become bright crimson; the blue litmus is bright red, and the brown rhubarb has become yellow. The whole chlorine has apparently entered into combination with the colouring matters, for the yellow tint of the gas has totally disappeared. In the southern tube, on the other hand, the colour of chlorine can yet be seen, and the reddening action is less decided, whilst the bleaching action is much more powerfully evidenced. I was led, from the appearances in the western tubes, to infer that I had employed too small a volume of chlorine, and I began a new set of experiments on the 1st of July, with a larger quantity of the gas, the results of which I now exhibit to the Section. A month's exposure to direct sunlight has not sufficed to effect the full bleaching of the colours, nor have those which have paled in tint changed in the way they should have done if an acid had been developed. This, I confess, has surprised me; for theory would lead us to expect that when chlorine bleaches, it should form hydrochloric acid, and the reddening observed in the exposed tubes seemed entirely to confirm what theory indicated. The general result, however, of my inquiry has been, that the action of sunlight in increasing the bleaching power of chlorine is less uniform than might have been expected; for whilst some tints have rapidly disappeared under its action, these colours have remained unaffected in apparently the very same circumstances. I propose accordingly to continue this inquiry. I shall describe much more briefly the effect of the other gases.

Sulphurous acid, when moist, acts powerfully as an acid on vegetable colours, and bleaches the more fragile among them. If thoroughly dried, it may be kept for months in contact with dry colours without altering them. Under the influence of sunlight, however, it recovers to some extent its bleaching power, so far as the wallflower tints and the litmus are concerned; but on the yellow rhubarb paper it has acted like an alkali, and changed it slightly to a brown.

Sulphuretted Hydrogen acts as a weak acid, and readily as a bleacher when moist, but becomes inactive in both respects if made dry and kept in darkness. With the assistance of sunlight, it recovers in no inconsiderable degree its bleaching power, especially over litmus, and like sulphurous acid, it changes the yellow rhubarb paper, like an alkali, to a brown.

Oxygen is a well-known bleacher when moist, and especially when nascent, but when dry, its action on colouring matter in the dark is extremely slow. In sunlight, however, it recovers its bleaching power, especially upon litmus.

Carbonic Acid, when moist, acts as a weak acid; when dry, it loses all action upon colouring matter, but with the assistance of sunlight, it acquires a slight power of bleaching.

Nitrogen has no appreciable action, whether moist or dry, upon colours; but a faint bleaching action is exerted by it under exposure to sunlight.

Hydrogen is without any action, when dry, upon colours, and is the least increased by the influence of sunlight in bleaching action, but does acquire a slight decolorizing power when exposed to sunlight.

A mixture of Carbonic and Sulphurous Acid acts like sulphurous acid alone.

The general result of this inquiry, so far as it has yet proceeded, is, that the bleaching gases, viz. chlorine, sulphurous acid, sulphuretted hydrogen and oxygen, lose nearly all their bleaching power, if dry and in darkness, but all recover it, and chlorine in the most marked degree, by exposure to sunlight.

The second result, which must however be considered less certain than the first, is, that the southern tubes, which were exposed directly, exhibit bleaching action more decidedly than those hung within a room where the light had to pass twice through glass before reaching the colour.

Whether the bleaching observed in the case of nitrogen and hydrogen was owing to any chemical action of those bodies, or was only such as might have occurred in a vacuum, I cannot determine. The experiments I have described can be considered nothing more than the commencement of what cannot but prove a protracted inquiry, which ought further to include the remarkable substance ozone, which ranks next to chlorine as a bleacher.

On the presence of Fluorine in Blood and Milk. *By* George Wilson, *M.D., F.R.S.E.*

The author having resumed the examination of this subject in the present summer, on a larger scale, and by simpler processes than he had employed for his communication to the Royal Society of Edinburgh in 1846, has presented the following summary of his results.

In my former examination of blood, I obtained a good result only when the serum alone was employed. This summer however I have employed the fresh-drawn blood of the Ox. About twenty-six imperial pints or three gallons of blood were made use of. This was obtained from different animals in quantities of about nine pints at a time, as this was as much as could be conveniently evaporated at once. The reduction of the blood to ashes was a tedious and not very pleasant process, but with the help of a powerful furnace and the active cooperation of my assistant, Mr. Stevenson Macadam, who took great pains with the whole process, I succeeded in the course of a month in reducing the whole quantity to well-burned ashes. These ashes contained some unburned charcoal, but not in large quantity, and presented the appearance of two distinct substances; the one a dark red mass, owing its colour to the peroxide of iron; the other a white fused salt, having a strong pure saline taste, and consisting in greater part of chloride of sodium. The presence of this substance interfered with the detection of fluorine, by evolving a large volume of hydrochloric acid, when the ashes were treated with oil of vitriol, which carried away any hydrofluoric acid evolved simultaneously. It was necessary accordingly to remove the chloride of sodium before seeking for fluorine, and to avoid the risk of introducing the substance sought for, by the employment of reagents which might possibly contain it: I effected the removal of the chloride of sodium by simply digesting the ashes in a minimum of distilled water. This risked the removal of a little fluoride of calcium or any other soluble fluoride which might be present, but precluded the possibility of any such compound being added to the ashes. After being washed accordingly they were simply dried and warmed with oil of vitriol, in a lead basin covered by a square of waxed plate glass, which had the words "Blood, 5th July 1850," traced on it by a blunt style in the ordinary way. The whole of the ashes was employed, but as the vessel could not contain the entire quantity, it was divided into two portions, the first of which remained for five days in the basin and was then replaced by the other half. The glass was thus exposed for ten days continuously to the vapour arising from the acidified ashes. They effervesced very slightly when treated with sulphuric acid, but evolved a sharp acid odour. The lead vessel was kept at a temperature of about 150° Fahr. during the day, and fresh quantities of oil of vitriol were added at considerable intervals, and the contents of the basin occasionally stirred. The glass, which was cooled on the upper surface by the frequent renewal of a stratum of cold water, slowly became dim, and slightly opalescent where the letters were traced, in consequence no doubt of the separation of silica, for the letters appeared deeply etched when the wax was cleaned off. From the large scale on which the experiment was conducted, and the simplicity of the process followed, the evidence in favour of the presence of fluorine in the blood of the Ox seems unexceptionable; and, it cannot be doubted that the blood of other animals will be found to contain the same element. I presume it to be present in the state of fluoride of calcium, and that its amount is very small, but I have not attempted its quantitative determination.

Milk was examined in a similar way, but its reduction to ashes was much more easily effected than that of blood. I failed however to obtain other than the faintest indications of fluorine from the ashes of about twenty imperial pints of cows' milk. It was from a town dairy, and left a suspiciously-small residue of solid matter. The main cause of the failure however I believe to have been, the neglect to deprive the milk ashes of the chlorides they contained. The experiment was repeated with nine imperial pints of rich milk from a country farm, the ashes of which were washed with a minimum of water and then dried and treated like those of blood. The vapour which they evolved etched glass distinctly. The ashes of 12 lbs. of new skim-milk cheese, made this spring, treated in the same way, occasioned deep etching of glass. The ashes of four imperial pints of whey, treated in the same way, have barely marked glass, so as to show the faintest outlines when breathed upon. In all probability the fluoride of calcium is associated with the phosphate of lime, and when milk is coagulated, separates along with the caseine.

Fluorine was long ago detected in another of the animal fluids, as well as in the skeletons, both external and internal, of all classes of animals. Some difficulty was found at one time in accounting for the presence of fluorine in the animal tissues and secretions. But when we learn that fluoride of calcium is soluble in water, and is present in many natural waters, and that it or some other salt of fluorine exists in the two great formative liquids of the animal organism, milk and blood, we shall cease to wonder at its presence in the animal solids and fluids and begin to inquire what its function may be.

The author added, in conclusion, some suggestions to chemists who desire to continue the investigation.

On the extent to which Fluoride of Calcium is soluble in Water at 60° *F.* *By* George Wilson, *M.D., F.R.S.E.*

The author, referring to his previous experiments on this subject, and taking into consideration the possibility of silicon having been present in some form, thought it well accordingly to repeat the results with solutions made in metallic vessels, and never allowed to come in contact with silica in any shape.

One set of trials was made last summer in the following way:—Well-crystallized transparent fluor-spar was boiled for some hours in a platinum basin with pure hydrochloric acid, so as to secure the conversion of any silica possibly present into fluosilicic acid, and remove any metallic oxide, sulphate of lime, carbonate of lime, or other foreign matter present in the spar and soluble in the acid. The purified fluor was then washed in the same vessel by copious affusion with warm distilled water, and in this state employed for the solutions to be evaporated. An aqueous solution of fluor-spar was prepared by boiling distilled water on the salt contained in a platinum basin, and the liquid was then transferred to a pewter vessel, in which it was collected, and left for some days at the temperature of 60°, that it might deposit the excess of fluor it had dissolved at 212°. The clear liquid was then filtered through a tin funnel, with the neck partially choked by zinc filings; and the filtrate was measured in a pewter vessel, which had been carefully graduated, so as to contain, when nearly full, 7000 grains of the solution. The liquid thus obtained and measured, and which had never come in contact with silica, was then evaporated to dryness in a platinum capsule, and the amount of residue ascertained. Six careful trials were made, and gave as a mean 0·25166 gr. as the amount of fluoride of calcium soluble in 7000 grains, or 16 fluid ounces, *i. e.* a pint apothecaries' measure. This result approaches so closely to that previously obtained with glass vessels, that the number found must be considered as making a near approximation to the truth.

A similar series of observations was made this summer; but the fluor-spar, which was of great apparent purity, as furnished through the kindness of Mr. Tennant of London, was not subjected to any preliminary treatment with hydrochloric acid, but simply boiled with distilled water, and the solution collected and cooled as before in a pewter vessel. The liquid was allowed thus much contact with silica that it was passed through a paper filter placed within a tin funnel. Few however will suspect that it can have transferred to itself any silica from the saline constituents of the paper. Six trials were made in this way, the mean of which gave 0·26 gr. as the quantity of fluoride of calcium soluble in 16 ounces of water. The numbers of which this is the mean, like those obtained in the previous determinations with metallic vessels, differ more from each other than the numbers did in the first series of experiments, where the solutions were made in glass flasks. This however was to be expected, for the liquid employed in the first series was prepared at once to the extent of many pints, and the uniform composition of the whole secured before any of the solution was evaporated. In the case of the metallic vessels, on the other hand, owing to their smallness, each pint had to be prepared separately, and its evaporation completed before another was procured. The numbers therefore could not but differ more in the second and third determinations than in the first. The highest number was 0·28, the lowest 0·24. We may therefore consider 0·26 as sufficiently nearly representing the true solubility of fluor-spar, so that pure water may be considered as able to dissolve $\frac{1}{26923}$rd part of its weight of this salt. The residue of 16 ounces of the solution etches glass rapidly and powerfully.

The amount of solubility observed, though comparatively small, is large for a salt reputed quite insoluble, and is plainly sufficient to occasion an appreciable error in the quantitative determination of fluorine by the ordinary process, since as much as a pint of water, and that perhaps at the temperature of 212°, must often be employed in washing a precipitate of fluoride of calcium.

A few unpublished particulars concerning the late Dr. Black. *By* George Wilson, *M.D., F.R.S.E.*

The object of this communication was to lay before the Section a few characteristic incidents concerning Dr. Black, gathered from Mrs. Elizabeth Wordsworth, who was a servant in his household during the last five years of his life.

The facts recorded do not admit of abridgement, but they completely confirmed the accounts contained in the published biographies of Black concerning his valetudinarian and methodical habits, whilst they gave no countenance to the statement which had been credited in some quarters that the great chemist was an avaricious or penurious man. Some interesting particulars were adduced illustrative of the amiability and gentleness which characterized Dr. Black; and the author concluded by noticing that an error had been committed as to the date of the philosopher's death, which was not the 26th of November 1799, as stated by Robison, but the 6th of December of that year, a fact which Mr. Muirhead first pointed out (Watt Correspondence, p. xxii.), and which is confirmed by the newspapers of the period. (Vide *Edinburgh Mercury* of the 14th of December 1799.)

GEOLOGY AND PHYSICAL GEOGRAPHY.

On the Fossil Fishes and Yellow Sandstone of Dura Den. *By* Dr. Anderson.

Dura Den occupies a central position in Fifeshire, and consists of the upper old red sandstone formation. The geological relation of the beds is well-marked and defined. They repose on reddish strata, of a fine as well as conglomerate texture, similar to those which occupy the basin of the Tay, and which are charged with organisms of the same character. The carboniferous deposits overlie and crop out in the immediate vicinity. The irruptive rocks form the line of separation, which have tilted up the latter to an angle of 26°, while the yellow sandstone is nearly horizontal, or inclining to the S.E. at an angle of 6° to 8°.

This interesting deposit traverses the valley of Stratheden, in the district of which Cupar, the county town, forms the centre, and rises to the height of 500 or 600 feet on the ridge of hills which skirt the valley on the south. The colour of the sandstone is grayish-yellow, often iron-shot, and exhibiting in some localities a deep reddish tinge. Some of the beds are coarse and gritty, and occasionally pass into a conglomerate; but for the most part they are of a fine texture, and extensively used for building purposes. The whole are interstratified with thin micaceous flaggy beds, which pass into a kind of shale or marl, and being of various colours, as red, blue, and white, give to the face of the rock a variegated appearance. The coloured marl beds are, some of them, four feet thick, and entirely destitute of organisms.

The organic remains are chiefly confined to the lower beds, and consist, according to Agassiz, of the following kinds:—*Holoptychius Andersoni* and *Flemingii*, *Glyptopomus minor*, *Platygnathus Jamesoni*, *Pamphractus hydrophilus* and *Andersoni* (the *Pterichthys* of Sir Philip Egerton). In addition to these, the same eminent ichthyologist has marked on specimens in the author's collection, a *Diplopterus*, new species; *Glypticus*, new genus, of which there are two species; and *Dipterus*, new species. The specimens presented along with the paper contain two or three entirely new generic forms. This remarkable deposit is, in many places, filled to repletion with these fossil remains, which are all in the most perfect state of preservation, and start from the matrix on the slightest stroke of the hammer. The author concluded a long and interesting paper, by calling upon the Chairman, Sir R. I. Murchison, to assign to one of the new and undescribed fossils the specific name of *Dalgleisianæ*, in honour of the proprietor of Dura Den.

On a Fossiliferous Deposit underlying Basalt in the Island of Mull. *By the* Duke of Argyll.

It occurred on the headland of Ardtun, in the S.W. end of the island. The headland is about 130 feet high, and is composed as follows, reckoning from the top downwards.

I. Basalt, rudely columnar.

II. First leaf-bed.

III. Tuff, or volcanic ashes, being thickly disseminated with while lapilli, imbedded in a pumiceous ashy paste.

IV. Second leaf-bed, about eighteen inches thick, and consisting in its lower part of pure compressed vegetable matter.

V. A second bed of tuff, or volcanic ashes, passing into a conglomerate of flints, water-worn, and containing some organic remains of the chalk flints.

VI. Third leaf-bed, thinner than those above.

VII. A thick bed of amorphous, amygdaloidal basalt.

VIII. Basalt, beautifully columnar; the columns being smaller, but as regular as those of Staffa, and dipping into the sea.

The leaves found in the fossiliferous deposits thus situated are of a considerable variety, being for the most part dicotyledonous plants. Many of the finest specimens obtained are of the Platanus family. Good specimens of the Pine-tribe also occur. Associated with the leaves, especially in the lower part of the second leaf-bed, many specimens of the *Equiseta* occur, a circumstance which, together with the absence of branches or larger twigs, and the full extension of the largest palmated leaves, seems to indicate that the vegetable remains had been accumulated in a marsh or shallow water, when overflowed by the volcanic matter.

On Recent Changes of Sea-level. *By* ROBERT AUSTEN, *F.R.S.*

In the present state of our knowledge, it is no longer sufficient to refer all changes of level, of apparently recent date, to the general head of "Raised Marine Beds or Beaches," inasmuch as many phænomena, which were originally so classed, are now known to be referable to distinct periods of time. Yet, though thus much has been ascertained, we have not hitherto been informed as to what may have been the exact nature and amount of oscillation recorded at any one particular spot; and it is only by observations to be made at, or on, the same vertical line, that this question can be conclusively settled; for such recent changes having taken place since the marine fauna was such as it is at present, its remains afford no assistance; and different levels, if observed at separate places, may possibly, on the assumption of unequal movements, belong to the same period. My object therefore in the present short communication, is to describe some sections which I have recently had an opportunity of observing on the south coast of Cornwall, whereby to define the order of some recent changes. It is only under certain conditions that the evidence in question is clearly presented, the oscillation having been of small amount; all traces of former lower levels of the land have disappeared along the whole line of the yielding strata of our southern shores; and along the greater part of the line of transition slates, the planes of bedding or cleavage, dipping at high angles southwards into deep water, offer but a few spots for the accumulation of beaches; the favourable conditions seem to be such as are presented by such situations as the headland west of Falmouth Harbour, and which may be taken as an illustration of them all.

The slate strata at this place are nearly vertical, and are composed of beds of unequal hardness, so that the action of the sea on their edges wears them out into a serrated surface of troughs and sharp ridges, from high-water mark to some depth below; at which depth is the usual accumulation of coast sand and shingle.

The rise of the tides at the spot in question is about 18 feet, and the lines which the coast presents at low water are,—1st, that which defines the upper limit of *Fucus vesiculosus*, which everywhere clothes the rocks in thick masses; and 2nd, a line defining a zone parallel with the former, presenting a perfectly clean surface of rock, and which represents the highest reach of coast waves, and along which their full power is exerted: the troughs of this zone are occasionally occupied by sand and large rolled blocks; these two zones are to be seen at places as far as the eye can reach, bearing a constant relation to the present sea level, and everywhere presenting a like character as to the form in which its surface is abraded: from the upper zone commences the rise, more or less steep, of the cliffs or wall of coast line.

At the place in question, however, a still higher zone is to be observed, and the foregoing detail has been required, inasmuch as this zone, in all its features, is an exact counterpart of the upper portion of the lower one, and must have been formed when the action of the line of breakers reached such level. This zone consists of bare rock, but the surface of the slates, instead of being clean, is covered with a growth of gray and orange lichens; whilst in the clefts and troughs are masses of sea-pink (*Armeria maritima*), *Plantago maritima*, and grasses. This zone is now constantly beyond the reach of the sea. At its upper limit, rises a vertical cliff of variable height, which must have been produced when the sea-level reached its base.

We have in this zone a clear indication of a change of level; the most recent, so far as elevation is concerned, which we find recorded, and the amount of which has not exceeded, or may be equal to half the present interval between high and low water.

The line of vertical cliff which here and in other places overhangs this raised marginal sea zone, consists of an accumulation of variable, but often of great thickness, on the nature and origin of which we need not now enter; but at its base, and extending inland beneath it, are marine beds of sand and shingle, corresponding exactly in composition with those of the present beach, and which, from their thickness, must have been accumulated about the level of low water.

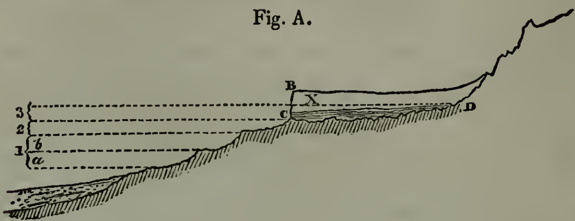
We have thus presented on a vertical section (Fig. A):—

1st. Zone (*d*) composed of division (*a*) covered with *Fucus vesiculosus*, and division (*b*) above the former, and extending to the upper limit of the present tides, or the actual tidal zone.

2nd. Zone 2, which represents the upper portion of a former tidal zone when the coast was at a lower level, and when the sea reached the base of the cliff B.

3rd. The still lower level indicated by the marine beds at the base of cliff, (which underlie the accumulations (X) and the marginal), and the upper limit of which is to be found at some distance from the present coast line, at D.

Fig. A.



I do not propose to offer any relative geological dates for the accumulation X, nor for a bed containing marine pebbles on its upper surface, nor yet for the underlying beds at C, D. The most recent change is obviously that indicated by zone 2, a movement of no great amount (8 to 10 feet), but of which we find evidences whereever the nature of the coast admits of it. A depression of the land of such like amount would convert many of the present river-valleys of the south of England into estuaries. The valley of the Exe, much to the east of the spots whence the foregoing observations have been made, as also that of the Ouse on the Sussex coast (*vide* Mantell), present mud-beds with modern estuary shells, at slight elevations above the present sea-level; these and such deposits I would refer to zone No. 2 on the line of section here described, as a first step towards disentangling the very complicated phænomena which the younger accumulations seem to present; and should this be correct, we may infer that the latest change of level was extended to the whole length of our channel with a like amount of effect.

On the constant Increase of Elevation of the Beds of Rivers. *By* Dr. Ludwig Becker.

Assuming as acknowledged facts frequently observed, that the older buildings in towns situated on the banks of rivers appear as if they had partially sunk into the ground, the germs of churches, the basements of the gates of towns, of towers, of ancient walls, all giving evidence of this kind, while old pavements, and steps down from quays are no longer visible, the author endeavours to account for these phænomena. Choosing Mayence, from its ancient importance, and its situation on one of the greatest of rivers, the Rhine, he shows the depth of ground which has been accumulated in layers, by the destruction of human habitations in Roman, Mediæval, and modern times. In one case, three layers, six feet each, occurred in the centre of Mayence. Close to the river banks, and forming a portion of the city walls, is the Fish-gate, which was built in 1050.

1. Excavations lately made by the side of this gate, brought to light the covered street-pavement of the time of 1050, and with it the basements, or, architecturally, the *socle* of the stone gate-pillars themselves. The pavement thus discovered was very nearly six feet deeper (5·9) than where the carriages travel in the present day.

2. On repairing the river quay in the vicinity of this gate, the workmen got down to two distinct layers or *strata* of road-paving, one two and-a-half feet, and one six feet below the level of the present causeway.

3. The old wall of the quay was discovered, which in the year 1750 was buried under the rubbish originating from the destruction by fire of the cathedral. A small stair descended from this wall to the Rhine; the two uppermost of these bore signs of having been much trodden; the third appeared to have been less so, while the lower one showed no injury from the impress of the foot.

4. In the neighbourhood of the St. Signaticus Church, a small brook, the Filgback, flowed in the eleventh century into the Rhine, at a level six feet lower than it does at present. The lately-discovered remains of buildings, which enclosed the sandy bed of this little brook, give evidence of that period. The average level of the waters of the Rhine at Mayence has been long held as being five feet above the zero of the *Pegel* there. [By *Pegel* is meant a fixed point taken about a hundred years ago, as being at that time, and indeed since, a mark of the depth of the water, and therefore a guide to the boatman.] In the year 1750, the point of this Pegel, and at the same time the mean level of the waters of the Rhine, were 8⅝ inches deeper than now, which agrees tolerably well with the half-trodden condition of the descending stairs just mentioned.

It is not to be supposed that the body of water in the Rhine has since then increased; but the increased height of its waters may be naturally accounted for by the facts just mentioned, which show the increasing height of the level of its bed. *This height increases, according to these facts,* 8⅝ *inches in a century.*

We therefore arrive at the following figures:—

	Eng. ft.	in.	
The Rhine in 1050	13	4	
1750	5	9	
1850	0	8⅝	inches deeper than in 1 A.D.

These standards seem to agree together, as the remains of Roman structures in the neighbourhood of the water are to be found thirteen feet under the mean level of the streets, and are not found higher. Again, the ruined basements (in architectural terms "socle") of buildings of later centuries are found less and less deep as the date of their creation comes nearer and nearer to the present century.

To suppose that the bed of the river has not become considerably higher, would be to conclude that the architects of earlier times were far from what we are accustomed to believe of them. A foundation for the Fish-gate could hardly have been attained even with the water at its present middle height; whilst we further notice, that on occasion of a very moderate increase of water, the lower part of the town would have been wholly overflowed. The rings set in for the purpose of securing the boats, and even the architectural ornaments, would only have been seen and available when the water was accidentally at the lowest. But, in a word, the bed of the river *has* risen, and man has been obliged to evade the progress of the waters by raising from time to time the surface of the bordering lands.

If, then, the surface of the river-bed does become elevated, and in the proportion of 8⅝ inches every century, the protecting dams must be made to rise in the same proportion. The surrounding grounds cannot, however, rise in that proportion, and it consequently occurs, that land under cultivation lies lower than the water, and therefore, in case of flood, is the more exposed to danger, should the defensive dams be broken down.

Remarks as to the earlier Existence of the Binnen or Inland Lake. *By* Dr. Ludwig Becker.

In the year 1846, some buildings were undertaken in Mayence on the spot where an ancient Roman castle formerly stood. For this purpose the side of a sloping hill had to be lowered. The formation I found to be of the more modern tertiary chalk. At the depth of fifty feet I found innumerable remains of fishes in a stratum of clay. Agassiz travelled with me about this time, being on his way to North America, and I let him see these fossils. He recognized amongst others, a Perca, to which Herr Von Meyer gave the name of *Perca Moguntina.* I also found fragments of Crocodiles, Tortoises, Microtherium, &c. At the depth of fifty feet there is a great deposit of plastic clay, over which are broken strata of chalk and Paludinæ. The surface-water, which had easily found its way down to these, had given the clay (which dipped considerably down town towards the horizon) a slippery surface, thus occasioning many splits and separations of the above-resting strata, some remaining on the same elevation as before, others having sunk down or broken off, as it were, so that the strata no longer fit together, and there is a split between. These divisions or gaps, which were of a surface breadth of from ten to thirty feet, and in depth from twenty to fifty feet, were filled with sand, flint-stone, and pebbles. Amongst them I found remains of the Horse, the Marmot, the Deer, and others. The other parts consisted of the fragments of broken rock from either side, unmixed with diluvial remains or any foreign substances. This enabled me to perceive that nature had by these means preserved the mark of what the water-level had been in an anterior period. It is usually held as true, that once the Valley of the Rhine, from Strasburg to Bingen, was under water, and known as the Binnen or Inland Lake. The indubitable traces which the waters of this lake have left behind them, support this theory. It has not, however, till now been easy to decide what their surface level was. The above-mentioned crevices in the hill-side, however, seem to offer a decided clue. The upper crevices, those, namely, filled with diluvial remains, are but fourteen feet lower in level than the other ones which contain only the materials of the tertiary formation. The water may have had its normal level at the middle height of the two formations, which then would give it 115 English feet higher than the present Rhine bed. In proof of this, other appearances offer themselves. The precipices of the mountains which must have surrounded this lake, present, at this elevation, a direct line of precipice of about ten feet up and down, which seem to tell of the washing of the waves, the collision of ice-blocks, &c. Again, for the length of about 100 English miles, we find, but never above the height of 115 feet, diluvial loam, flint-stone, and rolled stones. All the sand above this is desert or moveable sand.

The outlet of this lake was apparently at Bingen, and it is probable that its waters descended by a considerable waterfall. At a later date it seems that the natural dam has given way, and that a mighty mass of water has all at once flowed down. Some time ago boring experiments were entered upon at Mayence, at the confluence of the Maine and Rhine, but at a depth of 240 feet down no rock was to be found; alluvial formation was alone to be met with.

Remarks on the Stonesfield Slate at Collyweston, near Stamford, and the Great Oolite, Inferior Oolite and Lias, in the Neighbourhood of Grantham. By the Rev. P. B. Brodie, *M.A., F.G.S.*

The author presents the following notices of the Collyweston beds:—

	ft.	in.
1. Rubble, consisting chiefly of broken slate	5	0
2. Sand.........	A few inches.	
3. Hard slate (ragstone)	4	0
4. Yellow sand	3	0
5. Slate	1	0
6. Yellow sand	1	0
7. Blue stone, with traces of vegetable matter in fragments.........	1	6
8. Slate	3	0
	18	6
Further on some inferior strata are visible, viz.—		
9. Sand	4	0
10. Ferruginous oolite	14	0
11. Clay		
Total.........	36	6

No remains of insects, fishes or reptiles were noticed, and other differences appear zoologically, between the slaty beds of Collyweston and Stonesfield, though their mineralogical characters and geological position are similar. The Collyweston deposit is conjectured to have been formed in deeper water, and at a greater distance from land, than the Stonesfield slate in Oxfordshire and Gloucestershire*.

The great oolite of Ancaster gives the following section :—

	ft.	in.
1. Blue clay, in which I could detect no fossils; near the top it is traversed by a thin dingy white kind of marl, with a few imperfect impressions of plants	12	0

May this not be the representative of the Bradford clay which in Wilts immediately overlies the great oolite, and often separates the minor subdivisions?

	ft.	in.
2. Ragstone—coarse shelly hard oolite	5	0
3. Sandy, soft (rarely shelly) oolitic freestone, variously coloured, yellow, pink and white, which, from its variegated hues, gives it a beautiful appearance. This constitutes the serviceable building stone, and yields very large blocks	17	6
4. Hard shelly oolite, generally of a blue colour, not worked	16	0
5. Soft white stone below, depth uncertain		
Total feet	50	6

In an adjoining quarry the strata above the freestone are thicker, the blue clay (No. 1) amounts to a thickness of twenty feet, and is succeeded by a hard blue stone, containing many shells, especially a large species of *Avicula*, and broken fragments of carbonized plants, but too imperfect to determine. There is a soft, yellow sandy band at its base, also full of similar vegetable remains: the total thickness of these two beds does not exceed two feet. The white rag, equivalent to No. 2 in the previous section, is only 1 foot 3 inches thick, and reposes on the freestone. The frequent remains of plants, and their rarity in Gloucestershire and Somersetshire, in the *great* oolite, seem to indicate a closer affinity, zoologically, with the Yorkshire oolites. Mr. Lycett and Mr. Morris identify very few of the great oolite fossils of the north with those of the south of England.

The inferior oolite offers in particular places much analogy to that of Gloucestershire. Green's quarry at Denton, near Grantham, gives the subjoined section :—

	ft.	in.
1. Rubble (about)	2	0
2. "Oolite marl"	4 or 5	0
3. Soft, shelly, white and yellow, though sometimes brown oolite, not quarried deep.		

The oolite marl (No. 2) is nearly identical with that near Cheltenham, though rather darker in colour, and much reduced in thickness. It is loaded with corals as inGloucestershire, and many of the species, as far as could be judged, seem to be identical. Some parts of the bed are softer and full of shells, among which were procured several species of *Cerithium*, *Nerineæ*, *Natica* and other genera. *Natica macrostoma*† is abundant, and a species of *Rostellaria* occurs, though rarely; the edges of the beds have been much water-worn, probably by currents, and the shells are exposed in relief and are much weathered. Mr. Lycett examined the small collection procured, and he states, that although the greater number were new to him, yet the tendency of the others was decidedly towards the inferior oolite, and agree specifically with some which are common in the Cotswolds; such, for instance, as the *Natica adducta* (an oolite marl shell, but also found in the great and inferior oolite of Yorkshire), *Trigonia striata* from the freestone and gryphite grit; while at the same time there is a new species of *Acteonina*, *Monodonta*, &c.

In the inferior oolite of the Cotswold Hills, corals are more or less distributed

* I had not read Captain Ibbetson's and Mr. Morris's paper on the Collyweston slate, published in the Reports of the British Association for 1847, until after the present notice was drawn up, and it appears that we had independently arrived at the same conclusion.

† Mr. Lycett considers this to belong to a *new* species, which is a highly characteristic one in the oolite marl of Gloucestershire.

throughout the whole, but no one stratum contains them in greater abundance than the oolite marl, the upper division of which has at one spot in particular been correctly denominated 'the coral bed,' and evidently formed an extensive coral reef beneath the ocean; but with the exception of the Pisolite, we have no other evidence of such reefs in any of the other subdivisions. Hence the abundance of corals in the oolite marl near Grantham, coupled with other facts, such as the frequency of *Nerineæ*, which are usually found associated with corals, and are believed to have inhabited shallow seas, tends to support the probability that the marl in Lincolnshire was deposited under similar conditions to the marl in Gloucestershire.

One of the numerous trial borings for the railway now in progress on Harroby Hill, near Grantham, gives the following section:—

	ft.	in.
Soil	0	6
Rubble	6	0
Inferior oolite	40	6
Lias (blue bind) (continued downwards)	10	0

The junction of the inferior oolite and upper shale may be observed near Stamford, where many of the characteristic fossils have been noticed. The upper lias also crops out at the base of some of the numerous valleys which traverse the oolitic district round Grantham. A few miles on the north-west a low and extensive flat is occupied almost exclusively by the *middle beds* of the lower lias, so largely developed in the Vale of Gloucester, and in no respect differing from them. In that neighbourhood the marlstone abounding in fossils forms a range of low hills, and is exposed again in the descent from Denton Hill into the valley in which Grantham stands. It there occupies the same relative position, and presents the same geographical features as it does in Gloucestershire, Warwickshire and Somersetshire. A railway cutting through Gonnerby Hill, close to Grantham, has laid open the top beds of the lower lias undistinguishable, either lithologically or zoologically, from their equivalents at Hewletts and Robinswood Hills, near Cheltenham and Gloucester, and at Chipping Campden in the north-eastern extremity of Gloucestershire*.

The lower lias generally may be best studied N.W. and W. of Grantham; the oolitic Wolds in their range N.E. and S.W., rarely display the upper lias at their base. West of the town towards Nottingham the junction of the red marl and lias is probably visible, though the author did not see it; at all events, the *insect limestone* occurs at Granby, between Denton and Nottingham; for in the Grantham Museum there is a beautifully preserved fish, apparently a Dapedium, from this stratum; the structure of this limestone being so peculiar, that in the absence of *insect* remains, Mr. Brodie had no difficulty in recognizing it. In this case, this is the farthest point *northwards* in which it has been hitherto detected.

On Striated and Polished Rocks and "Roches Moutonnées" in the Lake District of Westmoreland. By JAMES BRYCE, *jun., M.A., F.G.S.*

The discovery of these rocks is due to the active zeal of Edward Wakefield, Esq. of Birklands, near Kendal. Knowing that the surface of the rocks had been laid bare in many places along the line of the Kendal and Windermere railway, he instituted a careful search in May last, and was so fortunate as to discover two extremely well-marked cases. These he showed to the author in July; other examples were afterwards observed by them jointly. The author has visited almost all the localities in Scotland in which scratched rocks have been found, and he has perused the accounts of others; he considers that those now to be described are by far the most perfect specimens yet discovered in these islands. The best marked case occurs about one mile south of the Staveley station, fifty yards from the railway on the N.E. side, and on the northern edge of a wood called Jacob Wood. Here a surface 53 ft.

* My friend Mr. G. E. Garey, the intelligent engineer on the Oxford and Worcester Railway now in progress at this place, has discovered many rare and interesting fossils in this division of the lower lias, especially some new species of Asterias (*Tropidaster*, Forbes), Pentacrinites, and Crustacea.

by 16 ft. of the Lower Ludlow Rock was exposed two years ago by the removal of the covering of till and boulders in opening a new road; it was intimated that the rock should be removed, but it turned out to be so hard and tough, that it could not be quarried without great expense and loss of time, and hence the preservation of the scratched surfaces. The striæ are extremely numerous and generally very fine; but there are also many coarser striæ, and also grooves of various widths. The greater part of these markings are in the direction of 10° west of magnetic north, or 34° west of true north, taking the present variation at 24°. They thus point almost exactly towards the opening of Kentmere. The surface is divided into three or four rounded eminences, smooth and polished to a high degree, and presenting exactly the character of the most perfect specimens of the "Roches Moutonnées," so well described and figured by Agassiz, and considered by him as the most decisive evidence of glacial action.

Another example is to be seen at the Birthwaite station, where a large extent of surface of the same rock is rounded, polished and striated in a manner exactly similar. The striæ and grooves run in the direction of the valley, or very nearly magnetic north and south, that is, rather more to the south than in the former case. Other examples occur at Birthwaite Church, within the enclosures, and at several points near; and also in the valley between Staveley and Birthwaite, in all of which the direction of the striæ is the same as at the Birthwaite station. The Grasmere valley, Raise Gap, a portion of Thirlmere valley, and the sides of Helvellyn, were afterwards traversed without finding any additional cases; but the examination was rather cursory.

With respect to the cause which gave origin to these striæ, the author observed that they might certainly have been produced by glaciers; but as the agency of ice is insufficient to explain all the erratic phænomena of the lake district, for example the dispersion of the Shap granite, besides others, it is unnecessary to have recourse to it at all; he would refer them to the action of the waves and currents charged with detritus, which, according to the elevation theory so ably developed by Mr. Hopkins and Professor Whewell, in several most valuable memoirs, must have, at many different epochs, proceeded from the centre of this district. In confirmation of this view, it was shown that the striæ conform in their direction, so far as yet examined, to the lines of the great radiating faults, and the valleys diverging from the central group of mountains, whose first formation is probably due to the existence of these faults, and along the lines of which the transported materials would be conveyed with the greatest facility and in greatest quantity, on each successive disturbance of the waters by the elevating forces. In exact agreement with the faults, the striæ at Jacob Wood have more of an easterly tendency than further west, and the gravel ridges in the open country southwards to Kendal, &c. have a corresponding direction, while they contain detritus from rocks existing only to the north. It would be interesting to ascertain, as bearing upon the theory of Mr. Hopkins, whether this partial conformity is really an isolated phænomenon, or is part of a great system of diverging striæ, marking the *quaquaversal* direction of the denuding and transporting forces. It is highly desirable that the valleys descending towards the N.E. and N.W., and opening in the direction of Penrith and Cockermouth, should be carefully examined with reference to the existence of such markings upon the rock-surfaces.

On the Lesmahagow and Douglas Coal-field in Lanarkshire.

By James Bryce, *jun., M.A., F.G.S.*

The author stated, that he had undertaken an examination of this field in consequence of its being hitherto undescribed,—the inquiry being entered upon, many peculiarities were noticed. The coal district of Scotland, ranging from Ardrossan to near St. Andrews, is but a single field, the older rocks on which the coal measures repose, nowhere rising so as to form independent basins. It is indeed pierced through transversely to its length, on the borders of Lanark and the Lothians, and again on the borders of Lanarkshire and Ayrshire, by high ridges of trap rocks; but these do not wholly interrupt the continuity of the coal measures. The coal-field in question was found to be an exception; it is cut off on the one hand from the Clyde basins, and on the other from those of the east of Ayrshire, by ridges of Devonian rocks, amid which igneous products are variously intercalated. On the S.W. side this separation does not take place, as we should be inclined *à priori* to expect, at the highest part of the ridges forming the watershed between the two systems of river drainage; on the contrary, the strata of the Muirkirk field in Ayrshire rise up over this ridge at the height of 1000 or 1200 feet, and pass down into the basin of the Clyde, where they rest upon a narrow band of Devonian rocks. The boundaries of the field on the east reach out to near the base of Tinto. There is no great body of carboniferous limestone at the base of the series, but several beds of limestone are interstratified with the coal, of great continuity, and containing a complete suite of fossils of true carboniferous types. The coal shales, sandstones and ironstones, afford similar remains in abundance; and there can be therefore no doubt that the coal of this field is of the same age as that of the Clyde basins. It is worthy of remark, that several species of Trilobites occur in the shales and limestones, far up in the series; that a white grit, resting on one of the lower limestones, contains a prodigious quantity of fish remains, and corresponds, apparently, with the great "fish-bed" of some English fields; and that from one of the middle shales a fossil has been obtained agreeing exactly with the *Serpulites longissimus* of the 'Silurian System,' pl. v. fig. 1. The field contains fifteen seams of coal, whose thickness varies from 2 ft. to 15 ft., the aggregate amounting to about 65 feet of workable coal. There are black band and clay band ironstones, the principal seam of the former averaging 11 inches; but neither these nor the coal beds have yet been worked to any considerable extent, owing to the greater accessibility of the fields further down the Clyde. The importance of this field to the south-eastern districts of Scotland was pointed out, and the attention of capitalists invited to its more thorough examination.

The author exhibited a coloured map, with numerous sections, showing the internal structure of the field.

On the Glacial Phænomena of the Neighbourhood of Edinburgh, with some Remarks on the General Subject. By ROBERT CHAMBERS, *F.R.S.E.*

This paper opened with a description of the local phænomena, partly with a view to the gratification of the strangers present at the meeting of the Association. The Corstorphine Hill is a stratum of trap resting on sandstone, and dipping to the west, with a cliff in a line north and south. In its crest, which rises to 470 feet above the sea, are four transverse clefts. On the west surface of the hill, the rock, wherever it is exposed, is found to be rounded (*moutonnée*), smoothed, and grooved. The grooves and the clefts in the crest of the hill all lie in one direction, viz. directed to a point north of east. There are also, to the east of the hill, long hollows with intervening swells, and these run in precisely the same direction. At various places, in this region east of the hill, are seen sandstone surfaces worn down to a remarkable flatness and smoothness, and in several instances marked with striæ, all pointing in the same direction.

Throughout the valley of the Forth, from the Pentlands to Fife, from Linlithgow to Dunbar, the sandstone surfaces, wherever they come up, are likewise smoothed, and in many instances striated, the striæ all pointing to the E.N.E., or thereabout, such being the general direction of the valley itself. The trap hills rising in this valley are all long and narrow, generally free from abruptness on the sides, often abraded on the west, and generally sloping away gently to the east; the direction here also is always E.N.E. Surfaces on the Pentlands and in Fife exhibit striation precisely conformable. In short, if a deep ice-flow passed through this valley, it might be expected to produce precisely the phænomena which have been observed.

The similar markings in other districts of Scotland were shown, for the most part, though not without striking exceptions, to be directed towards the east and south. Mr. Chambers adverted to the theory of *debacles*, which was started to account for the appearances, as now nearly given up. Ice was generally acknowledged as concerned in producing them, because the appearances were precisely those which existing glaciers produce. But there was great room for speculation as to the circumstances under which the presumed glacial agent was applied. Mr. Chambers declined theorizing on the subject, but pointed out various conditions which any theory on the subject must explain. 1. How ice could move over so large a portion of the North American continent, in a direction admitted to be tolerably uniform, allowing for slight deviations easily explicable as owing to irregularities in the original surface, and this without any mountain chain to give it forth. 2. How this ice was capable of ascending slopes and topping mountains of considerable height. 3. How, in such a valley as that of the Forth, there could be an ice-torrent of undeviating flow for many miles, and deep enough to envelope hills many hundred feet high

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Gold Mines of the Isthmus of Darien, Emigration to New Granada, and Canalization of the Isthmus of Darien. By Dr. CULLEN.

Mr. John Hogg in reading this paper, stated that the author (Dr. Edward Cullen, of Dublin) intended to publish a new map of the Isthmus of Darien on a large scale, which would be of advantage to our knowledge of the geography of that part of America.

The paper commenced with a geographical account of that Isthmus, which forms a territory of the Republic of New Granada; the most important part of which is that portion included between the Gulf of Wraba, or Darien, on the Atlantic, and the Gulf of S. Miguel del Ballano on the Pacific. In the author's opinion, nature had marked out this portion as the true medium of communication between the two oceans. A minute description then followed of this entire district, which enumerated some of the chief geographical characters.

The gold mines of that Isthmus were likewise noticed. On the banks of the Cana, a branch of the river Tuyra, is situate the *Mina Real*, in the Cerro del Espiritu Santo, the richest mine that was ever worked. Dr. Cullen said, that for a number of years, the sums transmitted to Spain for the king's *Veintavo* from that mine, averaged upwards of $3\frac{1}{2}$ millions of dollars per annum, giving upwards of 70 millions of dollars *per annum* for the *whole* produce. This he considered as a prodigious return, which completely throws into the shade the recent gold digging in California, where the produce seldom reaches *one* million of dollars *per month*. Besides the Cerro del Espiritu Santo, there are many mountains near Cana, very rich in gold, which have never been worked. Also, the author found in the Isthmus of Panama, *auriferous* soil in many places.

As a suitable district for emigration, the territory of Darien was detailed as offering brilliant prospects, and possessing excessive fertility combined with great geographical advantages. The lands set apart by the Republic of New Granada for colonization, consist of the table-lands and elevated valleys of the Cordilleras of the Andes, where the soil is very rich, and the climate temperate; the thermometer during the year ranging from 50° to 80° Fahrenheit.

The paper concluded with some observations on the canalization of the Darien Isthmus, and Dr. Cullen stated that on his return from the interior of Darien, he ascended the Chuquanaqua and Savana Rivers; these, but more particularly the latter, in his estimation, afford the most direct and feasible mode of communication with the Atlantic. No bar exists at the mouth of the Tuyra, or of the Savana; nor is there any difficulty in the navigation of the Gulf of San Miguel on the Pacific, nor on the coast of the Atlantic.

On the Succession of Strata and Distribution of Organic Remains in the Dorsetshire Purbecks. By Prof. EDWARD FORBES, *F.R.S.*

During the autumn of 1849, Professor E. Forbes was deputed by the Director-General of the Geological Survey, Sir Henry De la Beche, to examine the organic remains of the Purbeck strata in Dorsetshire, and to investigate their distribution *in situ*, acting in cooperation with Mr. Bristow, the officer engaged in constructing the geological map of the district. The results of this inquiry were so novel and curious, that it was thought by the Director-General desirable, before publication in an extended form, to lay them before the British Association, in the hope that by such a course attention may be directed to similar phænomena in freshwater formations in other districts. Our knowledge of the Dorsetshire Purbecks has been derived chiefly from the memoirs by Professor Webster, Dr. Fitton, Sir H. De la Beche, Dr. Buckland,

and Dr. Mantell. With the exception of certain vertebrata (reptiles and fishes), we owe to Dr. Fitton our information respecting the fauna. No minute investigation of the strata, in connexion with their organic contents, had, however, been undertaken, nor had the latter been collected to any extent, as may be seen when the published lists, including about twelve species of Mollusca and Crustacea from these beds, are compared with those now submitted to the Section, in which more than seventy members of those classes are enumerated. This increased catalogue is not merely of value on account of the great numbers of species, it is remarkable on account of the new and interesting light it throws on the distribution of freshwater creatures during the oolitic period.

The points at which these observations were made were Lulworth Cove and the neighbouring bays, Warbarrow Bay, (on one side of which, at Meup's Bay, is the clearest and most complete of all the Purbeck sections,) Osmington, Upway and Ridgeway, between Weymouth and Dorchester, and Durlestone Bay, near Swanage. Subsequently the base of the Purbecks exposed in the great Portland quarries at Swindon, a section which had previously been examined and accurately described by the Rev. P. B. Brodie, was visited, and found to correspond exactly in mineral characters and organic contents with the beds at the base of the Purbecks in Dorsetshire. From all these localities ample collections were made, in which the author had the assistance, for several months, of Mr. J. Gapper, of the Geological Survey. The results of these researches, whether new or confirmatory of older observations, may be stated briefly as follows :—

1st. There is no passage from the Portlands into the Purbecks. The top beds of the Portland stone are purely marine: the lowermost beds of the Purbeck are purely freshwater, containing *Cyprides, Valvata* and *Limneus*. At Meup's Bay, these lowest freshwater beds, forming the "cap," occupy a thickness of a little more than eight feet, and are surmounted by the great dirt-bed, containing the stools of *Cycadeæ*. A little above this dirt-bed is a second, less developed, and a similar one occurs in many places below it.

Above the highest dirt-bed, the Cypridiferous shales which follow are strangely contorted and broken up in all the sections at the west end of the Isle of Purbeck.

These are capped by undisturbed beds full of Cyprides, succeeded by twenty feet or more of shales, calcareous slates, marls and limestones, with occasionally siliceous bands, all for the most part deposited in brackish water, and filled, in many places, with *Rissoæ* of the subgenus *Hydrobia*, and a little *Cardium* of the subgenus *Protocardium*.

Many of these beds abound in a species of *Serpula*, closely allied to, if not identical with, *Serpula coacervites* of the German Purbecks. There are above thirty feet of these brackish water-beds at Meup's Bay. They are capped by purely freshwater marls, containing the same species of *Cypris, Valvata* and *Limneus*, as occur in the lowest beds of the Purbecks.

Suddenly, without any disturbance, a change takes place. A very thin band of greenish shales, full of impressions of leaves like those of a large *Zostera*, and with traces of marine shells, cuts off the freshwater strata. Immediately, however, new freshwater beds succeed, filled in many places with fossils, species of *Cypris, Valvata, Paludina, Planorbis, Limneus, Physa* and *Cyclas*, all different from any we had previously seen in the lower beds. Thick bands of cherty stone, filled with these fossils in a beautiful state of preservation, occur, and among them are for the first time in the oolitic series, *Gyrogonites*, the spore vesicles of *Charæ*. Immediately above these interesting bands (in which many remains of fish were also found) is the great and conspicuous stratum long familiar to geologists under the local name of "Cinder-bed," formed of a vast accumulation of *Ostrea distorta* shells. In this bed the author discovered the first Echinoderm ever seen in the Purbecks. It proved to be a species of *Hemicidaris*, a genus characteristic of the oolitic period; it was accompanied by a species of *Perna*. The cinder-bed is succeeded by limestones and shales, partly of fresh water and partly of brackish origin. In these the same species of *Cypris* occur which mark the shaly bands near the chert below the cinder. Many fish, especially species of *Lepidotus* and *Microdon radiatus*, are found in these bands; and in the fine collection of Mr. Wilcox of Swanage, are the heads of two magnificent species of the reptile *Macrorhynchus*, from this horizon in the Purbecks. Among the mollusks a remarkable ribbed *Melania*, of the section *Chilina*, is found here. After the deposition of these strata, there came another powerful influx of the sea, introducing marine species—*Pectens*, *Modiola*, *Avicula* and *Thraciæ*—all undescribed forms. Brackish-water strata full of *Cyrena*, and traversed by bands abounding in *Corbulæ* and *Melaniæ*, are next in order; in them is a *Protocardia*, but quite distinct from its representative species in the lower portion of the Purbeck limestones. Cyprides, turtles and fish, crown these brackish-water bands, and are specifically connected with the beds of the middle Purbecks below them.

Lastly, a third series of freshwater strata commence with a new series of fossils—*Cyprides*, *Paludinæ*, *Physa*, *Limneus*, *Planorbis*, *Valvata*, *Cyclades* and *Unio*, and fresh forms of fish. These continue until they merge into the base of the Hastings sands, and the Purbeck series is completed. The total thickness of all the Purbecks at Meup's Bay is about 155 feet. Of this one-half is occupied by the lower portion of the series, and the remainder is divided between the middle and upper portions, the former being rather the more extensive. At Swanage the thickness is greater.

It is very remarkable, that whilst we can strictly divide the Purbecks into upper, middle and lower, each marked by a peculiar assemblage of organic remains, the lines of demarcation between these sections are not lines of disturbance, nor indicated by striking physical characters or mineral changes. The features which attract the eye in the Purbecks, such as the dirt-beds, the dislocated strata at Lulworth and the cinder-bed, do not indicate any breaks in the distribution of organized beings. The causes which led to a complete change of life three times during the deposition of the freshwater and brackish strata of the Purbeck series, must be sought for, not simply in either a rapid or a sudden change of their area into land or sea, but in the great lapse of time which intervened between the epochs of deposition at certain periods during their formation. A most striking feature of the molluscan fauna of the Purbecks is this—so similar are the generic types of these mollusca to those of tertiary freshwater strata and those now existing, that, had we only such fossils before us, and no evidence of the infraposition of the rocks in which they are found, we should be wholly unable to assign them a definite geological epoch. An examination and comparison of these Purbeck fossils with the collections from the Hastings sands and Wealden in the Museum of the Geological Society (to which they were chiefly presented by Dr. Fitton), and in the cabinet of Dr. Mantell, leads the author to believe that the fauna of the middle and upper divisions of the Wealden series is, so far as species are concerned, almost entirely distinct from that of the lower or Purbeck division. Many of the species reputed to be common to the whole series, are found on inquiry to include more species than one under one name; whilst some other forms recorded as Wealden, but so far as the author has observed, peculiar to the upper Purbecks, and occupying only a limited horizon in that part of the series, are derived from certain anomalous strata near Tunbridge Wells, which the author believes will prove, on closer examination and accurate survey, to be Purbeck strata, brought up among the Wealden clays by faults. The excellent monograph on the Wealdens of North Germany, by Dunker and Von Mayer, in which a vast number of species of animals and plants are described and accurately figured, affords the strongest confirmation of this view, and shows that while the faunas of the German Weald clays and Hastings sands correspond in essentials with that of the same formations in Britain, the Purbecks of the continent, just as here, differ from the superior beds almost entirely in their organic contents, and correspond with similar beds in our own series.

The marine or brackish-water bands in Germany containing *Ostrea Fittoniana*, appear to be represented in England by corresponding bands with the same fossil, accompanied by species of *Corbula*, *Cardium* and *Melania*, in the upper part of the Hastings sand at Swanage. All the investigations of the author, so far, have gone to indicate the probability of the presence of several distinct assemblages of organic remains (similar to those which he has shown to exist in the Purbecks) in the higher portions of the Wealden series of formations, whilst the true position of the strata, now described, is shown without a question to be in connection with the oolitic or lower, and not with the cretaceous or upper division of the secondary rocks.

Brief Notices of Earthquakes in South America in 1844, 1845, 1846 *and* 1847. *By* Mathie Hamilton, *M.D.*

In the preliminary part of his paper, the author mentions, that, having placed a mountain barometer in good condition at Tacna in 1843, it was found to be hardly at all affected by the ordinary earthquakes which were observed there. The pendulum of the seismometer which he employed, was of little use for ascertaining the *direction* of one earthquake shock; but the sand-glass instrument acted well. It is for moderate shocks that instruments of this description are required, for in violent convulsions, even things the most ponderous act as seismometers, and it often occurred at Tacna, that in shocks there considered moderate, the bell in the tower of the church was tolled by lateral movements.

Whoever would devote attention to the observation of phænomena concomitant on earthquakes in Peru, should, in addition to other necessary instruments, have an efficient electrometer, if such can be obtained; also an anemometer of simple and delicate construction.

On the 18th of October, 1844, the provinces of Salta Tucuman, Santiago del Estero, and others, were convulsed by a terribly destructive earthquake, which was felt over an extent of territory above 1000 miles long from N. to S., and several hundred miles wide. When notice of the calamity reached Tacna, I transmitted to Salta a few queries; and in reply received a document, from which a translation of some paragraphs is here offered. This horrible earthquake happened at half-past ten P.M.; there is not a house in Salta which is not damaged, and many have fallen; our estate has suffered much, for the tanks which contained the 'Miel' (cane-juice) all gave way during the earthquake. These tanks are subterraneous, and each of them held about 1000 arobas, *i. e.* 25,000 lbs., which burst into one another, forming a pool of miel.

In the districts of Xuxuy and Tucuman, the earthquake happened at the same time as here, reducing these towns and other places to a similar state of ruin. There were two earthquakes or great movements; and in the suburbs of Salta, as in various places more distant, the earth opened and threw out quantities of water and sand of various colours, with explosions as if from volcanoes. During the night of the earthquake, from the time of the first shock till sunrise, heavy rain fell. Prior to the concussion being felt, dogs began to bark, while beasts of burden and others, if moving, were observed to stop, and so place themselves as to prevent their falling by the coming movements of the ground. Also it was noted by people in Salta, that previous to the first great shock, there was a profound calm in the atmosphere.

Numerous shocks which occurred at Tacna and Arica within the four years above noted, may be passed over without notice*. On the 26th of Nov. 1846, a new volcano in Chili appeared in action; its first eruption was preceded by many land reports, which were heard over a circumference of twelve leagues. It is on one of the highest points of the Cordillera, that known as the 'Cerro azue,' blue mountain, which is distant thirty leagues from Talca, at which distance the sulphur thrown out from the volcano is smelt. Talca is about midway between the cities of Talcahuana and Santiago*. 1847, Jan. 19th †: a severe earthquake was felt at Copiapo, which threw down a number of houses, and damaged nearly all the town; fourteen other shocks occurred within four hours from the first one. They were mostly vertical, and were considered the worst there which had happened since 1822†. The same paper of the 26th of May, notices a violent movement of the sea in the harbour of Callao, when three vessels anchored near the shore were in danger of being lost, in consequence of commotion in the water, a phænomenon rarely seen there. The following explanation was at the same time offered: "The origin of what has been stated above was a furious submarine earthquake, which was felt by the captain of the American Whale Frigate 'Acushuett,' when distant about sixty miles W.S.W. from the island of San Lorenza, at 3 A.M. of the 24th. The movement of the water in the bay of Callao lasted several hours, and the three vessels were saved from being carried on shore by assistance from the English and French ships of war." In that paper of the 4th of June, it is stated that an officer of the army had written from Ayacucha on the 10th of May, stating that at the town of Huancarania an earthquake had occurred which lasted four days,

* Vide *Mercury* of Valparaiso of 19th January 1847.

† Vide *Comercio* of Lima of 11th February 1847.

that the earth had opened and destroyed various animals, and that Talavera with other places had suffered.

On the 28th of June, 1847, a severe earthquake happened at Ica, which continued at intervals during two days. The shocks were both vibratory and vertical, and did much damage to the town: one writer complained of heavy loss from the fracture of large jars in the ground which contained liquors. Tacna, 10th September, 1847, 10 P.M.: rain has fallen all day, which is rare here; also the sun has not been seen since yesterday; barometer has fallen $\frac{1}{20}$th since morning, night very dark. 11th, 3 A.M.: awakened by a violent earthquake, which lasted I think half a minute; others say it continued two or three minutes. The motion was both vertical and in oscillations, with land noises more like a succession of reports or explosions, than the usual subterranean rumble; little damage was done beyond cracking some walls; immediately I examined the barometer, which was as at 10 P.M., rain still falling, atmosphere thick and heavy, sand in tube fallen.

It appears from *Ee Comercio* of Lima, of 8th October, that two strong shocks of earthquake were felt at Arequipa, on the 11th ultimo, one at five minutes before 3 A.M., *i. e.* about the time of that above noted at Tacna and Arica; the distance in a direct line from Arequipa to Arica is about 200 miles.

On the 8th of October, 1847, an earthquake was felt throughout Chili, from N. to S., and more severely at Melepilla, which is between Valparaiso and Santiago; at Melepilla, the earth was shaking or swinging during two days, within which time several hundred shocks were experienced, the convulsion having been the worst here since that of 1822.

Though no certain indications of an approaching earthquake can be noted, yet I have heard persons in Arica and Tacna affirm that previous to heavy shocks, they were often sensible of a peculiar disagreeable smell or state of the atmosphere, which they assert may be considered a precursor of a coming shock. Between 1843–48, the said odour was more rarely referred to in that quarter, which may have resulted from the greater paucity of earthquakes there within that period. In 1826 and following years, prior to some severe shocks there, my olfactory organs were affected by the invisible agent above noted, which was something different from the effluvia emanating from decaying animal and vegetable matters. Native Peruvians call it 'Olor de tierra,' smell of the earth.

Another indication of a coming earthquake, in the opinion of the people there, is, that when the atmosphere is profoundly calm or stagnant, an almost imperceptible movement of it, a breath, as it were, of wind is felt, so gentle as to affect only the faces of persons who are peculiarly sensitive. These, and other alleged precursors of severe earthquakes, such as movements of the lower animals, should be diligently watched by those who would study these so often dire visitations; which, though no human power can avert, yet perchance may, in some cases, be made less destructive; as, with the aid of properly adapted instruments and other means, attentive observers may obtain, not only a solution of the problem as to the causes of these terrestrial convulsions, but also a knowledge of their premonitory symptoms, if any, which would be of vast importance as affecting precautionary measures for saving life and property.

On the Position of the Footsteps in the Bunter Sandstone of Dumfries-shire.
By ROBERT HARKNESS.

The Bunter sandstone occupies four separate portions of the county of Dumfries: one occurring in the north-west, in which as yet no footprints have been discovered; another is found filling up the flat parts of the Vale of the Annan; the third is met around Dumfries; and the fourth stretches east from near the village of Cummertrees along the shore of the Solway, and occupies the lower part of the parish of Cannobie. It is in that portion which lies in the low part of the Vale of the Annan that impressions of footsteps occur in the greatest abundance. At Corncockle, and also at Templand quarries in this district, and likewise at Locherbriggs, Craigs, and Green Mill, in the sandstone of Dumfries, footsteps are met with. At the former of these places they are found more commonly and in greater variety, as well as in better state of preservation than at the other localities. The nature of the sandstone which affords the tracts, is to a great extent similar; and the direction of the dip is generally uniform. At Corncockle the sandstone consists of beds of rock of varying thickness, having laminæ which are better developed in the upper than in the lower parts of the stratum. In some cases the beds are separated from each other by thin layers of clay; on these, and also on the upper surface of some of the strata, the impressions abound; those on the rock being more perfect than what the clay beds afford, owing in some cases to the thin layer of clay being completely pressed through, and the less yielding sand having confused the impression. Of the general characters of the steps from Corncockle, Templand, Locherbriggs, and around Dumfries, there is such a resemblance between them as to show that the position of the strata at each of these localities is similar, and the general agreement in the composition of the sandstones also bears out this opinion. In the area occupied by the Bunter sandstone about Annan and the neighbourhood of the Solway Firth, we find considerable difference, both in the composition of the sandstone, and also in the nature of the footsteps. At Corse Hill, which may be taken as a type of this deposit about Annan, we have beds of clay about nine inches in thickness, interstratifying the sandstone; and the general appearance is such as to show that here the deposits are not far removed from the Keuper. The upper surface of these clay beds is commonly marked by vermicular-like ridges, which appear to have resulted from the erosion of currents on the soft surface of the clay. Amongst these markings, impressions of the footsteps of the Cheirotherium are sometimes met with, and in some instances marks of desiccation occur.

In the districts about Corncockle and around Dumfries, above the beds which contain the impressions, coarser sandstones are met with which exceed a thickness of 100 yards; and above this coarse sandstone a thick deposit of conglomerate of more than that thickness is also found. Resting upon this conglomerate, we have beds which represent the lower portion of those which occur in the neighbourhood of Annan. But in this latter locality we have fully 100 yards of beds exposed, and consequently, connecting the whole thickness of the beds together, from the lower portion of Corncockle Muir to the beds which afford the steps of the Cheirotherium at Annan, we have a thickness of about 300 yards: as however the conglomerate would accumulate much more rapidly than a common sandstone, by excluding this deposit, we should have more than 200 yards of sandstone, through which different impressions of footsteps are met with.

As regards the different kinds of footmarks, we have associated at Corncockle the steps of what has been termed a small tortoise, with at least the impressions of three other animals. This small tortoise-like impression also occurs at Weston Point in Cheshire, where it is found in company with the steps of the Rhynchosaurus; but as no traces of this latter animal have been met with in Dumfries-shire, we may infer that it was not called into existence when the sandstone of Corncockle Muir was being deposited; and moreover, inasmuch as we have no traces of the other three animals coexistent with the little tortoise, we may infer that these animals had disappeared before the creation of the Rhynchosaurus. As before stated, the Cheirotherium steps are found near Annan, and the general character of the beds here shows that they are nearly related to the Keuper. At Stourton, and also at Lymn, both in Cheshire, the footsteps of this animal occupy a high position in the Bunter sandstone. At Bemburg we find the Labyrinthodon also occurring in the higher beds of the Bunter; and Dr. Lloyd considers that the *Labyrinthodon Bucklandi* belongs rather to the higher portion of this deposit than to the lower beds of the Keuper.

Considering the footsteps of the Bunter sandstone, we have in the highest portion the impressions of the Cheirotherium. Below these the footmarks of the Rhynchosaurus occur associated with what are termed the steps of the tortoise; and at a depth of about 200 yards from the highest part of the Bunter, we have the tracts of several other animals, amongst which the small tortoise, which coexisted with the Rhynchosaurus, also appears. Mr. Harkness exhibited a drawing of the steps of a biped from Western Point, the first which has been noticed in this country.

On the Representatives of the Mountain Limestone as they occur in Dumfries-shire. By Robert Harkness.

After describing the relative position of this limestone to the other geological formations, the author proceeded to point out the district occupied by it, and also its peculiar character. The lower beds, which consist of white grits, having their upper parts interstratified with beds of red, blue and black shale, are most abundantly developed in the neighbourhood of Langholm, and have a thickness exceeding 300 yards. Above this lower bed deposits of limestone, ironstone, sandstone, and shales of various colours occur, having in some instances a bed of coal about four inches intercalated in them. These deposits are best seen at Couthart Burn, near Ecclefechan, where they have been perforated to the depth of about 100 yards in search after coal; and in this portion of the representatives of the mountain limestone, the lime quarries of the southern part of Dumfries-shire are worked.

The whole thickness of this second portion of the formation appears to exceed 150 yards in thickness, and abounds in fossils common to the mountain limestone. Above this, a higher series of beds are found, consisting principally of variegated grits, having in their lower parts shale beds; these grits are generally of a reddish colour, and in them *Producti* and *Terebratulæ* occur; and in some places portions of coal plants. This higher series of grits is best developed at Brown Muir, Woodcockair, and Repentance Hill, and they seem to have a thickness exceeding 200 yards; the whole representatives of this formation, as it occurs in Dumfries-shire, being more than 650 yards in depth.

These representatives of the mountain limestone appear to occupy a low position amongst the deposits which constitute that formation, the whole of the fossils being such as to indicate rather that they are equivalent to the great Scar limestone of the north of England, than to either the Yoredale rocks or limestone shales; since, with the exception of one or two species of Goniatites which are met with at Kilnhead, we find no traces of the fossils which indicate the higher portion of the mountain limestone formation.

The district of country occupied by the representatives of the mountain limestone is strongly marked, and the contrast between it and the Silurians, which lie to the north thereof, is so great, as at once to point out the different formations, the former consisting of flat-topped hills of comparatively low elevation covered by coarse herbage, while the Silurian hills are round, and have hummocky sides clothed with that fine vegetation which so well adapts them for sheep-walks; and to them the south of Scotland owes its pastoral beauty.

On the Erosions of the Earth's Surface, especially by Rivers. By the Rev. EDWARD HITCHCOCK, *D.D., LL.D., President of Amherst College, Massachusetts, and Professor of Geology.*

The evidences of extensive erosions exist in the enormous amount of gravel, sand and loam on the surface; in the rounded and striated appearance of mountains in high latitudes; in the marks of erosion in gorges and valleys, and in the loose materials along rivers; and, above all, in the vast extent of strata that must be supplied to fill up deficiencies.

1. The agents of erosion are—first, atmospheric air; second, carbonic acid; third, water: the latter the grand agent,—1, as vapour; 2, as water; 3, as ice.

It (water) operates,—first, chemically as a solvent of great power, at high temperature especially; second, mechanically;—first, as running water; second, by its expansive power, as ice; third, by the movement of masses of ice, as glaciers or icebergs. The results of these agencies are seen—first, in the encroachments of the ocean on the land; second, in the erosion of hills and mountains, when the land was beneath the ocean, or rising from it.

2. Long and straight gorges, called durgatories in New England, as in Newport R. Island, 7 rods long, 70 feet deep, and 8 feet wide; second, in Sutton, Massachusetts, half-a-mile long, and 60 to 80 feet deep, and 50 feet wide; third, in Great Barington, Mass., 80 rods long, 60 feet wide, and from 60 to 80 feet deep; fourth, Dixville Notch, N. Hampshire, 500 feet deep.

3. *Drift Agency*, or the joint action of ice and water.

4. The erosive agency of rivers, which is chiefly considered in this paper. Drift agency and sluice action may be distinguished,—first, by the direction of the force; second, drift agency has rounded and smoothed the northern sides of hills: it has not conformed, like river action, to the sinuosities and anfractuosities of the rocks;

third, it has striated the surface, as rivers have not done; fourth, it has operated uphill extensively, as rivers have not.

Specific Effects of River Action.—First, pot-holes, sometimes twenty or thirty feet deep, and ten feet diameter; second, rounding the edges of the strata; third, the drift materials are less rounded than those by rivers.

Distinction between Oceanic and Fluviatile Action.—First, the latter produces pot-holes, but not the former; second, the gorges made by the ocean are usually straight, those by rivers usually sinuous; third, rivers cannot produce wide valleys, as the ocean can; fourth, the force of the ocean is directed towards the axis of mountain chains; fifth, steep-worn cliffs, with no opposing cliffs, are due to the ocean; sixth, several parallel valleys of erosion on the crest of a mountain evince oceanic agency.

Mode and Extent of Erosion by Rivers.—First, when they began to flow, they would choose the lowest portions of the surface, and probably form a chain of lakes at first; second, as the barriers wore away, the lakes would at the same time be filling with detritus; third, deltas, constantly increasing, prove that the excavation exceeds the filling up (the Mississippi carries to its mouth one cubic mile of mud in five years); fourth, rivers passing through loose materials have high banks, and are sinking deeper and deeper; fifth, at cataracts, the water-worn appearance of the walls proves excavation; sixth, rivers evade their beds,—first, by solution; second, by friction; third, by producing disintegration; fourth, by freezing in crevices; fifth, by ice floods; sixth, at cataracts chiefly do we see rivers lowering their beds.

Modifying Circumstances.—First, the older the rock (*cæteris paribus*) the greater we should expect the erosion; second, the position of the strata in respect to the current; third, in similar rocks the amount of erosion would depend considerably—first, upon the chemical composition; second, upon the presence or absence of some peculiar mineral (*ex. gr.* sulphuret, or carbonate of iron); third, upon the relative position of the strata and the current.

In applying these principles and means of discriminating the effects of river action, the author referred to numerous examples of erosion, chiefly in gorges, which he supposed were the result of river action. In gneiss and mica-slate he pointed out eighteen cases, one of which was on Deerfield River, a tributary of the Connecticut in New England, where a gorge, called the Ghor, several hundred feet deep, cuts across mica-slate eight miles, and through a hill 400 or 500 feet high, eighty feet of which has been excavated since the drift period, although, probably, the river does not now lower its bed an inch in 100 years. In another case, he showed that Connecticut River was once 682 feet above its present bed, and that the barrier through which it has worn its way shows marks of river action to that height. He pointed out eleven examples in Silurian and newer sandstone rocks, among which were the Niagara river, that has run back seven miles, Geneva River, and Oak Orchard Creek, that have worn an equal distance in the same rocks essentially. In limestone he quoted ten examples, including the natural bridges of Virginia and Armenia. In unstratified rocks, he referred to twelve examples. He distinctly disclaimed referring all valleys to erosive action of any sort, much less to river action. He contended only, that the gorges to which he referred were thus produced; and that the rock was of enormous magnitude, although but seldom recognised in the writings of geologists. He never had recognized them himself, till by learning how to distinguish river action from all other agencies, he had, as it were, acquired a new set of eyes. The paper closed with the following inferences:—

1. Rivers in general, for the greater part of their course, have ceased to lower their beds, and in many places are filling them up.

2. But wherever there are cataracts, the work of erosion is still going on.

3. In many cases streams have worn backward through a succession of barriers, with intervening basins, and the sum of erosion through these barriers gives us its true amount, rather than the distance worn into the highest one.

4. In some instances the gorges of rivers have been modified by vertical movements, and such cases should be omitted as examples of erosion.

5. We ought to expect not a minute, but only a general resemblance between erosions in different parts of the globe.

6. Yet the facts detailed show nearly the same amount of river erosion in different parts of the globe.

7. The commencement of this action may run back to the time when the rock was consolidated, and was first elevated above the ocean.

8. The regions where these erosions have taken place, may have been once or more beneath the ocean after the work commenced; and the action of the ocean during these vertical movements may have modified the gorges.

9. The period requisite to produce the erosions that have been pointed out, must have been inconceivably long, corresponding to the other facts of geology, but more easily understood by men generally than other evidence derived from organic remains.

On Terraces and Ancient Sea Beaches, especially those on the Connecticut River, and its Tributaries in New England. By the Rev. Edward Hitchcock, *D.D., LL.D., Pres. Amherst Col., and Prof. Geol.*

The classes of terraces and beaches that are formed of loose materials on the globe are three:—1. River terraces. 2. Ancient beaches around ponds and lakes. 3. Ancient sea beaches.

Those described in this paper are all more recent than the drift, though tertiary strata sometimes have a terrace form.

The materials of the post-diluvian terraces are derived—1st, from drift, modified by subsequent aqueous or glacial agency; 2nd, from the erosion of the solid rocks by water and ice.

The sides of the valleys of the rivers of New England, and eminently those of Connecticut River, are composed at the surface as follows, beginning at the top of the hills:—1. Unmodified drift, sometimes pierced by rock in places. 2. The same materials more rounded, yet coarse, and disposed somewhat on a level, especially in the directions of the valley, resembling a modern sea beach. 3. The materials not only rounded, but more or less sorted into layers of gravel and sand, forming fringes on the sides of the valley, and sometimes showing irregular mounds on the top, analogous to moraines. 4. Terraces of rounded and sorted materials, gravel, sand and loam, with level tops. 5. Alluvial meadows, sometimes overflowed.

Means of distinguishing between Drift and Modified Drift.—1. Unmodified drift contains the greatest amount of angular blocks. 2. It is also usually unstratified, though limited spots in it sometimes show lamination; whereas modified drift is usually more or less sorted and stratified. 3. The former conforming to the surface, unless too steep, the latter more or less level-topped.

Character and Position of the Materials.—Usually the highest beach or terrace consists of coarse materials, such as gravel, often very coarse; the next lowest, of coarse and fine sand; the next, of clay; and the lowest, of loam, or a mixture of sand and clay.

Means of distinguishing between Sea Beaches and Terraces.—1. The lowest shelves are usually the most perfect, having an appearance highly artificial, and forming, in fact, the sites of some of our most beautiful villages. 2. As we ascend, the tops of the shelves become more and more broken and irregular. 3. At length we reach rearranged and modified materials, that are not level-topped, except lengthwise of the valley, and are more or less rounded towards the valley: these resemble beaches. 4. But whenever these materials lie along the banks of a river, or the former bed of a river, so that they might have been deposited by that river at a higher level, when its barriers might have been blocked up, they constitute terraces. But when they exist where water, standing at that height, must have communicated with the ocean, they are beaches.

Varieties of River Terraces.—1. *The lateral terrace*, occurring only along the sides of rivers where there are meadows. 2. *The delta terrace*, existing at the mouths of tributaries: generally the delta terraces are fringed by lateral terraces. 3. The *gorge terrace*, found sometimes at both ends of a gorge, cut out by a river. 4. *Glacis terrace*, occurring in the form of a *glacis* in alluvial meadows.

Here the author introduced many details of the terraces in the valley of Connecticut River and its tributaries, where they occur in several basins, which might have been more or less separated since the drift period by gravel or ice; as these wore away, the terraces were produced. Drawings of 154 of these terraces and beaches were exhibited, which the author had measured, mainly with a common levelling instrument, so as to show their height above the rivers and above the ocean. They varied in height above the rivers, from 7 feet to 1882 feet; and above the ocean, from 36 to 2022 feet. These details cannot here be given, but they formed the basis of the following conclusions:—

All the beaches and terraces described in this paper were formed subsequent to the drift, since they lie above the remodified drift and the scratched surfaces of the rocks. The process of rounding, sorting, and re-arranging the materials (drift chiefly) has been going on ever since the drift period. As high as we find such processes to have gone on, we must infer the presence of water. Hence we may be sure, that since the drift period, water has covered the valley of the Connecticut to at least 1200 feet above tide water, since we find distinct beaches (in Shutesbury) at that height; also less modified shelves (in Shutesbury, Pelham, Heath, Washington, and Peru), 1237, 1590, 1658, and 2022 feet. It is the ocean which has covered the greater part of New England since the drift period, for there could be no basins to hold bodies of fresh water at such a height.

To account for the effect by barriers of ice in the region under consideration, would have required the improbable supposition of ice more than 1000 feet thick. The author added various applications of these views to explain the formation of deltas, by a quiet and equable process, free from sudden or paroxysmal efforts and alternating pauses; the occurrence of many lateral terraces at successively lower levels, and the downward slope of these terraces. He allows of paroxysmal movements in the case of Glen Roy, whose phænomena are of a different order, and admits the occasional evidence of floating ice on the irregular mounds of the upper terraces. On the distinction between *drift* and *modified drift*, the author rests some conclusions regarding the lapse of time in the production of particular phænomena. Thus Deerfield River has worn 80 feet into very bad gneiss since the date of the drift; the occurrence of man's remains is limited to the most recent terraces of modern river action; the evidence of modern organic forms on the area of North America is in like manner limited to a period since the drift. Drift is regarded by Prof. Hitchcock as mainly produced under an ocean crowded with great icebergs, derived from corresponding glaciers, which ocean has been gradually withdrawn.

On the Dispersion of Granite Blocks from Ben Cruachan. By William Hopkins, *M.A., F.R.S.*

Remarks on the Central Heat and Density of the Globe, as also the Causes of Volcanic Phænomena. By Stevenson Macadam, *Edinburgh.*

The object of the present paper is to substitute for the commonly received theory of a central heat, one which will demonstrate that a cool external crust is quite compatible with a hot central mass. The author admitting, with geologists in general, the gradual augmentation of heat downward from the surface, finds no necessary connexion between this fact and an internal fluid nucleus, on the ordinary laws which regulate the movement of heat. The view which he proposes is founded upon the assumption by matter when raised in temperature of the peculiar state distinguished as the spheroidal. The author describes the state of knowledge on this subject, for the greater part of which we are indebted to M. Boutigny, who made similar observations upon water and other liquids, as well as on various solids, and arrived at the following conclusions:—

1st. That all bodies can pass into the spheroidal state.

2nd. That the temperature of bodies in the spheroidal state, whatever be the temperature of the vessel which contains them, is invariably inferior to their point of ebullition.

3rd. That there is no contact between bodies in the spheroidal state and the surfaces of the heated vessels on which they are placed.

4th. That bodies in the spheroidal state exhibit absolute reflexion in regard to heat.

Referring to the several modes of experiments from which these conclusions have been derived, the author proceeds to the more immediate object of this paper, viz.

the application of the results of observations on bodies in the spheroidal state to the physical constitution of the globe. He assumes that our globe at the present time consists essentially of three distinct portions :—

1st. A central nucleus in a state of igneous fusion.

2nd. A crust at a comparatively low temperature, the inner side of which is in the spheroidal state.

3rd. A space between the crust and central nucleus, possibly filled with vaporized mineral matter.

The arrangement of these several portions, and their connexion one with another, may be better understood by reference to the constitution of an egg, which bears a strong analogy to it, in point of arrangement, though differing in shape. The yolk of the egg represents the mass of matter in a state of igneous fusion ; the white of the egg the space between the heated mass and the crust ; and the shell of the egg the crust of the globe. When referring to the experiment with the platinum rod, he stated, when it was heated to the required temperature and plunged into water, that the liquid did not touch the rod, it was seemingly repelled by it, and that therefore a space intervened between the rod and the water. In the proposed theory, no difference is made in point of arrangement, merely the substitution of one kind of matter for another. In the experiment, there is the heated rod, the space and the water in the spheroidal state; in the theory of the globe, there is the hot sphere, the space and the matter, the inner surface of which is in the spheroidal state. The crust of the globe under these conditions is influenced by two great forces, viz. gravitation and spheroidal repulsion, the former tending to draw the crust towards the central nucleus, the latter repelling it from it. The crust will therefore have assumed the position where the equilibrium of the two forces is established.

To account for a fluid internal nucleus at a higher temperature than the solid crust of the earth, the author applies that remarkable property which bodies in the spheroidal state present, of total reflexion of the heat incident upon them. The effect of this property must be to make the inner surface of the crust of the globe (which it will be remembered is in the spheroidal state) equivalent in every direction to an immense concave mirror, whose temperature will be very slightly affected by the heat which falls upon it. Such a condition of matters is manifestly compatible with the presence of a much higher temperature at the central nucleus than at the inner surface of the crust, and necessitates a much lower cooling of that crust, and consequently of the nucleus which it robs of heat, than would be the case if the power to reflect heat were not characteristic of the spheroidal condition of matter.

The author then draws attention to the applicability of this hypothesis to explain the *density* of the earth (5·67 according to Baily), which should have been much greater than it is were the globe wholly a mass of liquid and solid matter. When the space between the liquid and solid portions is taken into consideration, there is ample room afforded, by which the density of the globe, as a whole, might be more or less lowered.

In applying the observations upon matter placed in the spheroidal state to explain volcanic phænomena, it is assumed that there exists, contiguous to the volcanoes of our globe (either formed, or in the act of formation), basin-shaped cavities, more or less deeply seated, the under part of which is composed of metallic bodies at a high temperature. Water, either from lakes, &c., at the surface or from subterranean reservoirs, finds access to one of these cavities. The first portion which descends instantly assumes the spheroidal condition; more water enters, and still it is spheroidized ; the stream continues, till in course of time an immense volume of water is there rolling about, but not yet touching the metallic surface ; ultimately, however, the balance is overturned; the liquid, by robbing the metal of a sufficiency of heat, is enabled to touch the metallic basin; an immense volume of water is thereby instantly converted into steam, while at the same moment chemical action on a large scale speedily ensues between the liquid and metallic bodies, the latter action giving rise to heat quite sufficient to fuse large portions of mineral matter. The almost instantaneous generation of large volumes of vapours and gases, and these promptly augmented in bulk for some time, would soon produce a force quite able to raise large tracts of land; and when a vent was made or obtained, would eject the fused mass, as seen to happen from our volcanoes.

On Traces of Ancient Glaciers in Glenmessan. *By* C. Maclaren, *F.R.S.E.*

Certain deposits of clay and gravel in Glenmessan (Argyleshire), resembling the moraines of glaciers, were described in this communication. The valley of Glenmessan is about three miles north-west from Kilmun. The upper part is narrow and steep in the sides, and bounded on the east and west by mountains probably 1500 feet in height. Two ridges of clay and gravel, lying side by side, cross this part of the valley at right angles to its length, the one 77, the other 40 feet in height above its bottom. The northern one is about 350 feet long, the southern and higher 320. Both seem at first to have extended completely across the valley, the river Messan having subsequently cut a narrow passage for itself between their east ends and the rock. The two ridges are similar in shape, and both are covered with herbage. Externally, each resembles the roof of a long thatched barn or row of cottages. At the truncated ends, the materials are seen to consist of clay and gravel with a few considerable blocks of stone intermingled, and without any apparent trace of stratification. Below these ridges the valley widens, and its bottom assumes the form of an undulating plain, on the surface of which, half a mile southward, four detached eminences present themselves. Two of them are sharp ridges 200 feet long and 30 feet high, and stand transversely to the direction of the valley; the other two are in the form of flattish mounds, from 20 to 30 feet high, and are placed obliquely to the line of the valley. Several large boulders rest on the surface of these ridges and mounds, and their materials, position and appearance suggest the idea that they are remnants of terminal moraines formed during the gradual and final retreat of the glaciers from the valleys of the Grampians. It is confirmatory of this conclusion, that the rocks on the sides of the valley exhibit most distinct marks of powerful abrasion. Sometimes they present a smooth and a rough side, the former always facing the head, the latter the foot of the valley; sometimes they are cut into vertical planes 50 or 100 feet in height. These planes run across the laminæ of the slate, are as smooth as a wall of dressed masonry, and at many parts show well-marked *horizontal striæ* and *groovings*, such as are seen on rocks in contact with the sides of glaciers in the Alps. It seems scarcely possible to account for the abraded and striated surfaces of the rocks and ridges and mounds of gravel, except upon the hypothesis that they have been produced by glaciers at an ancient epoch.

Parallel between the Superficial Deposits of the Basin of Switzerland and those of the Valley of the Po in Piedmont. *By* Dr. Charles Martins *and* B. Gastaldi.

1. *Ancient Moraines* (part of the Terrain Cataclystique of Necker).—In proceeding from the higher to the lower ground in both basins, we find great accumulations in the form of ridges, composed of erratic blocks, sand, angular gravel, of striated pebbles, derived from the Alps, and of clay (lehm), all mixed together, and without any trace of stratification, indicating the long existence of glaciers at the localities. In Switzerland, the towns of Berne, Zurich, Sursee, &c. are built on moraines; also the moraine of Mont Sion, between Geneva and Annecy, and finally the great moraine of the ancient glacier of the Rhone, which extends from the Fort de l'Ecluse to Soleure, along the eastern declivity of Jura. In Piedmont there is the moraine of Rivolri at the opening of the valley of Susa; that of Ivrea formed the ancient glacier, which, descending from Mont Blanc, Mont Rose, and the mountain of Coyne, filled the valley of Aoste, and extended in the plain as far as Calosso.

2. *Scattered Erratic Formation* (part of the Terrain Cataclystique of Necker).—It is composed of gigantic angular blocks brought from the Alps, of gravel composed of striated angular pebbles, and of lehm or glacier mud. These materials have been brought by the glaciers at the period of their greatest extension, and show that they had not remained long at the place where the materials are found. In Piedmont the scattered erratic formation forms a band round the moraines, and is seen on the hill of Superga. In Switzerland it covers all the plain from the lake of Geneva to the lake of Constance, and penetrates into the valley of Jura.

3. *Glacier Diluvium.*—This great formation is formed of rolled and rounded

pebbles, but never striated, coming from the Alps, sometimes stratified, but without fossils. In Switzerland this formation covers a great part of the basin, and it is of great depth round Geneva and Berne. We think it is owing to the fusion of glaciers at the period of their oscillations. The glaciers of the Alps, those of Grindelwald, of Bosson, and of the Aar, produce a similar diluvinm at present, but upon a small scale.

4. *Ancient Alluvium with bones of Pachydermata.*—In the two countries this alluvium is composed of rolled pebbles of moderate size, which do not come from the Alps situated in front. There are found in it bones of the *Elephas Primigenius*, (*Mastodon angustidens*), *Rhinoceros Tichorinus*, *Bos Priscus*, *Cervus Euryceros*, &c. This formation is altogether aqueous, and has nothing in common with those of the glacial epoch. In Switzerland this alluvinm rests on the miocene molasse, and in Piedmont on marine pliocene beds.

If a parallel is attempted to be drawn between these formations and those of Scandinavia, Scotland, and North America, it should not be forgotten, that since the glacial epoch the coasts of these countries have been submerged beneath the sea and again raised above it, from which it follows that very recent marine deposits would take place, contemporary with or posterior to the scattered erratics.

On certain extraordinary Peculiarities of Structure in the more Ancient Ganoids. By HUGH MILLER, *Edinburgh.*

Mr. Miller began by stating, that it was his purpose to introduce to the notice of the Association in his paper a curious suite of fossils from the lower old red sandstone of Scotland, many of which were still without duplicate in the public museums of the empire, and but imperfectly represented in those of Russia. In one important respect there attached to them a peculiar interest. They belonged to the earliest animals of the vertebral division, of which our knowledge is not rather inferential than direct. The most ancient fishes known to the geologist are the Placoids of the Silurian system; the next most ancient, the Placoids and Ganoids of the lower old red sandstone. Of the Placoids, however, little comparatively could be known; from their perishable cartilaginous structure, an entire species might be represented by but a few spines, teeth, or shagreen points; whereas the Ganoids, from the peculiar armature of solid bone in which they were enveloped, continued to exist, not as mere ichthyic fragments, but as ichthyolites. Hence our absolute knowledge of the ancient forms and mechanism of ichthyic life was mainly to be derived from the study of the first Ganoids. In illustration of this remark, Mr. Miller submitted to the meeting two sets of specimens,—the one consisting of minute toothed ichthyodorulites,—those of the *Homocanthus arcuatus*, a Placoid of the lower old red sandstone, and a larger spine belonging to another old red Placoid, the *Haplacanthus Marginalis*; while in the other set, consisting of ganoidal remains, there occurred a specimen—specially referred to by Agassiz in his great work—which exhibited a considerable part of an old red Ganoid,—the *Osteolepis Microlepidotus*. The *Homocanthus* and *Haplacanthus*, which, though previously known in the old red of Russia, had been only recently added to the fossil fauna of Scotland by the researches of Mr. Robert Dick of Thurso, were represented in the specimens by mere spines; whereas the *Osteolepis* was in such a state of keeping, that Agassiz, from the very specimen before the Association, had determined that the creature was possessed of the sense of smell,—nay, he had even detected it in a certain peculiarity in the structure of the nostrils, restricted in the present time to those of a single fish,—the *Lepidosteus* of the American rivers. Under one occipital plate on the table there might be seen the remains of not only the upper part of the brain-pan, but also marked indications of auricular chambers, resembling those of the sharks and of some of the reptiles. Some of the other specimens exhibited the openings through which the eyes had once looked out. In a Dura Den specimen of *Pterichthys*,—the property of Mrs. Bonar of Cupar-Fife,—the very capsules of the eyes were preserved; and we had thus evidence of at least the three senses with which these earliest of the Ganoids took note, in an incalculably remote period, of the sights, sounds and odours of the material world.

There was a peculiarity in the mouths of some of the existing Placoids, to which Mr. Miller begged leave to call the attention of the Association. In some of the sharks we find teeth taking exactly the form of the external shagreen. This is the case in the angel fish (*Squatina*), the whole of whose palate within the teeth proper is covered by a shagreen undistinguishable from that which covers its back. The same peculiarity occurs, too, in the mouth of the Port Jackson shark (*Cestracion*), immediately within the pavement teeth. Now, in the palate of the Dipterus, we find, apparently on a similar principle, the dermal enamel of the external plates and scales of the creature completely reproduced. The *skin* within the mouth, if one may so speak, completely corresponds with the *skin* outside. We find it bearing the same rich gloss, and punctulated by the same thickly-set microscopic tubes. There occurs what seems to be a similar reproduction of dermal peculiarities within the mouth of the Asterolepis. Immediately behind its reptile teeth we find the surface roughened on a base of bone with osseous tubercles, that in some places seem elongated into squat teeth, and in some assume the characteristic stellar shape, but which present generally the appearance exhibited by the tubercles which fret the external plates of the cranium, especially as these appeared in the young animal, and ere they attained to their normal star-like form. This tendency of tubercles to assume the form of teeth in the ancient Ganoids, and of teeth to assume in some of the existing Placoids the appearance of shagreen, seemed a curious and not uninstructive circumstance; and threw light on some otherwise puzzling peculiarities in the dental structure of ichthyolites, such as the Coccosteus and Asterolepis. The teeth of the former, especially those placed so uniquely in the symphysis, and all the ichthyic teeth of the latter, seem to be nearly as much mere continuations of the osseous plates on which they are based, as the external tubercles of these same plates. A very different state of things obtains among our ordinary fishes of the present time;—the teeth are of a different formation from the bone on which they rest; but be it remembered, that as in the existing Placoids, teeth and shagreen are alike of dermal origin, so in not a few of the ancient Ganoids teeth and tubercles were alike of dermo-osseous origin. The plates on which they grew acted as jaws or portions of jaws, but they also represented skin, and differed very materially, in consequence, from the skin-covered jaws of the ordinary fishes. Mr. Miller had lately succeeded, he said, in procuring a cerebral plate of the Asterolepis, that presented one of the sockets in which the under jaw of that animal had acted, and which in one respect resembled the sockets of the jaw of the Lepidosteus of America,—one of the few reptile fish which still continue to exist. It contained two antagonistic processes, placed on opposite sides of the socket; on one of which the condyles had acted every time the jaw opened or shut; whereas the other merely served as a check, which prevented the jaw from opening beyond a certain width. In the under jaw of a large Thurso ichthyolite of the reptile family, still unnamed and undescribed, and some of whose internal bones could not at the present stage be distinguished from those of Asterolepis, the under jaw seemed to consist of five pieces,—first of a central key, like that of the Dipterus in its fœtal state; next, of two side bones, that were united to it; and lastly, of two slender bones, that seemed to occupy a similar place in the under jaw of this fish that the intermaxillary bones do in the upper jaws of most other fishes.

Mr. Miller next proceeded to describe the under jaw of the Coccosteus as one of the most extraordinary of the period, or perhaps of any period. It consisted of two bones, one on each side, which were furnished each with its group of from six to eight teeth, placed exactly where in the human subject the molars occur. And these groups seem to have acted against corresponding groups in the upper jaw. But at right angles with these molar groups, exactly in the medial symphysis, there was another group of teeth from three to five in number; and these could not have acted against teeth placed in the upper jaw, but were directly opposed,—the terminal group in the one bone of the nether jaw to the terminal group in the other bone. Mr. Miller stated, that about nine years ago he had called the attention of palæontologists to something very peculiar in the jaws of the Coccosteus, and had solicited inquiry respecting them; but the restoration of Agassiz, who had been misled by imperfect specimens, several of them derived from Mr. Miller's own collection, had been regarded as settling the point the other way; and it was only during the last season that Mr. Miller was enabled to demonstrate, from newly-found specimens, that the peculiarity had really existed. One of these specimens he owed to a lady of Cromarty (Mrs. James Hill), an intelligent geologist and successful collector. The teeth of the Coccosteus, viewed as prepared transparencies in the microscope, were singularly instructive and beautiful. They were formed of true bone, and thickly speckled over towards their bases with the characteristic life points, whereas towards the apex they abounded in anastomosing canals, which, throwing out to the sides and point of each tooth numerous minute parallel branches, gave to the bone in these parts a structure very much approximating to that of ivory. It would seem as if in these ancient teeth we had caught bone passing into that finer substance of which the teeth of all the higher vertebrata are composed. From the character of the surface of the jaw of Coccosteus on both sides, it seems to have been covered, said Mr. Miller, like jaws of the more modern type, by integuments. It was altogether an internal, not a dermal bone, and was probably the oldest internal bone that had as yet presented its structure to the microscope. And it is surely not uninteresting to see the osseous substance,—destined to perform so important a part in the animal œconomy,—presenting in this early age its distinguishing characteristics, especially those numerous life-points from which its organization begins, and which still remain open as the sheltering cells in which vitality should reside. Was it impossible, in the nature of things, that life should be equally diffused over hard and rigid earth, built up into this new animal substance, bone? and was it therefore merely thickly sown over it in hollow microscopic points? Is bone rather strongly *garrisoned* by vitality than itself vital?

Mr. Miller then went on to exhibit several specimens of a well-marked though doubtfully interpreted bone, which, in all the ordinary fishes, and in almost all the Ganoids, forms the largest and most important part of the scapular belt or ring, and which appears first in the lower old red sandstone. The gill-cover also appears in the same deposits for the first time; and Mr. Miller went on to show how they are necessarily connected in the scheme of creation, and that the one of necessity accompanies the other. At the close of his paper, Mr. Miller exhibited a set of the remains of *Asterolepis*, and made large acknowledgments to Mr. Robert Dick of Thurso, to whom he owed all the finer specimens, and whose labours had done more to introduce this fish to the palæontologist than those of any other man, whether in Russia or our own country.

On peculiar scratched Pebbles and Fossil Specimens from the Boulder Clay, and on Chalk Flints and Oolitic Fossils from the Boulder Clay in Caithness. By HUGH MILLER, *Edinburgh.*

Mr. Miller began by stating that, when examining, a good many years ago, the boulder clay of Ross and Cromarty, in the vain hope, as it proved, of finding in it organic remains belonging to itself, he was struck by a peculiarity in the dressing of the smaller pebbles which he had not seen described or adverted to by any writer on the subject. He was aware that many of the larger boulders which it contains are scratched and polished like the rocks on which it rests, but he was not prepared to find the smaller pebbles scratched scarce less characteristically than the larger ones in every case in which they were not of too coarse a grain to retain the markings, or of too hard a quality to receive them originally. If of limestone, or of a coherent shale, or of a close, finely-grained sandstone, or of a yielding trap, they are scratched and polished invariably on one, most commonly on both their sides; and it is a noticeable circumstance, that the lines of the scratchings occur, in at least four cases out of every five, in the lines of their longer axes. When decidedly oblong or spindle-shaped the scratchings run lengthwise, preserving in most cases on the under and upper sides a parallelism singularly exact; whereas when of a broader form, so that the length and breadth nearly approximate,—though the lines generally find out the longer axes and run in that direction,—they are less exact in their parallelism, and are occasionally traversed by cross furrows. Of such general occurrence is this longitudinal lining on the softer and finer-grained pebbles of the boulder clay, that it forms the special characteristic of the deposit on which the geologist can with the greatest certainty rely for purposes of identification.

Though in many cases, as on the western coasts of the mainland of Scotland, in the islands of Skye and Rum, with several of the other Hebrides, in Sutherlandshire, and in various localities in the neighbourhood of Edinburgh, Mr. M. had found the scratched and polished surfaces dissociated from the boulder clay, in no instance had he ever found the boulder clay, if not, as in the case of our common brick clays, a re-formation, dissociated from the scratchings and polishings. Every rock on which the clay rests *in situ*, if of a quality capable of bearing these markings, is seen when newly uncovered to bear them. The more impressible pebbles and boulders, too, from top to bottom of the deposit, are similarly lined and polished; and both rock and pebbles, when first laid bare, are as sharp and well-defined in their grooves and lines, even to the slightest scratch, as if the work of wearing them down had been performed but a day previous; though when subjected to the weathering influences, the exposure of a few months, or at most of a few years, serves to efface the marks.

Now, from these data the inference seems unavoidable, first, that the rock on which the clay rests was scratched and polished either at the time when it was receiving its first coating of the clay, or so immediately before, that the markings were not in the slightest degree effaced when it was covered up; and, second, as the pebbles in the entire thickness of the deposit are also scratched and polished, that it was not before, but at the time; seeing that the process of scratching and polishing went on during the entire period of the formation, beginning with its lower layers, and not terminating until its uppermost were cast down. The dressed surfaces and the boulder clay are contemporary phænomena. Further, it is a significant circumstance that small pebbles of only a few ounces are scarce less distinctly marked than the larger stones; it is further not less significant, and bears apparently in the same line, that in the preponderating majority of cases, at least, the smaller and flatter stones are marked in the lines of their longer axes.

The agent which produced such effects could not have been simply water, whether impelled by currents or by waves. No force of water could have scarred with such distinct, well-marked lines, such small stones. The blacksmith, let him use what strength of arm he may, cannot bring his file to bear upon a minute pin or nail, until he has first locked it fast in his vice, and then, though not before, his tool bears upon it, and scratches it as deeply as if it were a beam of iron of a ton weight. The smaller stones must have been fastened ere they could have been scratched. Even, however, if the force of water could have scratched and furrowed them, it would not have scratched and furrowed them longitudinally, but across. Stones, when carried down a stream, or propelled upwards on a beach by the waves, present always their broader and longer surfaces to the moving force; and the broader and longer these surfaces are, the further are the stones propelled. They are not *launched* forwards, as a sailor would say, *end-on*, but *tumbled* forwards *broadside*. They come rolling down a river in flood, or upwards on the shore in a time of tempest, as a hogshead rolls down a declivity. In the boulder clay, on the contrary, most of the pebbles that bear marks of their transport at all were not *rolled* but *slidden* forward in the line of their longer axes. They were *launched*, as ships are launched in the line of least resistance, or as an arrow or javelin is sent in its course through the air. Mere water could not have been the agent here; nor yet an eruption of mud propelled along the surface by some wave of translation produced by the sudden upheaval of the bottom or shore of the sea.

When a large raft of wood, floated down a river, grates heavily over some shallow bank of gravel and pebbles resting on the rock beneath, it communicates motion, not of the rolling, but of the launching character, to the flatter stones with which it comes in contact. It slides ponderously over them, and they, with a speed diminished in ratio from that of the moving power, in proportion to the degree of friction below or around, slide over the stones or rock immediately beneath. And thus, to borrow the terminology of our Scotch law courts, they are converted at once into *scratchers* and *scratchees*. They are scratched by the grating raft, which of course moves quicker than they move; and they scratch in turn the solid mass or imbedded fragments along which they are launched. A vast number of rafts dropping down some river from day to day and year to year, and always grating along the same ledges of sandstone, trap or shale, would at length very considerably wear them down; even the continual tread of human feet in a crowded thoroughfare soon wears down the trap or sandstone pavement and converts the solid stone into an impalpable mud; and the materials of the waste, more or less argillaceous according to the quality of the rock, would be deposited by the current in the pools and gentler reaches of the stream.

Further, the colour of the mud or clay would correspond, as in the thoroughfare or public road, with the colour of the rocks or stones which had been ground down to form it. Now for rafts of wood we have but to substitute rafts of ice, a submerged land, covered by many fathoms of sea, for the shallows of the river, and some powerful ocean-current, such as the Gulf or Arctic Stream, for the river itself, and we at once arrive at a theory of the boulder clay and its origin, which seems to account more satisfactorily for the various phænomena of the deposit than any of the others. It is a theory that plays so easily along the intricacies of the various wards of the locked mystery, that Mr. M. had come to regard it as the true key.

There is a peculiar kind of clay which forms on the surface of a hearthstone or piece of pavement under the hands of a mason's labourer engaged in rubbing it smooth with water and a polisher of gritty sandstone. It varies in quality and colour with the character of the stone; a flag of Arbroath pavement yields a bluish-coloured clay; a flag of the lower old red sandstone, a reddish-coloured clay; a flag of Sutherlandshire oolite or of the upper old red of Moray or Fife, a pale yellowish clay. The polishing process is a process which produces clay out of stones as various in tint as the colouring of the various stones which yield it; and in almost every instance does the clay thus formed resemble some known variety of the boulder clay. The boulder clay, in the great majority of cases, is in colour and quality just such a clay as might be produced by this recipe of the mason's labourer from the rocks on which it rests. The *red* sandstone rocks of Cromarty, Moray, and Ross, are covered by *red* boulder clay, and a similar *red* boulder clay overlies the *red* sandstone rocks of Forfarshire. Again, in the middle and north-western districts of Caithness, where the prevailing flagstones render the average tint of the rock a sombre gray, the boulder clay assumes, as in the neighbourhood of Wick and Thurso, the leaden colour of the bed which it overlies; while over the coal-measures of the south of Scotland, as in East and West Lothian and around Edinburgh, it is of a bluish-black tint—exactly the colour which might be anticipated on the *polishing* theory from the large mixtures of shale-beds, coal-seams and trap rocks which occur amid the prevailing light-hued sandstones of the deposits beneath.

Another circumstance specially worthy of remark, is the general direction of the grooves and scratchings on the dressed surfaces of the rocks *in situ*. With slight divergences in various localities towards the south or north, they run generally from west to east; and this westerly direction seems to be exactly that, which, reasoning from the permanent phænomena of nature, might be premised. There must have been trade-winds in every period of the world's history in which the earth revolved from east to west on its axis, and with trade-winds the accompanying drift-current; and of consequence, especially ever since the existence of a great western continent, stretching far from south to north, there must have been also a Gulf-stream. The water heaped up against the coasts of this western continent at the equator by the drift current ever flowing westwards, must have been always, as now, returning eastwards in the temperate zone, to preserve the general level of the ocean's surface. Ever, too, since winter took its place among the seasons there must have been an *Arctic* current. The ice and snows of the higher latitudes that accumulated during the winter must have again melted in spring and early summer, and a current must in consequence have set in as the seasons of thaw came on, just as we now see such a current setting in, in those seasons in both hemispheres which bears the ice of the Antarctic circle far towards the north, and the ice of the Arctic circle far towards the south. The point at which, in the existing state of things, the Gulf-stream and the Arctic current come in contact, is that occupied by the great bank of Newfoundland, and by some the very existence of the bank has been attributed to their junction and to the vast accumulations of gravel and stone cast down year after year where these two great tides meet and jostle. That the point where the Gulf and Arctic currents come in contact should now lie so far to the west, is a consequence of the present disposition of the Arctic and western continents—perhaps, also, of the present position of the magnetic pole. A different place and disposition would give a different point of meeting, and it is as little improbable that they should have met in the remote past some two or three hundred miles to the west of what is now Scotland, as that in the existing period they should meet some two or three hundred miles to the east of what is now Newfoundland. The northern current would be deflected by the more powerful Gulf-stream into an easterly course, and would go sweeping over the submerged land in the direction indicated by the grooves and scratches, bearing with it every spring its many thousand gigantic icebergs, and its fields of sheet ice many hundred square miles in extent. And these, by grinding heavily along the buried surface, would gradually wear down the upper strata of the softer formations, leaving the clay which they had thus formed to be deposited over, and a little to the east of the rocks that had produced it. It is in further accordance with the theory, that in this part of the country the deeper deposits of the boulder clay occur on the eastern line of coast.

Mr. Miller, at the close of his paper, exhibited a collection of Boreal shells, with fragments of oolitic fossils, chalk, and chalk flints from the boulder clay of Caithness, and referred to the meritorious labours of Mr. Robert Dick of Thurso, the original discoverer in that county of the oolitic fossils and the chalk, and the collector of most of the shells.

On the Discovery of Palæozoic Fossils in the crystalline chain of the Forez in France, and on lines of dislocation between the Lower and Upper Carboniferous Deposits of France and Germany. By Sir RODERICK IMPEY MURCHISON, *President of the Section.*

During a visit this summer to the baths of Vichy, in the department of the Allier (France), the author had great pleasure in revisiting the tertiary lacustrine deposits of the Limagne d'Auvergne, which occupy the low and undulating country between the mountains of the Puy de Dôme on the west, and the Forez on the east. He was also led to pay some attention to the structure and age of the last-mentioned crystalline chains. No French geologist had noted the occurrence of a fossil in them, but on his first visit to the banks of the Sichon, a tributary of the Allier, Sir Roderick discovered that certain peculiar and hard grits of the tract contained encrinites, and in a second examination he further detected in the schists a few remains of bivalves, univalves, trilobites, and corals. The form of one of the best preserved of these bodies has a resemblance to a Silurian Leptæna, or Chonetes; but the occurrence of a Productus of a form very nearly allied to *P. fimbriatus* (Sow.), (identified by M. de Verneuil), leaves no doubt that the deposit belongs to the lower part of the carboniferous epoch. Another fossil resembles the palæozoic Cypricardia, but approaches nearest to the *Pleurophorus costatus* (King) of the Permian system. A portion of the head of a Trilobite belongs to the genus *Phillipsia* (Portlock), so characteristic of the British mountain limestone; and thus the age of these rocks is determined. In the geological map of France these strata are placed as old transition and crystalline; and for such, or for the lowest Silurian rocks, they might unquestionably very well have passed, if lithological structure and aspect had alone determined their age.

The slaty schists, porphyritic grits and other varieties of the sedimentary portion of these rocks, as well as the various porphyries by which they are penetrated, are indeed well depicted by M. Dufrenoy in the 'Mémoires pour servir'; and the very locality in question was specially described by M. Visquesnel*. These authors having never observed fossils, and judging from mineral character only, naturally assigned too high an antiquity to the rock. Sir Roderick having ascended the Sichon from the castle of Busset for some leagues to near its source (Ferrières), found that owing to the eruptions of the porphyry (often very granitiform) the schistose rocky grits were usually so metamorphosed and dislocated, that he was wholly unable to attempt to define anything like a descending series from the above-mentioned lower carboniferous rocks to others which might be considered Devonian and Silurian. Besides fossils, he observed two thin bands of scaly, hard, subcrystalline limestone, associated with the schists of Cusset. In truth, the limestones increase in volume near Ferrières, where they are in the state of marble, of grayish, reddish, veined, and even of white colours. In order to satisfy himself whether the loftier and bolder portion of the chain of the Forez belonged to the same class of rocks as those he had examined in its lower and northern end, Sir Roderick made an excursion to Thiers. There he recognized precisely the same phænomena (but on a grander scale, and in

* Sur les environs de Vichy, Bull. Soc. Géol. France, vol. iv. 1st series, p. 145.

broken and picturesque gorges) which he had witnessed along the banks of the Sichon and around the castle of Busset.

Towering masses of dark gray and reddish quartziferous porphyry, with veinstones of quartz (occasionally very like granite), have there penetrated in every direction the mutilated schists and grits, which can notwithstanding be recognized as fragments of the very same strata as those of the Sichon; although the graywacke schist has in many parts become a crystalline, amphibolic schist, and the grit has been converted into quartz rock.

In examining the granitic and schistose chain of the west of the Limagne, the author was disposed to think that parts of it (particularly near Ebreuil) will eventually be assigned to the palæozoic deposits also; but the engagement to return to the meeting of the British Association prevented the completion of researches to establish this point.

In the mean time he calls attention to the importance of the discovery of Lower Carboniferous fossils in rocks of so crystalline a nature as those of the chain of the Forez. It has long been known that small but true coal-fields occur in many parts of Central France, some of which the author described long ago in conjunction with Sir C. Lyell; but at that time no geologist could have dared to think that any portion of the crystalline or slaty schists of the adjacent mountains could also pertain to the Carboniferous system. Yet such is the fact. For independent of this discovery in the chain of the Forez, M. de Verneuil had observed, that the "Producti" and other fossils found at Regny, near Roanne, in a system of hills parallel to the Forez, and of very similar composition, unquestionably placed such rocks in the Carboniferous or Mountain Limestone group of the Carboniferous system. These facts, as well as the occurrence of numerous true carboniferous Producti at Sablé in Britanny, where these rocks are unconformable to overlying coal-fields, have, it is understood, induced M. Elie de Beaumont to renounce an opinion which he formerly entertained, in considering the inclined formations as belonging to a different natural group to those which are horizontal. In their exploration of the palæozoic rocks of Germany, Professor Sedgwick and Sir R. Murchison long ago indicated that the true carboniferous limestone with large Producti, near Hof, had been raised up conformably with underlying Devonian and Silurian rocks (see Trans. Geol. Soc. New Ser. vol. vi. p. 298. pl. 23. f. 15), *the adjacent Bohemian coal being horizontal.* Although this indisputable fact, since confirmed by a subsequent visit to the tract, was at the time received incredulously, it is now sustained by independent evidence in France. The conclusion, therefore, is, that very powerful continental dislocations have operated both in Germany and France, after the close of the deposits of the mountain or carboniferous limestone, and before the accumulation of the great overlying coal-fields. Seeing the facts in this light, and M. Elie de Beaumont having now introduced a new epoch of disturbance into his classification, Sir Roderick considered this subject to be one eminently meriting discussion at a meeting of the British Association, in order to test the application of such periods of dislocation to the carboniferous series of England, Scotland and Ireland, it being understood that in many tracts of Britain no apparent unconformability had yet been observed between the carboniferous limestone and the overlying coal-fields. The existence of such dislocations in some regions, and their non-occurrence in others, bear out, he maintains, the view he has long contended for, that all *dislocations are local only* when viewed in a general sense. Phænomena, for example, which are true in France and Central Germany, do not apply to Russia or the British Isles.

Review of the Labours of M. Barrande *in preparing his important work "The Silurian System of Bohemia." By* Sir RODERICK IMPEY MURCHISON, *G.C.St.S., F.R.S. President of the Section.*

The Silurian rocks of Bohemia offer, on the whole, a striking analogy to those of the classical region or type of the same deposits in England and Wales. The same two chief divisions, though easily distinguished from each other, as in the British Isles, by local circumstances, are in the one country, as in the other, so bound up together, as in reality to constitute, in the opinion of M. Barrande, one inseparable 'system' only. The lower Silurian rocks reposing upon granite and gneiss, are composed of powerful masses of semi-crystalline schist (a great thickness of the lowest deposits being azoic or without fossils), covered by other masses of argillaceous schist, conglomerates and quartzose rocks (quartzites), alternating with each other and occasionally swelled out by contemporaneous igneous rocks. Whilst little or no calcareous matter occurs in the lower division, limestone constitutes nearly the whole of the upper Silurian rocks, argillaceous schists appearing principally at their base and summit. Notwithstanding this contrast in the petrographical characters of the two divisions, it is the decided conviction of M. Barrande, that *they form but one uninterrupted sequence of deposits*; for all the formations exhibit a conformable stratification throughout their succession, and the two halves of the basin are arranged with a synclinal inclination in reference to its longitudinal or major axis.

The palæontological distinctions between the two divisions are scarcely less striking; since in each we find a special fauna which alone distinguishes them sufficiently if compared in their general character. M. Barrande has, however, discovered a sufficient number of species, common to his upper and lower Silurian rocks, to prove, that in Bohemia they are as much *united in one natural system as in England*. He estimates that already 40 to 50 species (possibly many more) are common to the two divisions.

The manner in which the species common to the upper and lower Silurian rocks occur, has occasioned M. Barrande to point out a new and remarkable fact. At about 3600 feet below the limit between the upper and lower Silurian rocks, and therefore at a considerable depth in that part of the lower division, which he says represents both the Caradoc and Llandeilo formations of Britain, he discovered a mass of peculiar strata regularly and conformably intercalated in the vertical series. They differ entirely in their lithological nature and in their fauna from those of the lower Silurian division, in which they are enclosed. These beds, having a geographical range of from 2000 to 3000 feet only, and parallel to the axis of the basin, reoccur symmetrically on each side of that axis; so that they constitute a large, lenticular-shaped mass, whose maximum thickness is about 300 feet. Now, the rocks which compose these strata are exactly the same as those which form the base of the upper Silurian division; *i. e.* black schists with graptolites, alternating with trappæan layers, and containing many spheroidal concretions of black limestone. Further, all the fossils of this mass are identical with those which characterize the base of the upper division, and are almost entirely the species common to the two divisions. None of the forms which really characterize the lower division are present, though that fauna is abundantly developed *both above and below* this interpolated mass. It also appears, that no mixture has taken place between the animals belonging to the insulated mass and those of the inferior division which surround it.

M. Barrande has given the name of "colony" to the peculiar fossils thus buried at great depths in the lower Silurian rocks—a denomination which at once indicates his opinion of their origin. He conceives, that the animals deposited in the interpolated graptolite schists have been derived from a centre foreign to the Silurian basin of Bohemia. Having existed for a lapse of time in seas lying to the N.W., these animals were, he conceives, introduced into Bohemia by favouring circumstances, such as currents carrying with them calcareous mud. When these conditions ceased, the associated animals perished. Their remains were then covered by deposits of an entirely different nature, enclosing the relics of creatures inhabiting the surrounding Bohemian sea, whose aborigines regained possession of all the area, from part of which they had been so long excluded. After a lapse of time represented by 3600 feet of marine deposit, this ancient or lower Silurian fauna was itself entirely destroyed by sudden eruptions of igneous matter which spread out over the tract. The sea of Bohemia being deserted after this *local* revolution, was re-inhabited by a new immigration, proceeding from the same centre of creation which had furnished the *colonies* of a former æra. But on this occasion the new comers occupied all the Silurian sea in Bohemia, and continued to propagate during the whole of the deposit of the upper Silurian rocks; constituting a very emblematic and separate fauna, in harmony with the corresponding divisions of England, Sweden, &c.*.

The fact of the Silurian *colonies* of Bohemia leads to the belief, that in the older

* See the final views of the classification of the Silurian rocks, by Murchison, Journ. Geol. Soc. Lond., vol. i. p. 467; and especially in the work Russia in Europe, vol. i. chap. 1.

palæozoic times there was a coexistence of different centres of creation, analogous to those with which we are acquainted in the present day. Geological science ought therefore (as M. Barrande has well said) to lay due stress on this coexistence of different creatures, in comparing formations more or less typified by analogous faunas, but separated by notable geographical spaces.

The simple form of the Silurian basin of Bohemia, the regularity, in a horizontal sense, of the concentric deposits of which it is composed, and the order of their superposition when viewed vertically, have enabled M. Barrande to recognise in the clearest manner, the order of succession of different partial faunas which characterize each of the stages of his basin.

The fauna, which in Bohemia he names 'primordial', is composed almost entirely of Trilobites (*Paradoxides, Conocephalus, Ellipsocephalus, Sao*, &c.), an Orthis, and two species of Cystideæ. The trilobites which then predominated are all distinguished by the common character of the great development of the *thorax*, as contrasted with a very slender *pygidium*. This primordial fauna of Bohemia is represented, according to M. Barrande, in our country by the beds containing the Olenus in North Wales, and near the south-western extremity of the Malvern Hills, where those minute trilobites were discovered in lower Silurian rocks by Professor John Phillips. Now, the Olenus is found with species of *Lingula* in the lowest fossiliferous beds of Britain, associated with trappæan ashes and with the *Paradoxides*, &c. Again, the same genera, *Olenus* and *Paradoxides*, reoccur in the lowest fossiliferous formations of Scandinavia, as well as in Britain and Bohemia. Thus, in the North of Europe, three countries, remote from each other, confirm the denomination of primordial given by M. Barrande, and sustain the published opinion of Sir Roderick Murchison, that the *lower Silurian rocks contained the first created animals*, which we can now recognize or describe*.

The Silurian basin of Bohemia explored by M. Barrande during more than twelve years, and at a considerable expense, exhibits a richness of fossils of the older rocks hitherto quite unknown. That author estimates 1100 species at least; whilst the distinct forms now assembled in his own cabinet, and the following list, indicate the manner in which the different classes are represented.

Crustaceans, nearly all Trilobites	(about)	250
Cephalopods	,,	250
Pteropods	,,	25
Gasteropods	,,	140
Acephalous Mollusks	,,	140
Brachiopods	,,	200
Echinoderms, Zoophytes, &c.	,,	100
	Total fauna (about)	1105

The state of preservation of these fossils, and the great number of specimens of each species collected by M. Barrande, have enabled him to throw much new light on the fauna of *the most ancient* (*recognizable*) *inhabitants of our globe*; and thus zoology will not less profit than geology by his labours.

At the preceding meeting of the British Association held at Birmingham, Sir Roderick Murchison communicated one of the facts the least expected in the natural history of Trilobites. M. Barrande had then established the metamorphosis of three or four species of that family, and had sent one of the plates of his work in which were figured twenty distinct forms, all belonging to one species, the *Sao hirsuta*—from the embryo to the completion of the individual†. A similar mode of transformation has now been recognized by M. Barrande in nineteen forms of Bohemian trilobites, thus enabling the author to reduce considerably the number of supposed species‡.

* See chap. i. of Russia and the Ural Mountains, 1845, and Journ. Geol. Soc. Lond. 1845.

† See the commendation then bestowed on M. Barrande's discoveries by the eminent naturalist M. Milne Edwards. Report of the Brit. Assoc. 1849, Transactions of the Sections, p. 59.

‡ The fact of the metamorphosis of a British trilobite, the *Ogygia Portlocki*, has since been recognized by Mr. J. W. Salter.

The results of the researches of M. Barrande will soon be published *in extenso*; and Sir Roderick Murchison concluded his review of them by exhibiting several plates of the forthcoming work, with the accuracy of which he had made himself well acquainted by visits to Bohemia, and which he had no doubt would take its place as one of the most remarkable geological productions of our century.

Notes on the Geology of the Southern Extremity of Cantyre, Argyleshire. By James Nicol, *F.R.S.E., F.G.S., Professor of Geology, Queen's College, Cork.*

The peninsula of Cantyre is very remarkable both for its geographical and geological peculiarities. Its general direction from north to south differs widely from the usual N.E. to S.W. range of the Scottish mountains. At Tarbet, it is connected with the mainland by an isthmus only a mile in breadth, and a depression of the land for a few feet would convert it into several detached islands. The great formation of mica-slate which runs nearly S.W. along the border of the Grampians, through the whole of Scotland, in this place seems to turn to the south; whilst the clay-slate resting upon it disappears on the east side of the granite of Goatfell in Arran. The geology of this district has, however, been scarcely noticed, except in some incidental remarks in the works of Professor Jameson and Dr. Macculloch.

The oldest or fundamental rock of the district examined is mica-slate, forming the wild country round the Mull of Cantyre, the mountain Bengollion near Campbeltown, and most of the high ground north of that town. It is generally a light gray, arenaceous rock, often more resembling a micaceous sandstone than the typical mica-slate of the northern Highlands. The beds are also less contorted, and dip at a low angle, or about 30° on the average to the east, or correctly to E. 8° S. Occasionally it is connected with a dark-coloured, large-grained, crystalline limestone, in several beds. In Knock Scalbert, north of Campbeltown, this limestone group differs in direction from the mica-slate, the beds dipping more to the south (E. 33° S.), and hence it may perhaps form a distinct part of the series. The primary rocks are followed by red sandstone and conglomerate, which often rest almost conformably on the older strata. This parallelism is seen in Knock Scalbert; on the north shore of the harbour; very markedly in Glenramskill Burn; and at the south of the peninsula near Keills. In all these places the dip and direction of the two formations approximate as closely as those of the separate beds in each. The conglomerate is often of immense thickness, and consists of rounded blocks, varying in diameter from a few lines to three feet or upwards, imbedded in a red ferruginous, sandy basis. The blocks have a very local character, being in some places almost exclusively a clove-brown porphyry; in others, hard sandstone or hornstone; in others, again, quartz or trap rocks. It is remarkable that no fragments of the mica-slate on which they rest, or of other primary rocks, were observed in these conglomerates. The red sandstone on the east and south-east coast of the peninsula is often almost a tufa, and consists merely of the materials of the claystone porphyries, with which it seems in part at least contemporaneous.

To the west of Campbeltown, in the low valley named the Laggan of Cantyre, coal has long been wrought. The true character of these beds, as a portion of the great central coal-field of Scotland, was pointed out by Prof. Jameson in his 'Mineralogical Travels.' Dr. Macculloch, in his 'Western Isles,' seems to have adopted the same opinion, but afterwards, in his map, coloured this region as lias. The remains of *Lepidodendra, Sigillariæ, Stigmariæ,* and other plants found in the coals, as well as in the connected shales and sandstones, prove the true age of these beds, and no trace of lias fossils was anywhere seen in this place. The coal is broken up by dykes; and in Tirfergus Burn, where some fine sections are exposed, they are seen to rest upon, and to be overlaid by trap. The igneous rocks are chiefly claystone and felspar porphyries, some of them, like those in Davar island, of great beauty; others, as at Kilkivan, containing large fragments of jasper or altered shale. Augitic trap rocks also occur, especially to the east of Southend, and connected with the limestone series north of Campbeltown. In the cliffs south of Losset, veins of trap are seen rising up through the strata, both of mica-slate and of carboniferous sandstone and limestone, and resting on the latter in vast beds. The igneous rocks, mixed with fragments of sandstone and altered limestone, form a broad band across the country from the coast near Lossel to Macharioch, in the region coloured by Macculloch as mica-slate. They are evidently of very diverse ages, veins of one kind often intersecting masses of another. Thus, at Kilchousland, a vein of dark greenstone, divided into nearly horizontal columns, intersects a mass of light gray trap, often highly concretionary, and in one place forming vertical columns, like a miniature Giant's Causeway, the intervals between the prisms being filled with veins of calcspar, hæmatite and malachite.

The next deposit is the red boulder clay or till, containing striated blocks, and forming low hills in the Laggan of Cantyre. On this rests shingle beds, composed of rounded water-worn stones, gravel and sand, usually more or less stratified, and forming several low terraces. In the hollows among these masses, beds of peat containing large trunks of trees, apparently oak and birch, with nuts and leaves of the hazel, alder and other trees, occur, resting on red clay, and overlaid by other beds of white and red clays. This deposit seems lacustrine, and resembles the recent tertiary beds with lignite on the coast of Norfolk, with which it probably agrees in age. The lake was perhaps drained during the recent elevation of the land, marked by a line of cliff round the whole peninsula. In this cliff are many large caves, of which two, 130 feet long and meeting in the interior, cut in the hard porphyry of Davar island, show the long period the sea must have remained at its former level.

Some of the general results of this investigation are interesting. The peculiar arenaceous character of the mica-slate intermediate between the crystalline rocks of the north Highlands and the Silurian beds of the south of Scotland, the amount of limestone beds in some parts of the series, the diversity in its dip and direction from the mica-slate of the more northern Highlands, indicate that it belongs to a different group. In a paper read to the Geological Society of London, the author formerly stated that the mica and clay-slates on the southern border of the Grampians were probably the northern synclinal of the great trough in which the central coal-fields of Scotland were deposited, and of which the Silurian strata of the south were the other side. These beds are chiefly of lower Silurian age, and hence the author infers that the metamorphic schists of Cantyre are probably altered Upper Silurian or Devonian strata, and that the great mica-slate formation of the Scottish Highlands will eventually require to be divided into several subordinate groups. The introduction of the large overlying mass of trap and sandstone, covering many square miles of the region coloured by Macculloch as mica-slate, renders this part of Cantyre closely analogous to the south of Arran. It also completes the great band of trap, which, commencing on the shore of the German ocean near Montrose, is now seen to extend across the whole of Scotland to the Atlantic, and even into the north of Ireland.

On the Gradual Subsidence of a Portion of the Surface of Chat Moss, in Lancashire, by Drainage. By G. W. ORMEROD, *M.A., F.G.S.*

This paper was in continuation of a communication to this Association, made by Mr. Ormerod at the Swansea meeting. The result of a series of levellings taken by Mr. Ormerod during the last four years over an extent of about 200 acres, where drainage was carried on, proved an average subsidence at the rate of one foot per annum.

Notice of the manner in which Trap or Igneous Rocks intrude into the Sandstone and Conglomerate near North Berwick. By Lt.-Colonel PORTLOCK, *R.E., F.R.S., Pres. Geol. Soc. of Dublin.*

Lieut.-Colonel Portlock observed that two classes of phænomena engage the attention of geologists,—1st, the vital phænomena of the earth as exhibited in the organic remains of its past inhabitants; 2, the physical phænomena, as exhibited in the effects produced by the action of igneous rocks, and of other agents.

It was his object to draw attention in a few brief remarks to the latter, as they were so widely and so strikingly exhibited in Scotland. North of the Friths of Forth and of Tay, there is a band of old red sandstone; and a broken band of similar sandstone, doubtful, perhaps, in position, though by many considered also old red, occurs south of the Frith of Forth, the carboniferous strata between being dotted by detached masses of igneous rocks. Near North Berwick a small patch of the sandstone and conglomerate occurs, separated entirely from either of the great bands, and totally isolated from even the carboniferous strata by a great mass of trap rock, rendered remarkable from the eminences of North Berwick Law, and the Bass Rock. Proceeding from Tantallon Castle towards North Berwick, the first remarkable fact connected with this association of igneous and secondary rocks occurs on the shore about one mile from Tantallon Castle, where a conglomerate rock appears enveloped in the trap, a low ridge of which borders on each side a mass of the conglomerate, fifty yards wide, and about the same number of yards long. This conglomerate is due to igneous intrusion, and contains fragments of various sizes of the secondary rocks, sandstone, limestone, &c., arranged promiscuously, the larger axis of some being in one and of others in another direction, and all manifestly much affected and altered by the contact with a trap rock. Leaving this locality, and advancing towards North Berwick, conglomerate occurs again, which has been much altered, or rather mixed up with igneous matter, until near North Berwick the rocks appear in their natural state.

Taking these circumstances into consideration, and combining them with the isolated position of the secondary patch, Lieut.-Colonel Portlock is disposed to believe that this position itself is also due to the action of the igneous rock, which has raised up the sandstone and conglomerate, and disconnected them from the great body of the old red sandstone.

On the Geological Position of the Black Slates of Menai Straits, &c.
By Professor RAMSAY, *F.R.S., F.G.S.*

The author briefly stated some of the details of work that led the Geological Survey of Great Britain to certain conclusions respecting the age of the black slates of Menai, &c. These slates had previously been considered by Professor Sedgwick to underlie the purple and green sandstones and slates of Llanberis and Harlech, and therefore to be the lowest member of the Cambrian group of Wales. Mr. Sharpe included them with a part of the Upper Silurian strata. It was now shown that they belong to the Lingula beds, the lowest member of the Silurian series, these gradually folding round the purple sandstones towards Aber, in a dome-shaped form, when they are cut off by a N.E. fault throwing them down on the N.W.; from thence to the neighbourhood of Caernarvon, interrupted by intrusion traps, and the second outcrop of the Cambrian purple beds near Bangor.

He next showed that the rocks of the higher part of Snowdon, &c. are the equivalents of the Bala limestone and its underlying volcanic ashes (proved by a series of outliers, &c.), the igneous portion of these beds prodigiously thickening out from the neighbourhood of Bala to the N.W., whereas the underlying igneous series of Merionethshire (Cader Idris, Aran Mowddwy, &c.) thins out and disappears before reaching the parallel of Snowdon.

The greenstones are not of a contemporaneous origin with the ordinary strata, though apparently interstratified with them in the same manner as the felspathic traps and ashes. They were thrust in between the beds before the main disturbance, the whole having been subsequently redisturbed together. There are other masses of intruded felspar trap of a granitic character of later date (Llanberis, Caernarvon, the Rivals, &c.), for various reasons of detail, probably all older than the old red sandstone.

Notice of the recent Discovery of Plumbago or Graphite in the Island of Mull, Hebrides. By ALEXANDER ROSE. *Communicated by* Professor Fleming.

This deposit of plumbago, or as it is more vulgarly named black-lead (the graphite of mineralogists), was discovered in the month of June last, by Charles Murray Barstow, Esq., of India Street, in the estate of Killimore, on the northern side of

Loch Seriden, Isle of Mull. It immediately occurred to Mr. Barstow, that advantage might be taken of his discovery for the interest of the estate, and I was appointed by him to visit professionally the deposit, and to report on its probable quantity and quality. I accordingly went, and arrived about the beginning of July.

The locality of this deposit is about two miles from the head of the Loch. It is bounded on the south by the sea, from which it rises by a pretty rapid ascent to the north. The plumbago occurs in detached masses from one or two inches in dimensions to a foot or eighteen inches, imbedded in the rock, no vein having yet been discovered. Neither are the including masses continuous, but isolated, and everywhere surrounded by trap rocks of various kinds, which constitute the great formation of the island. The extent of the plumbago-bearing rock cannot, in the present state of the surface, be ascertained, much being covered by soil and vegetation, and much probably overlaid by trap; but may safely be estimated at half a mile square in horizontal direction, and in thickness from the level of the sea, gradually rising to at least 150 feet above it; and it is extremely probable that much is overlaid by trap beyond those limits.

Having directed the proper operations to be made, the result has at once happily justified expectation. At one of the blasts, a large mass was thrown out (now upon the table) weighing above thirty pounds, while the fragments of the same mass weigh as much more; but it is of much more importance to observe that the quality is of that description of which the finest drawing-pencils are made.

On the Geological Structure and Relations of the Frontier Chain of Scotland. By the Rev. Professor Sedgwick, *F.R.S. &c.*

§ I. *General Remarks on the Chain.*

This chain, as is well known, extends from St. Abb's Head, on the east coast, to the Mull of Galloway, on the west coast of Scotland; and it reappears, with identical mineral composition and in the line of its strike, on the east coast of Ireland. Whatever, therefore, may be proved respecting the general relations of the chain in Scotland, must apply to, at least, a considerable portion of the prolonged chain in the north of Ireland.

Leaving out of account all igneous and intrusive rocks, the chain is essentially composed of a peculiar form of grauwacke, often coarse and sometimes, though rarely, passing into a very coarse conglomerate, not unlike some of the conglomerates among the old rocks of South Wales. These hard, coarse beds alternate indefinitely with a peculiar soft, earthy and often pyritous alum-slate, which frequently has undergone such compression and induration that it passes into an earthy flagstone, and, more rarely, into a pretty good roofing-slate; but in no instance is the slaty structure distinct from the stratification in any quarries that are worked for use.

From one end of the chain to the other the beds are highly inclined, strike generally in the mean direction of the chain, and are thrown into contortions and undulations. The great protruding granitic masses never form any true mineralogical centre, though producing, as might be expected, considerable local derangements, local changes of structure; and, in a few instances, they are accompanied, near their junction, with the phænomena of mineral veins. The axis of the chain, the centre of the vast undulations, seems to be very ill defined; and the difficulty of determining this point is greatly increased by the bogs and extensive vegetable accumulation by which the sections are much covered.

The author crossed the chain in 1841 with Mr. J. Carrick Moore (now one of the Secretaries of the Geological Society of London); and in 1848 he again crossed it, both on the western coast line and on two other traverses, in the hopes of determining (on the principles laid down by Professors Rogers of America) the line from which the undulations had originated. He also (being himself crippled in 1849) employed Mr. John Ruthven in making out a detailed section on the line of the railroad from Carlisle to Edinburgh (carefully noting the steep sides of the successive undulations) and in collecting fossils. The evidence of the coast sections of St. Abb's Head, the author has not examined personally since 1830, and dares not therefore pronounce any decided opinion on their bearing on the question of the mineral axis of the chain. On the whole of the evidence he however proposes (not without much doubt and hesitation) to separate the chain into the following groups, beginning with the lowest.

§ II. *Successive Groups in ascending order.*

(1.) A great group, always in a highly inclined position (and often so nearly perpendicular that it is very difficult to know whether we are reading off the details in an ascending or a descending order), in which a pyritous alum-schist abounds, sometimes so much that the coarse hard arenaceous beds become subordinate to it. In other places the schist becomes subordinate, indurated, and passes into a coarse slate or flagstone. The group ranges from the neighbourhood of Lockerby till it is succeeded by a superior group (north of Moffat) on the line of the railroad. It stretches into the high hills connected with Harter Fell, and into the ridges forming the water-shed of the Moffat water and the Yarrow. But its limits to the N.E. and S.W. are not ascertained. Through the alum-slates of this group (the *Moffat group*) are innumerable graptolites, well preserved and of many species. Its whole thickness is great, but the estimate is made difficult by the undulation.

(2.) A great arenaceous group with bands of earthy flagstone and coarse slate, a part of which is well exposed, in numerous undulations, in the cuttings of the railroad. The author thinks that this second great group passes into Peeblesshire and the upper parts of the valley of the Tweed, and that it thence extends to St. Abb's Head. He wishes also (but not without hesitation, and on very inadequate evidence) to spread this group through a considerable part of the coast of the Mull of Galloway, and over the great promontory of Barrow Head. If this view be correct, the graptolite bands on the shores of Loch Ryan, and in other parts of Wigtownshire, must be referred to this group. He states, however, that this great group is provisional and very ill-defined, and that it may admit hereafter of new subdivisions and a more definite arrangement.

After examining the valley of the Tweed, the author is very doubtful about the true place of the slate beds (with innumerable impressions of annelides) at Thorneyley on the Tweed, and of the slates of Grieston near Inverleithen (which contain many fine graptolites as well as impressions of fucoids and annelides); but he puts them provisionally in this second group.

Two miles north of Peebles are some concretionary calcareous bands, associated with very coarse conglomerates of considerable thickness, and containing a few obscure traces of encrinites; and about two miles further north are some brecciated beds with veins of quartz and calc-spar; and associated with them are slaty and more earthy bands, with concretions of rottenstone and calcareous veins. These beds are perhaps but a repetition of the conglomerates last noticed, for the whole system undulates and is very highly inclined. Traces of calcareous bands appear also on the hill above Stobo House further up the Tweed; and they finally are seen, along with a well-defined bed of limestone, at Wrae quarries, and in another quarry on the south bank of the Tweed, at Pretsell near Drumminelzier.

The associated beds near these two old quarries are made up of very coarse greywacke, of shale with calcareous concretions, and of one subordinate bed of limestone, varying from ten or twelve to twenty feet in thickness. The calcareous shale with concretions is almost identical with similar shales above noticed to the north of Peebles; and a line drawn from the calcareous bands north of Peebles to Wrae and Pretsell quarries, is very nearly in the strike of the country. The author is anxious to put this calcareous range nearly on the same parallel with the limestones of the Stincher; while he admits that the physical and zoological evidence to prove this point is at present defective, especially as it is difficult to procure a good series of organic remains from this limestone. The author procured a few fossils from it; but a much better series has already been described by Professor Nicol.

(3.) *South Girvan group.*—This is a very complicated group, and though spread over a wide surface by repeated undulations between Girvan and the valley of the Stincher, is of great thickness. The most remarkable beds are in the valley of the Stincher, and are composed of hard arenaceous bands sometimes passing into a very coarse conglomerate, and associated with them are calcareous shale and masses of concretionary limestone of considerable thickness, which in the lower part of the Stincher are nearly continuous. They are well seen at Colmonel, Daljeric and Aldens; also north of the valley on the Knockdolian estate, and at Loch Tor.

Further up the valley of the Stincher the same series (of limestone, shales and conglomerates) is seen at Barr and along the Gregg water. The conglomerates contain fossils and limestone bands. North of Barr is the Craigwell limestone underlaid by calcareous concretionary shale and a great conglomerate two or three hundred feet thick; and a little above the limestone is a conglomerate with a calcareous band about seven feet thick. Lastly, on the road a few miles south of Straiton, is a limestone twelve feet thick imbedded in a conglomerate. This Stinchard limestone is the most important calcareous zone among the rocks of the chain; and it is probably overlaid in its further range towards the N.E. by the carboniferous series of Dumfriesshire.

The coarse conglomerates remind us of some very coarse conglomerates associated with the Llandeilo series in some parts of South Wales. That the Stincher limestone is repeated in almost vertical undulations at Knockdolian farm and Loch Tor, is, the author thinks, undoubted: he thinks also that the same may be said of a limestone that appears on the neighbouring coast, near Bennan Head, associated with dark indurated shale and conglomerate.

Still higher in the group here described (at Ardwell, on the coast south of Girvan) are hard, greenish-gray, coarse flagstones, with graptolites, and orthoceratites (of a Trenton limestone species). The whole series forming this third group ends (as seen on the shore near Girvan) with a great mass composed of greenish, arenaceous slate in thin bands, alternating with greenish bands of hard quartzose sandstone, and occasionally with irregular beds of conglomerate, much contorted here and there, but on the whole dipping N.W. at a great angle. The beds last noticed are erroneously coloured in M'Culloch's map as old red sandstone.

(4.) *North Girvan group.*—This last (and the author thinks the highest group on the north flank of the chain) rises from beneath the carboniferous rocks of Girvan water above Dalquharran, into a rudely dome-shaped mass about three miles long, and extends to a great concretionary and highly inclined mass of limestone at Craig Head, which is near the S.W. end of the group. This limestone is associated with, and partly penetrated by, a great mass of trap; and its structure is partly metamorphic, so that good fossils can only be procured from its more earthy associated beds. The whole group (to which the limestone seems subordinate?) is overlaid by trap rocks, by the carboniferous rocks of the coast of Ayrshire, and partially also by the conglomerates of the old red sandstone. It seems also to be underlaid by indurated shales and flagstones, which contain numerous trilobites. Its prevailing character is, however, that of a shelly sandstone, like that which in South Wales separates the Llandeilo flag from the tile-stone and the old red sandstone; and this is the geological place which the author gives it, both on what he considers good physical and zoological evidence.

(5.) *Balmae group.*—Under this name is included a group of rocks which, near Balmae farm, bound the S.E. extremity of Kirkcudbright Bay. The group is essentially composed of a hard, coarse and thick-bedded greywacke, alternated with flagstone in thin beds, and with thick masses of indurated slate containing septaria and other calcareous concretions. In some of these beds are numerous graptolites; and associated with the calcareous concretions were corals, orthoceratites and shells, both bivalves and univalves. The fossils are not easy to procure; but a good series, submitted to the Geological Society of London by Earl Selkirk, was collected by Messrs. Underwood and Fleming, and they appeared to belong to a deposit of the age of the Wenlock shale. Knowing this apparently decisive zoological evidence, the author went round Barrow Head and some other parts of the neighbouring coast, in the hopes of seeing some physical evidence for the existence of an upper group; but he was disappointed. The rocks along the neighbouring coast have the average character of the rocks he includes in the second group of the chain. They are very highly inclined and thrown into great undulations, and the Balmae group is involved in these undulations without any material change of structure that (independently of fossil evidence) would in any way suggest the existence of a new and upper group. A little way along the coast, towards the N.E., these rocks are overlaid by the old red sandstone; and still further to the N.E., beyond the old red sandstone, calcareous bands appear among the slate rocks, but apparently without fossils.

§ III. *Concluding Remarks.*

In concluding this summary the author remarks, that the chain above described is the true connecting link between the older rocks of England and Scotland. In comparing it with the Grampian chain, we have hitherto been deprived of all fossil evidence; but a careful examination of the zone of unaltered slates, that is packed between the metamorphic slates of the Grampians and the old red sandstone, might lead perhaps to the discovery of graptolites; and graptolites are found in all the groups of the frontier chain from the highest to the lowest.

Granite breaks out in (at least) five places in the frontier chain. Three are laid down (though very inaccurately) in M'Culloch's map; a fourth was found by Mr. J. C. Moore on the western shore of the Mull of Galloway; and a fifth mass (as shown by Mr. Stevenson) breaks out to the north of Dunse, near the junction of the greywacke and the old red sandstone. It is clear that these masses form no mineralogical centre, and that we have no reason to attribute the great undulations of the chain to their immediate agency, but to some more widely acting cause. Enormous masses of trap, sometimes associated with trappean breccias and conglomerate (and generally unmarked on the geological map of Scotland), break out in various parts of the chain from one end of it to the other, and sometimes pass into a form of serpentine. Many dykes, both felspathic and augitic, are seen in the cliffs and quarries; and we occasionally find bands of porphyry alternating with the slates; but in no instance did the author find any good example of that singular combination of porphyry, trappean shale (*schaalstein*), and slate, which gives such an impress to the higher mountains of Cumberland.

This fact explains the great difference in the features of the neighbouring Scottish and Cumbrian chains, and may perhaps help us in explaining the almost entire absence of slaty cleavage in the former.

The lowest fossils in the two chains appear to be graptolites. To this fact the author's attention was often called; but he does not pretend to identify the pyritous Moffat slates with the Skiddaw slates. The present evidence is not sufficient to bear out such a conclusion: and the whole Moffat group is only provisional.

On the second group he, from defect of evidence, makes no comparative remarks. The *South Girvan group* is compared with the Bala and Coniston groups, and the Stinchard limestone with the Bala and Coniston limestone. The *North Girvan group* is compared with the grits and shelly sandstones which overlie the Llandeilo limestone. The evidence for these conclusions will be found in the following list of fossils.

The Balmae group is arranged *provisionally* as the fifth and highest, on evidence formerly laid before the Geological Society of London; but from physical evidence, as well as from the list of fossils which (with the kind assistance of Messrs. Underwood and Fleming) he derived from the shores of Kirkcudbright Bay, the author would rather place this Balmae group on a lower parallel, and perhaps lower than the Stincher limestone.

Lastly, the author remarks, that the Grampians had probably their greatest elevation *after* the period of the old red sandstone, which is of enormous thickness and thrown off vertically from the older rocks of the chain; but the undulations and principal elevations of the frontier chain were produced *before* the deposit of the old red sandstone. For the old red sandstone, with a comparatively low angle of inclination, rests on the edges of the older rocks, and runs up the deep bays and hollows of the frontier chain; and (as shown by Mr. Stevenson) in one or two instances passes almost continuously through it. Similar phænomena are seen among the mountains of the great Cumbrian group, which were probably elevated contemporaneously with the frontier chain of Scotland.

This chain does not appear to have undergone any great elevation during the whole carboniferous epoch; for the new red sandstone, after this epoch, plays the same part that was before played by the older red sandstone, viz. it rests unconformably on the older rocks and runs up their deep indentations and hollows, sometimes so as almost to traverse the whole chain, a fact which has led to much misapprehension and many false colours on the Scotch geological map on which the old and new red sandstone have often been confounded.

List of Organic Remains. By Professor M'Coy.

First or Moffat Group.

Graptolites Sagittarius, Lam.; *G. tenuis,* Port.; *G. convolutus,* His.; *G. millipeda,* M'Coy, n.s.; *G. lobiferus,* M'Coy, n.s., common; *G. Sedgwickii,* Port.; *Diplograpsus rectangularis,* M'Coy, n.s., common; *D. pristis,* His., common; *D. folium,* His.; *Protovirgularia dichotoma,* M'Coy.

Localities.—East and west of the road from Lockerby to Moffat, Harter Fell, Moffat water Head, &c.

Second Group.

Myrianites tenuis, M'Coy, common; *Graptolites tenuis,* Port.; *G. Sedgwickii,* Port.; *G. Ludensis,* Murch.

Locality.—Grieston on the Tweed.

Crossopodia Scotica, M'Coy, very common.

Locality.—Thorneyley on the Tweed.

Diplograpsus mucronatus, Hall (*Diplograpsus* is a new genus proposed for the double-celled *Graptolites*; *D. sextans,* Hall, very common (an Utica slate species); *D. pristis,* His.

Locality.—Cairn Ryan.

Third or South Girvan Group.

Orthis (large species allied to *O. flabellum*), very common; *Orthoceras,* traces of; *Illænus latus,* M'Coy.

Locality.—Wrae on the Tweed.

Murchisonia angustata, Hall, Chazy limestone species; *Ecculiomphalus Scoticus,* M'Coy; *Orthis confinis,* Salt., common; *Illænus latus,* M'Coy; *Maclurea magna,* Le Sueur, a Chazy limestone species.

Locality.—Bugan near Knockdolian on the Stincher.

Maclurea magna, Le Sueur; *Cytheropsis,* n.s.

Locality.—Aldens on the Stincher.

Orthoceras annellatum, Hall, a Trenton limestone species; *Orthis? simplex,* M'Coy; *Graptolites,* traces of.

Locality.—Ardwell on the Stincher.

Orthis confinis, Salt.; *Orthis,* a species allied to *undulata.*

Locality.—Colmonel on the Stincher.

Orthoceras politum, M'Coy; *Orthis testudinaria,* Dal.; *O. simplex,* M'Coy; *Leptæna sericea,* Sow.; *Trochus lenticularis,* Sow.

Locality.—Glenquhapple, Upper Stinchard.

Atrypa hemisphærica, Sow.; *A. pulchra,* Sow.; *Tentaculites annulatus,* Schlot.; *Ptilodictya* (*Stictopora*) *costulata,* M'Coy.

Locality.—Half a mile east of Girvan.

Fourth or North Girvan Group.

Ecculiomphalus Scoticus, M'Coy; *Bellerophon dilatatus,* Sow.; *Murchisonia cancellatula,* M'Coy; *M. simplex,* M'Coy; *Euomphalus tricinctus,* M'Coy; *Trochus Moorii,* M'Coy; *T. helicites,* Sow.; *Modiolopsis semisulcata,* Sow., sp.; *Orthis reversa,* Salt.; *O. testudinaria,* Dal.; *O. filosa*; *Atrypa hemisphærica,* Sow., and some new species; *Illænus Rosenbergii,* Eich.; *Calymene diademata,* Bar.; *C tuberculosa,* Salt.; *Palæopora subtilis,* M'Coy; *P. tubulosa,* M'Coy; *P. favosa,* M'Coy; *Petraia æquisulcata,* M'Coy; *P. subduplicata,* M'Coy; *Ptilodictya* (*Stictopora*) *costulata,* M'Coy.

Localities.—Dalquharran, Mulloch, Drum Muck, &c.

Maclurea macromphala, M'Coy, very common; *Palæopora favosa,* M'Coy; *Atrypa,* n.s.; *Leptæna,* allied to *alternata,* Trenton limestone species; *Orthis,* allied to *pectinella,* Trenton limestone species.

Locality.—Craig Head Quarry.

Fifth or Balmae Group.

Murchisonia, allied to *M. gracilis,* a Trenton limestone species; *Atrypa circulus?,* Hall, a Trenton limestone species; *Orthis lynx,* Eich., var.; *Leptæna alternata,* Trenton limestone species; *Orthonota inornata,* Phill.; *Graptolites Sagittarius,* Linn.; *C. Ludensis,* Murch.

Notice on the Geological Structure of Spain, to explain an Outline General Map of the Peninsula. By M. E. de Verneuil.

Sir Roderick Murchison presented the first sketch of a geological map of the sedimentary deposits in Spain, communicated to him by M. de Verneuil, who has lately made two excursions in the Peninsula, and who, by his own observations, as well as through the information given to him by the Spanish geologists, has cleared up the distribution of the principal masses of rocks. The Portuguese portion of the Peninsula is coloured by Mr. D. Sharpe, whose views respecting the geological structure of large portions of Portugal have already been published in the Journal of the Geological Society.

On the mere inspection of the map, it is easy to remark that the central part of Spain is distinguished by three chains of mountains which constitute the skeleton of the country, the *Guadarrama*, the *Montes de Toledo*, and the *Sierra Morena*. Having emerged before the secondary period, these ridges formed islands, around which were accumulated the Jurassic and the cretaceous deposits. They have about the same direction, and strike W. and by S., E. and by N.

Primary rocks.—The highest of these, the Guadarrama, is principally composed of granite, gneiss and other crystalline schists. Towards the east, in the vicinity of Atienza or Siguenza, these primary rocks disappear under the secondary formations, whilst to the west they seem to proceed to the frontier of Portugal. The primary rocks are not limited to the Guadarrama, but occur in two other and very distant parts of Spain. According to the little map of Gallicia by M. Schulz, Inspector General of the Mines, that province is principally composed of granite, gneiss and mica-schist occasionally surrounding patches of slate and limestone, in which no fossils have yet been found. There is no doubt that these rocks are of great antiquity, situated as they are at the extremity of the palæozoic chain of Cantabria, of which they form a sort of expansion.

Such is not the case with the Sierra Nevada S.E. of Granada, which offers another example of a great mass of crystalline schists. The axis of that bold, high, but not extensive chain, striking from E. to W., is composed of mica-schist, the age of which appears rather doubtful. The abundance of garnets in the mica-schist, the crystalline structure and magnesian condition of the thick band of limestone which surrounds the central part, indicate the energy of the *metamorphic* action which has taken place in this part of Spain.

Palæozoic rocks.—M. de Verneuil paid more attention to the palæozoic rocks than to the others, studying their distribution and collecting their organic remains. The Sierra Morena is the only tract in which Silurian fossils have been discovered. The Silurian rocks are said to constitute the Montes de Toledo (or the Montes Carpentanos) and the Sierra Morena, but the fossils seem to be restricted to the last chain. This range, of moderate height, is composed of slates, psammites, quartzites and sandstones, the real order of which can be unravelled only by the study of their organic contents, in a country where very violent dislocations have often placed the strata in a vertical position.

Making a section across the chain from Almaden to Cordova, M. de Verneuil ascertained, that, proceeding from north to south, the formations are observed to succeed each other in an ascending order. The oldest or lowest traces of life are trilobites. They occur in black shivery slates, and belong to species very well known in the lower Silurian rocks of Brittany and Normandy. The most common, the *Calymene Tristani*, was up to the present time the only known Silurian fossil in Spain. It has been found at Santa Cruz de Mudela by M. Paillette, and at Almadenejos, near Almaden, by various Spanish geologists. These two places being situated about fifty miles from each other, in a direction nearly east to west, mark with some precision the true direction of the strata. M. de Verneuil, assisted by M. Eusebio Sanchez, Director of the Mines of Almadenejos, discovered also *Cheirurus Tournemini*, *Illænus*, near to *I. Lusitanicus*, Sharpe, *Ogygia Buchii*, *Phacops*, *Bellerophon bilobatus*, &c., associated with the *Calymene Tristani* and *C. Arago*; all species peculiar to the lower Silurian slates of Angers, Vitré, and other places in Brittany. It is worthy of notice, that these trilobites, though the lowest in Spain as well as in France, are not the earliest in the order of creation; they correspond only to the second fossiliferous group (stage D) discovered in Bohemia by M. Barrande*. The lowest group, characterized in Sweden, N. Wales, the Malvern Hills, and in Bohemia by the *Paradoxides*, is wanting both in Spain and in Brittany, an analogy which proves the intimate connexion which exists between the palæozoic rocks of these two countries.

The upper Silurian rocks appear to be poorly represented in the Sierra Morena. In a single spot about twenty miles N.E. of Cordova, M. de Verneuil saw bituminous schists with spheroidal calcareous concretions very similar to those which exist at St. Sauveur le Vicomte, Feuguerolles and St. Jean sur Erve in Western France, and which occur also in Bohemia. In this last country M. Barrande has paid much attention to such bituminous beds, as they there occur both in the lower and upper Silurian rocks, and, though separated by more than 2000 feet of strata, contain the same group of fossils. In Spain these concretions contain, as in many other tracts, *Cardiola interrupta, Orthoceras styloideum*, and *O. Bohemicum*†.

The Devonian rocks are fully developed in the Sierra Morena north and south of Almaden, and it is possible that even the quartzites and schists, in which the celebrated mines of mercury are worked, belong to that period‡: the Devonian fossils occur generally in sandstones or in very small bands of impure limestone; the most characteristic are *Productus subaculeatus, Leptæna Dutertrii, Spirifer Verneuili, S. Archiaci, S. Bouchardi, Orthis striatula, Terebratula reticularis, T. Orbigniana, T. concentrica, Phacops latifrons.*

The carboniferous deposits of the Sierra Morena are situated towards its southern part. They contain generally great masses of limestone, in which occurs the *Productus semireticulatus*, so characteristic of the mountain limestone of England, Belgium, Russia as far as the neighbourhood of Archangel, and even of Spitzbergen. Such a vast distribution of the same species over areas which at the present day present so great a difference of climate, is one of those phænomena which specially deserve the attention of philosophers.

The best coal-fields of the Sierra Morena are those of Belmez and Espiel on the Guadiato, and those of Villanueva del Rio, twenty miles N.N.E. of Seville. The first is about twenty-seven or twenty-nine miles long; the strata are vertical, and some are very rich; but the difficulty of the communication and the total want of roads have limited the working to some local uses. The coal tract of Villanueva del Rio, situated near the valley of the Guadalquivir, is more valuable.

If Silurian fossils are as yet known only in the Sierra Morena, it is not so with the Devonian fossils. The two sides of the Sierra Cantabrica in Leon and the Asturias, present one of the richest developments of the deposits of that age. Thanks to the researches of MM. Paillette and Casiano de Prado, many Devonian fossils have been discovered; and M. de Verneuil having himself visited the localities, has described or given a list of more than sixty species. Sabero in the kingdom of Leon, and Ferrones in the Asturias, ought really, he says, to be places of pilgrimage for all palæontologists. These Devonian rocks constitute the axis of the Sierra Cantabrica on its southern side, and are covered in the Asturias or on the north by the richest coal-field of Spain. In general the carboniferous strata are vertical, as in the Sierra Morena; but this disadvantage is lessened by the mountainous relief of the country, in some parts of which the beds of coal can be worked 1200 or 1300 feet above the level of the streams. There being more than eighty workable beds, the depth of the whole system must be very great, and may be estimated at 10,000 or 12,000 feet. At the base is a thick mass of limestone with *Productus*: but most of the carboniferous mollusca are to be found in bands of limestone alternating with the inferior strata of the great coal deposit. Among the fossils worthy of notice, are the *Fusulina cylindrica*, till now found only in Russia and in the United States,

* See the review of M. Barrande's labours which follows.

† The same fossils occur in Catalonia near San Juan de las Abadessas, where they have been discovered by M. Amalio Maestre; they have been quoted by Prof. Leymerie near St. Beat on the north side of the Pyrenees, and exist also in Sardinia.

‡ The mercury of Almaden is not in veins, but seems to have impregnated three vertical strata of a quartzose sandstone associated to slates rather carbonaceous. The association of mercury with carbonaceous rocks is still more remarkable in Asturias, where mines of mercury are worked in coal-measures.

together with the usual species well known in Belgium and England, such as *Productus semireticulatus, P. punctatus, P. cora, Spirifer Mosquensis*, &c.

The existence in Spain of the Permian system is still a problem, as no fossils of that age have ever been found. Led, however, by the analogy of rocks and stratigraphical indications, Professor Naranjo y Garza has referred to that formation the red magnesian limestone and the gypsiferous marls of Montiel and of the lakes of Ruidera, where the river Guadiana rises. In the same group this author includes the famous cave of Montesinos in La Mancha, described by the immortal Cervantes as explored by Don Quixote.

Secondary rocks.—Though equally deprived of fossils, the Trias is perhaps better known than the supposed Permian system. From the Pyrenees, where it is described by M. Dufresnoy, it may be traced to the provinces of Santander and Asturias, as well as to the kingdom of Leon, on both sides of the Cantabrian chain. It does not contain the three series of rocks from which the name originated; and the muschelkalk being entirely wanting, it is reduced to marls and sandstones of red colour placed between the lias and the carboniferous strata. According to M. Casiano de Prado, the same rocks occur in the mountains to the east of Madrid, where the Tagus has its source.

The Jurassic and cretaceous formations extend over most of the eastern and southern part of Spain, covering vast areas in Catalonia, Aragon, Valencia, Murcia, Malaga and Ronda; lying upon the red sandstone, they constitute most of the high lands and mountains which to the east of Madrid make the *divortia aquarum* between the Atlantic and the Mediterranean sea. In fact, they surround the central and more ancient parts, and may be traced to Portugal, where, according to Mr. Sharpe, they are principally confined to the littoral region. Along the Guadarrama, however, the chalk penetrates into the very heart of the country, extending southwest to Segovia, and crossing the high road from Madrid to Bayonne.

M. de Verneuil thinks it will prove a hard task to separate the Jurassic and cretaceous rocks of Spain; especially in the south, where the metamorphic action has produced so many alterations in the rocks, and has so obliterated the fossils. The difficulties will be about the same in the south of Spain, as those which have met the Italian geologists, and the districts of Malaga and Ronda seem to possess a geological constitution very analogous to that of the Venetian Alps. In effect, beneath miocene and nummulitic rocks, rises a compact white limestone not to be distinguished from the Italian *scaglia* and biancone, succeeded near Antequera and other places by a marble of reddish colour full of Ammonites, which may be compared to the Oxfordian *Ammonitico rosso* of the Italians. It is much used as an ornament in the churches of Malaga and Granada.

In the eastern regions the task is more easy; and M. Casiano de Prado, by collecting good fossils, has already laid the foundations of a great work. Appointed by the Government to make a geological map of the province of Madrid, this ardent geologist has extended his investigations in the mountains in which the Xalon, the Tajuna, the Tagus, and the Guadalaviar rise, and has ascertained that these mountains, more than 5000 feet high, are composed of triassic, Jurassic, and cretaceous rocks. The greatest part of the Jurassic fossils, as for instance at Siguenza and Alcolea, belong to the upper lias; viz. to beds characterized by the *Ammonites Walcotti* and *Spirifer verrucosus*. It is remarkable that most of the known Jurassic deposits of Spain belong to that subdivision. It is the case, for example, with those of the Sierra de Moncay, in the province of Soria, and with those of the neighbourhood of Burgos. Little time has elapsed since the Jurassic group has been known in Spain, and for the progress of our knowledge respecting it we are specially indebted to the researches of M. Ezquerra del Bayo and M. Schulz. In preparing a magnificent geological map of the Asturias, this last geologist had many opportunities of studying the Jurassic beds, which, being the prolongation of those of Santander and Bilboa, belong also in great part to the upper lias.

The Oxfordian Jura occurs also in some provinces, as at Teruel; but at present the upper part of the oolitic series, or the Portlandian group, is unknown. The same may be said of the Neocomian rocks. The chalk of Spain appears to consist only of the hippuritic limestone (or beds equivalent to the lower chalk of England and France), and of a lower member, which, largely expanded in the provinces of Santander and Biscay, seems to correspond with the upper greensand, but not with the Neocomian or lower greensand. M. de Verneuil speaks only of what is known in the present state of the geology of Spain, for it is probable that future researches will indicate the existence of the Neocomian formation in the peninsula.

The above-mentioned upper member of the cretaceous group is widely spread over Spain as well as over Portugal, where it has been described by Mr. Sharpe. From the province of Santander it extends to the Asturias near Oviedo, and to Bonor and Sabero (Leon). The same hippuritic limestone is known in the neighbourhood of Burgos, near Tamajon, in the province of Guadalajarra and not far from Segovia. One of the most common fossils of these beds is the *Exogyra flabellata* known at Teruel, Titaguas, Tamajon, Burgos, &c.

Above the chalk, and, having, apparently been submitted to the same disturbances, lie the nummulitic rocks, which most geologists now consider to be true eocene. They are very well exposed at Columbres (province of Santander). With Nummulites of all size, some being gigantic, occur the *Conoclypeus conoideus* and the *Serpula spirulæa*. Much uncertainty still reigns concerning the nummulitic tracts in Spain, for the double reason that *Orbitolites* have been sometimes mistaken for *Nummulites*, and that in other cases true *Nummulites* have been confounded and mapped with cretaceous rocks upon which they lie, but *into which they never descend*; thus according with the position they have been shown to occupy in the Alps, Apennines and Carpathians, by Sir Roderick Murchison. Among other places where Nummulites are known, the French geologist quotes the neighbourhoods of Malaga, Gualchos, Motril, Tarragona, Geronse, Olot, &c. At Malaga a great discordance may be observed between the nummulitic limestone and the miocene deposits, the first being highly contorted and the second slightly elevated. Judging from the few fossils collected by M. Ezquerra del Bayo, the lignites of Utrillas in Arragon must belong, like those of Entrevernes in Savoy, to the nummulitic period.

Tertiary rocks.—These rocks cover vast areas in Spain. Being generally horizontal and extending in vast plains, they contrast strongly with the secondary and nummulitic beds, which are always contorted and form undulating or mountainous countries. All the great valleys of the Ebro, the Douro, the Tagus, the Guadiana and the Guadalquivir, have been bottoms of seas or extensive lakes. The freshwater deposits cover a larger area than the marine ones, extending over Old and New Castile from the Cantabrian chain to the Guadarrama, and from the Guadarrama to the Sierra Morena through the great plains of the Mancha. In some places these deposits reach the altitude of 2500 feet; thus proving how great elevation Spain has suffered even in recent times; recent in effect, if we judge by the freshwater fossil shells which are said to be identical with those living now, and by the bones of great mammoths discovered in the *Cerro San Isidro* near Madrid. Most of the marine deposits, and especially those of the basin of the Guadalquivir, are miocene, and upon them lie here and there some small pliocene, or newer pliocene deposits, formed on the littoral shore and composed of pebbles and fragments of an *Ostrea* resembling the living species. Cadiz is built upon such rocks, which are also well-known in Algeria.. The Mediterranean coast presents many instances of small miocene deposits, some of which have been disturbed and support horizontal newer beds.

It was probably in the most recent of these periods that the extinct volcanos of the Peninsula broke out. Three foci of eruption are known; one at the cape of Gata, the other in the neighbourhood of Ciudad Real, and the third near Olot in Catalonia.

The geology of Spain is not sufficiently advanced to attempt a classification of its mountains considered with respect to their periods of elevation. It may, however, be said, that the Sierra Morena, though a low range, is the most ancient; for on both its sides the tertiary strata in contact with the old rocks are horizontal. Near Cordova, for example, the miocene beds with the huge *Clypeaster altus* are to be seen in that position, and on the northern side at Santa Cruz de Mudela horizontal bands of freshwater limestone loaded with Helix, lie upon highly inclined, trilobite Silurian schists. More recent movements have taken place in the Guadarrama; since at the southern foot of that high range, and on the road from Madrid to Burgos, the same freshwater limestone is slightly elevated. In the Pyrenees, as well as in the mountains which rise in the most southern part of Spain, the subsoil has been tormented by violent and recent disturbances. The tertiary formations of the Ebro, and those of Leon along the Cantabrian chain, are often much elevated. In Leon they are even vertical near the chain, but soon resume their horizontality to range over the great plains of Castile.

Postscript to Mr. Bryce's *Paper on Striated Rocks in the Lake District,* p. 76.

In the first paragraph of this paper it is stated that "up to this time striated rocks have not been noticed in the lake district." This is a mistake, which the author very much regrets; he had overlooked, when the account was drawn up, a paper by Dr. Buckland, in which the existence of scratched rocks in Westmoreland is alluded to. The passage occurs in the 'Proceedings of the Geological Society of London,' vol. iii. part 2. p. 347, under date of Dec. 2nd, 1840, and is as follows:—"Dr. Buckland had no opportunity of seeking for polished and striated surfaces in the high mountain valleys of the lake district; but he found them on a recently exposed surface of greywacke in Dr. Arnold's garden at Fox Howe near Ambleside; likewise near the slate quarry at Rydal; and on newly-bared rocks by the side of the road ascending from Grasmere to the Pass of Wythburn; he is also of opinion that many of the round and mammillated rocks at the bottom of the valley leading from Helvellyn, by the above localities, to Windermere, owe their form to glacial action."

BOTANY AND ZOOLOGY, including PHYSIOLOGY.

Botany.

On Anachâris Alsinastrum. By C. C. Babington, *M.A., F.L.S.*

On the Grass-Cloth (Chū Mā) *of India. By* Dr. H. Cleghorn, *Madras Army.*

The author stated that several species of plants belonging to the order Urticaceæ were employed in Hindostan for the purpose of yielding fibres used in the manufacture of textile fabrics. He exhibited several articles of dress very white and light, which were manufactured from the fibres of the *Bœhmeria nivea* of botanists, the *Urtica tenacissima* of Roxburgh (Fl. Indica, iii. 590). The plant is cultivated in Sumatra, where Marsden says, "the shoots are cut down, dried and beaten, after which the rind is stripped off;" the fibres so obtained are of very great strength and fineness. In Penang it is likewise cultivated; the Malay name in that island is *Rami*. Specimens sent to the Agricultural and Horticultural Society from Dr. M'Gowan of Ningpo, were found by Dr. Falconer to correspond exactly with those grown in the Botanic Garden of Calcutta, where it had been introduced from Sumatra in the days of Roxburgh, with a view to obtaining its valuable fibres. This is probably the very plant to which Kœmpfer alluded so long ago as 1712: "*Sijro* or the Wild Hemp Nettle grows plentifully in most uncultivated places. This plant makes good in some measure what want there is of hemp and cotton, for several sorts of stuffs, fine and coarse, are fabricated of it." (History of Japan, translated by Scheuchzer, i. 119.) In 1784, Thunberg, in his 'Flora Japonica,' p. 71, giving the *same* vernacular name to *Urtica nivea,* Linn., says, "Crescit copiosissime in Nagasaka, alibi. Cortex pro funibus conficiendis et filis validis ad texturas expetitur. E seminibus oleum causticum exprimitur." Dr. Cleghorn stated that the weight of the jacket was five ounces, and that it cost three rupees. The fabric is coming into increasing consumption in S. India, being imported from Singapore and China in narrow webs. It is much esteemed for light clothing during the hottest weather; in regard to which use James Cunningham wrote to Plukenet, "Planta sativa Cô dicta unde efficitur Copou, pro vestibus æstivis." (Almagestum Botanicum, 1796.) The specimen No. 2012 of Dr. Francis Hamilton Buchanan's Herbarium, corresponds with No. 4606 E. of Wallich's Catalogue.

On the Hedge Plants of India, and the conditions which adapt them for special purposes and particular localities. By Dr. H. Cleghorn, *Madras Establishment.*

The author first made some remarks on the low condition of agriculture generally throughout India, and stated that his remarks more particularly applied to the south of that continent, in the district of Mysore, which he had frequently traversed in the execution of duty. Having referred to the importance of hedges in any well-developed system of agriculture, he pointed out their especial importance in a country infested with wild animals, and where the crops needed especial protection. He stated, however, that those plants alone could be used for hedges which were adapted to the particular soil and climate where they were employed. Sandy districts produced a very different vegetation from that which is found in a rich alluvial soil. The following plants were named as those which might be used with advantage for hedges in various parts of India. Most of these plants are characterized by possessing spines, prickles and thorns, which render them dangerous to animals.

I. *Plants adapted for Field-enclosures.*

Opuntia Dillenii, *Haw.*	Hemicyclia sepiaria, *W.* and *A.*
Agave americana, *L.*	Epicarpurus orientalis, *Blume.*
Euphorbia Tirucalli, *L.*	Jatropha Curcas, *L.*
—— antiquorum, *L.*	Pisonea aculeata, *Rox.*
—— nivulia, *Buch.*	Capparis sepiaria, *L.*
Cæsalpinia sepiaria, *Rox.*	—— aphylla, *Rox.*
—— Sappan, *L.*	Scutia indica, *Brong.*
Pterolobium lacerans, *R. Br.*	Azima tetracantha, *Lam.*
Guilandina Bonduc, *L.*	Gmelina asiatica, *L.*
Parkinsonia aculeata, *L.*	Balsamodendron Berryi, *Arn.*
Poinciana pulcherrima, *L.*	Toddalea aculeata, *Pers.*
Mimosa rubicaulis, *Lam.*	Bambusa arundinacea, *Willd.*
Inga dulcis, *Willd.*	—— spinosa, *Rox.*
Acacia arabica, *Willd.*	—— nana, *Rox.*
—— concinna, *D.C.*	Dendrocalamus tulda, *Nees.*
Vachellia Farnesiana, *W.* and *A.*	Pandanus odoratissimus, *L.*

II. *Ornamental Plants forming inner fences.*

Lawsonia inermis, *L.*	Adhatoda vasica, *Nees.*
Lonicera ligustrina, *Wall.*	—— Betonica, *Nees.*
Citrus Limetta, *Riss.*	Graptophyllum hortense, *Nees.*
Morus indica, *L.*	Gendarussa vulgaris, *Nees.*
Punica granatum, *L.*	Gardenia florida, *L.*
Phyllanthus reticulata, *Poir.*	Allamanda cathartica, *L.*
Hibiscus rosa sinensis, *L.*	

III. *Plants used for edging garden walks.*

Pedilanthus tithymaloides, *Poit.*	Rosa indica, *L.*
Vinca rosea, *Willd.*	—— semperflorens, *Curtis.*
Heliotropium curassavicum, *L.*	

The *Cacti, Agaveæ* and *Euphorbiæ* are adapted to the arid districts, their structure enabling them to exist, when refreshed with only occasional showers; the *Mimoseæ* and *Cæsalpineæ* seem to enjoy the somewhat more cold and moist climate of the Balaghaut districts; while the *Bambuseæ* and *Pandaneæ* luxuriate in the rich loamy soil of the Mulnad (*i. e.* Rain country). Hence, for the railways now making in the Peninsula, the fences ought to differ as the line is continued through various districts, in accordance with the conditions under which particular plants thrive best between certain limits of temperature and moisture.

On the Epidermal Appendages of the Genera Callitriche, Hippuris, Pinguicula, *and* Drosera. *By* Edwin Lankester, *M.D., F.R.S.*

Although it was frequently stated that aquatic plants had no epidermis, yet many of them are covered with a very perceptible distinct layer of cells which Schleiden calls epiblema. In certain instances this external layer of cells seemed capable of developing appendicular organs, as was the case with plants growing in the air. The author had previously published a description of certain bodies which occurred on the surface of the stem and leaves of *Callitriche verna*. These bodies were stellate in form, and consisted of several cells attached to one which acted as the base and attached the rest to the surface. Since that time he had observed the same bodies covering the surface of the stem of *Hippuris vulgaris*. They were composed of a larger number of cells in *Hippuris*, and the author had not detected them on the leaves. Finding them on *Hippuris* and *Callitriche*, he had sought them on *Myriophyllum*, but had not succeeded in detecting them there. He had however detected similar bodies on the surface of the leaves of *Pinguicula vulgaris*. These had been previously described by Professor Dickie. In *Pinguicula* the stellate bodies were found lying directly on the surface of the leaf, or elevated upon one, two, or more cells, so as to resemble clavate hairs. In *Pinguicula* they were quite distinct from the stomates, and this might be taken as an indication of the nature of these bodies in *Callitriche* and *Hippuris*. The author had also observed bodies of a similar kind on the surface of the leaves and on the so-called hairs of *Drosera rotundifolia*. It was an old observation alluded to by Meyen and dwelt upon by Morren, that the hairs of *Drosera* contained spiral vessels. The author had traced these to the bundles of vessels which formed the veins of the leaf, and stated, that we must regard the hairs of *Drosera* as segments of the leaf. He regarded as the true hairs of *Drosera*, the stellate bodies above referred to.

A few Remarks on the Treatment and Flowering of a Plant of Dracæna Draco, *or Gum-Dragon Tree, in the Botanic Garden of Trinity College, Dublin. By* J. T. Mackay, *LL.D., M.R.I.A., Director.*

The *Dracæna Draco*, or Gum-Dragon Tree, on a plant of which I beg leave to make a few observations, was raised by me in the College Botanic Garden in 1810, along with several others from seeds brought from Madeira. After it had been grown in a pot for ten years, it was planted out into a bed of earth in a large stove or hot-house. About three years ago it became too tall for the house; and in order still to secure the plant for the collection, the following experiment, suggested by my intelligent chief-assistant Mr. Bain, was made by him:—The stem, which was then about eighteen feet high and fifteen inches in diameter, was during six months gradually cut across four feet above the root, about an inch deep at a time, when a little hot lime was applied to the wound to prevent bleeding. The root and lower portion of the stem were then removed as being useless, and the upper portion of the stem suspended immediately above the former station of the plant. In the course of eight months, during which time it was kept perfectly dry, it threw out several aërial roots from the edge of the stem where it had been cut. It was then lowered into its former position, and had the stem and roots sunk about four feet in dry sandy mould. This was done a year and a half ago; and the plant, which is now in excellent health, has lately flowered, and is, I believe, the only one that has done so in Great Britain or Ireland. It is a liliaceous plant, having numerous small flowers produced on racemes, composing the large panicle, which was four feet in length and three feet in diameter.

A portion of the panicle and two drawings of the plant I now lay before the meeting. As the above experiment on *Dracæna Draco* has succeeded so well, the author thought the same treatment would be well worth trying on palms and other endogenous plants, when they become too tall for the house.

On the Effects of Salt on Vegetation. By Dr. Aug. Voelcker, *Prof. of Chemistry, Roy. Agricul. Coll. Cirencester.*

This paper contained the preliminary results of some experiments undertaken with a view of studying the effects of salt on vegetation in general, and to determine more in particular in what quantity salt produces a beneficial, and in what quantity an injurious effect on different plants. The plants selected for experiments were cabbages, beans, onions, lentils, *Stellaria media*, *Senecio vulgaris*, *Carduus pratensis*, *Anthoxanthum odoratum, Poa annua,* and radishes. They were all grown on the same soil, of a calcareous character, potted on the 1st of May, and experimented upon with salt solutions of different strength on the 10th of May. The following are the general results derived from these experiments:—

1. Salt solutions, containing 3 grs. of salt, 6 grs., 12 grs., and even 24 grs. of salt, produced no injurious effect on the above-mentioned plants, which had been regularly watered with them during two months, with the exception of *Anthoxanthum odoratum. Anthoxanthum odoratum* was killed by a solution containing 24 grs. of salt in the course of a month.

2. Such weak solutions appeared to benefit most plants experimented upon, particularly cabbages, radishes, and lentils. The lentils, which were watered with a salt solution containing 24 grs. of salt per pint of rain-water, were nearly half larger in size than those watered with 6 grs. of salt per pint, and these again were more vigorous than the lentils which received no salt at all.

3. Salt solutions containing 48 grs. of salt proved to be prejudicial, in the course of a month, to lentils, *Stellaria media, Senecio vulgaris, Poa annua,* and exercised no injurious effects on cabbages, beans, onions, radishes, *Carduus pratensis.*

4. Salt solutions containing 96 grs. of salt had an injurious effect on lentils, *Stellaria, Senecio vulgaris, Poa annua,* cabbages and beans, but no effect on *Carduus pratensis,* onions and radishes.

5. Cabbages will continue to grow, though sickly, when watered regularly during a month with a salt solution containing 192 grs. of salt, and even when watered with a solution containing 382 grs. of salt per pint.

6. Solutions of salt containing 192 grs. of salt per pint, proved unprejudicial in the course of a month to onions.

7. Grasses are affected by salt more readily than any other of the plants experimented upon.

8. Solutions containing 24 grs. of salt, decidedly benefited radishes, lentils, onions and cabbages.

Many of the plants had taken up so large a quantity of salt, that they tasted like strong brine, and notwithstanding they grew healthily, which evidently shows that salt in a moderately diluted solution has no poisonous effect on many plants.

In conclusion, the author mentioned that his experiments differ from those of Mr. Randall, made with fuchsias. But as Mr. Randall used water from a particular source, and not with pure salt water, and may have contained other poisonous substances, it is the opinion of the author, that so small a quantity of salt as that contained in the water with which Mr. Randall experimented, cannot be regarded as the cause of the observed poisonous effects.

Zoology.

Notes on Crustacea. By C. Spence Bate.

I. *On the Development of the Shell.*—That crabs moult, from the larva state to that of the adult, is well known; in the earlier period of their existence the exuviæ are thrown off every two or three days, later it takes place at intervals of two or three months; but in the adult crab, the shell is cast but once a year, and probably in old age it is not so often repeated, even if they moult at all. But whether we contemplate the phænomenon in either stage, the process by which the shell is developed must be the same.

Immediately over the heart a pulp is formed consisting of nucleated cells, areolar tissue (and blood-vessels?); from this centre the pulp extends throughout the whole portion of the crab, which is represented by a hard dermal skeleton, beneath which it immediately lies, and from which it is separated by a layer of pigment which gives colour to the newly-developed organ. Near the base of the pulp (that is immediately above the heart) the cells are uniformly large; deeper in the pulp they become mixed with smaller, both of which are displaced by cells still smaller as they approach the layer of pigment, immediately beneath which, they being uniform in size, compress each other into a polygonal form; these cells are the ultimate secreting organs of the new shell, which is developed from a repetition of these layers, into which eventually the whole pulp is converted.

II. *Shedding the Exuviæ.*—As the period approaches for the completion of the new shell, it, being larger in extent than that which it is about to replace, is therefore compressed into wrinkles or folds. It is by this compression, arising from the internal growth of the crab, acting upon the principle of the lever, that the old shell is removed; the first external sign which I have observed of the approaching change in the animal's œconomy, is an increase in the thickness, whereby the sections of the abdomen become more conspicuous from above; as this increases, the crab wanders about in search of a resting-place, and often becomes very savage, darting at any and everything that approaches it, until when the moment draws near it hitches the point of one of its feet into some crack or crevice and withdraws itself from its old skin, escaping between the carapace and the abdomen. The moment after it is free the full size is obtained.

I cannot help here remarking, that in the case alluded to by Reaumur it is stated, that with the crayfish (*Astacus fluviatilis*) the process was one of great labour and difficulty as well as duration, whereas in every case that I have watched of the crab (*Carcinus Mænas*), the operation has been very quick and easy; and also up to the moment of their throwing off their extraneous skeleton, they have the use of all their limbs with perfect freedom, and display as much activity upon being disturbed as at any other time. They also seem to have the power of retaining the old shell at will until a suitable moment occurs for them to cast it with security; for although in *many* instances I have seen them before and after the process had commenced, and patiently watched for hours at a time, yet they have endeavoured to take advantage of a temporary absence of sometimes a few minutes to get rid of the shell. At this time they are very liable, in their defenceless state, to be preyed upon by larger animals both of their own and other species, of which they themselves seem to be aware, and being excited by fear, are much more active and less easily caught than at any other period.

III. *The Reproduction of Limbs.*—When a limb is injured all crustacea have the power of rejecting it (provided it be not below the last joint); this is done by a violent muscular contraction, and ultimately a blow from another limb or against some external body; the amputation is performed in a few seconds, except when they have but recently cast the exuviæ, when for the first few days (while the new skeleton is being hardened) they have not that easy capability, and the wounded limb will sometimes remain for perhaps half an hour or more before it is thrown off. I once cut the large didactyle claw of a crab through the joint, so as to remove only the thumb and finger; and although the animal exhibited signs of severe suffering for some hours, yet it did not throw off the limb, and when the exuviæ in its regular time were shed, the limb continued a maimed member and never was produced. The new limb is formed within the old carapace in connexion with the *new* shell, and lies folded up until the old coat is thrown off, and becomes apparent only at the period of the development of the new shell, and is larger or smaller in accordance with the duration which existed between the period of the amputation of the limb and the shedding of the exuviæ. The condition in which the limb is then in remains, as the rest of the animal, stationary in growth, until the shell is again cast, when the whole creature advances in size, but the newer-developed limb more rapidly in proportion than the remainder of the animal, until the new limb is equal to the others in size and importance. It is to this variety of sizes (dependent upon the period which occurs to allow the new limb to be developed previously to the next succeeding moult), that the commonly received idea of the continual growth of the limb is based.

IV. *On the use of the False Feet in Male Brachyura.*—These appendages, which consist of two pair, the anterior being the larger and more important, are attached to the first annular segment of the abdomen, the posterior or less belongs to the second ring, and in all that I have observed, the second or less pair is inserted posteriorly into the first or larger pair, except in *Cancer Pagurus*, in which the posterior is of equal length, though less in other proportions.

In the female, as is well known, the false feet are the appendages by which the ova are supported by the parent during their development. But in the male they assume a more important function, being no other than the intromittent organ of generation. I am well aware that the high authority of Prof. Milne-Edwards has asserted, that they are of no other use than to excite the female, in his 'Histoires des Crustacés,' "Ces appendices paraissent devoir servir à diriger les verges vers les vulves, et peut-être aussi à exciter ces derniers organes," which he has since repeated in the 'Cyclopædia of Anatomy and Physiology,' article *Crustacea*. But I have myself repeatedly taken *Carcinus Mænas* in the act of copulation, in which these styliform processes were deeply inserted into the vulvæ of the female. Since which time it has been my object to make out the anatomy of the organ as distinctly as possible, for which purpose I have dissected *Cancer Pagurus, Xantho rivulosa, Portunus puber, Carcinus Mænas*; in the whole of which, and I doubt not but also in the remainder of the *Brachyura*, the internal organs lie folded upon themselves, one on either side of the stomach, each of which continues to the first joint of the fifth pair of legs, through the membranous portion of which in some—while in others a separate orifice exists through the calcareous portion of the leg—a membranous tube, the vas deferens, passes out, and is continued externally until it is inserted into the second joint of the first pair of the so-called false feet, through which it passes and ultimately opens at the extremity. For many days may the male be seen running about holding the female by one or more of his legs, pressing the carapace against its sternum; this continues for a period more or less long, until the female throws off the exuviæ, when copulation immediately ensues, face to face, and continues from eighteen to twenty hours, or perhaps until the new shell becomes sufficiently calcified to act as a protecting skeleton.

V. *Number of Broods from one Female in one Season.*—I have been induced to believe that crabs, like some insects, have more than one brood from a *single impregnation of the male*; the facts which incline me to this idea are, that in the month of May last I took a female, to the false feet of which were still attached the hair-like threads, the external case of the ova, showing that the larva had been but recently let free, whereas upon dissecting the crab I found the uterus gravid with ova in an early stage of development. Upon considering, as before-mentioned, that impregnation takes place immediately after the period of moulting, and that the exuviæ are cast but once in the year, I can only imagine that in the brood after the first, the ova are fertilized by spermatozoa retained within the cul de sac of the parent from the first or previous inoculation.

VI. *On the uses of the Fifth Pair of Legs in the Anomoura.*—The fifth pair of legs in the *Anomoura* are apparently useless, appearing as if formed by an arrest of development, which altogether incapacitates them from assisting in the office of perambulation. These, which in the *Brachyura* are connected with the last annular segment of the thorax, in the *Anomoura* belong to the first segment of the abdomen, and generally lie folded up and at rest on either side of the carapace.

In both the *Brachyura* and *Macroura*, within the branchial chamber are organs whose office is chiefly to excite currents over the surface of the gills, as also (probably) to remove any irritating substance which may have been brought in by the aërating fluid; these organs are called the flabellæ, which, though common, I believe, to all of the above-named sections, yet in the *Anomoura* are wanting. This absence of an important agent in respiration, entails upon the animal death by asphyxia much more rapid, which still would be increased but that the office is partially fulfilled by the fifth pair of legs, which are, when required, inserted beneath the carapace into the branchial chamber; and this is assisted by a peculiar power which the crabs of this order possess, in being able to raise up their own carapace; a power of which they take advantage when respiration is impeded, in order to admit a greater body of water into the gill-chamber, but which is precluded from entering into the thoracic cavity by a thin membranous wall which unites the carapace with the sternum and abdomen at the inner wall of the branchial chamber. Neither is this the only purpose for which the fifth pair of legs serve in the œconomy of these crabs; they are invariably supplied with strong cilia at the extremity, which also is sometimes didactyle, the prehensile form being obtained by the last joint being arrested in its development, impinging upon a process or excess of development of the penultimate; with this didactyle and brush-like extremity I have seen the *Pagurus Bernhardus* mop every joint in succession, and when required, cleansing the brush in the pedipalps. This pair of legs also carries the male organs of generation.

The author added descriptions and figures of new species, viz. *Pagurus Dillwynii* and *Pandalus Jeffreysii*.

A List of Sertularian Zoophytes and Polyzoa *from Port Natal, Algoa Bay, and Table Bay, in South Africa; with Remarks on their Geographical Distribution, and Observations on the Genera* Plumularia *and* Catenicella. *By* George Busk, *F.R.S.*

The 17 species of *Sertulariadæ* belonged to the following genera, viz. *Sertularia*, 9 species; *Plumularia*, 5 species; *Thuiaria*, 1 species; *Antennularia*, 2 species. The species of *Sertularia* were, as far as they could be ascertained,—1. *Sertularia argentea*; 2. *S. rosacea*; 3. *S. polyzonias*; 4. *S. abietina*; 5. *S. operculata*; 6. *S. nigra*; 7. *S. arbuscula*?; 8. *S. unilateralis*?; 9. *S. Gaudichaudi*. With respect to the first six of these, no remarks appear to be called for, as they correspond in all respects with the species of the same name in the British Fauna. The *Sertularia operculata* of South Africa is undoubtedly the same species as the British, although from a rather general deviation from the more usual toothing of the margin of the cell, which obtains in specimens from the southern hemisphere, this variety has been denominated *Sert.* or rather *Dynamena bispinosa* by Mr. Gray. This species appears to be of a cosmopolitan character, occurring in Europe, South Africa, Australia, New Zealand, and in at least one of the South Sea Islands; specimens from the latter locality, differing merely in colour, which is in them deep brown. The seventh species, here named *S. arbuscula*, is most probably that species, which is one of those described by Krauss, but stated by him to come from New Holland. This statement may, however, probably turn out to be incorrect, as the species in question does not occur among those sent home from H.M.S. Rattlesnake from Australia. The eighth species, which does not appear to have been previously described, is characterized by the position of the double series of cells toward one side of the rachis, in consequence of which the polypidom affords something of the aspect of a *Plumularia*. It may prove to be the *Sertularia unilateralis* of Quoy and Gaimard, although in their figure of that species the cells are much wider apart than in the specimen from Algoa Bay. The species of *Plumularia* are:—1. *Plumularia formosa* (Busk); 2. *Plumularia*, sp.?; 3. *P. falcata*; 4. *P. pennatula*?; 5. *P. cristata*. There is a sixth very small species, but so closely resembling *P. cristata*, that it is not deemed advisable at the present time to separate them. The species named *P. formosa* is of a beautiful feather-like habit, growing in simply pinnate fronds of a deep brown colour, from two to nearly six inches high. As it does not appear to have been hitherto distinctly described or named, it is designated as above, with the following characters:—

P. erecta, pinnata, subincurvata; cellulis crenatis, dentatis, rostro antico elongato basi utrinque spicato; processu rachidis antico inferiori canaliculato: processibus lateralibus rachidis, canaliculatis, brevibus. Capsulis ovarialibus, elongatis, costatis. Hab. Africa austr.

The second species also appears to be unnamed, but as, from its size and remarkable habit, it can scarcely have escaped notice, it is thought better not to name it on the present occasion. It has a remarkable shrub-like aspect, having a very thick and strong stem, irregularly branched, the ultimate ramules pinnate, pinnules small, in proportion to the size of the rachis. The cells are cup-like, with several shallow indentations, and a sharp ascending point anteriorly. The anterior rachidian process, and also the two lateral ones, are long and of uniform diameter.

With respect to the species of *Plumularia*, it was remarked that four out of the five belonged to that group of this artificially constructed genus, of which *Plumularia cristata* may be taken as the type, and of which the most striking characteristic hitherto noticed is the pod-like, costate, ovarial capsule. It was pointed out, however, that this group is not distinguished from the rest of the species in this genus, with which it has been artificially associated, by this character alone, but by several others also, sufficient perhaps hereafter to justify the erecting of the group into a distinct genus. Omitting the peculiar and elegant feather-like port of most of these species, there may be noticed more particularly the existence on each side of the rachis of the pinnæ, and on a level with the upper part of the cells, of a short curved or straight process, usually tubular, but sometimes only channelled, which is continuous through a rounded opening with the interior of the rachis. Many of the species, but not all, have also a similar tube or process, arising from the rachis immediately below the cell. It is this process which has sometimes been denominated a "bract." Where this anterior process is wanting, there is usually a tube projecting from the cup itself, but in this case the tubular process seems to be of a different nature, supporting at its extremity a small cup-like cell. *P. cristata*, in one of its varieties, affords an instance of this arrangement. Should a division of the genus *Plumularia*, as at present constituted, be eventually made, those species of which *P. setacea* may be taken as the type, would form a second genus, closely allied to *Laomedea*; and *Plumularia falcata* might safely be referred to *Sertularia*. A link between the latter genus and the so-called *Plumularia* in question, might be indicated in the eighth species of *Sertularia* above noticed under the name of *Sert. unilateralis*. The species of *Thuiaria* differs from *Thuiaria articulata* in the exact opposition of the pinnæ, and in the frequency with which the extremities of the pinnæ are furnished with long tendril-like tubes, by which the polypidom clings to surrounding bodies, or one frond to another. As this is in all probability the species referred to by Ellis "as having been sent to him from the East Indies," and as it is undoubtedly distinct from our *T. articulata*, the name of *T. Ellisii* is proposed for it, with the character,—"T. pinnata, pinnis oppositis. Capsulis ovarialibus ovatis, ore rotundo, incrassato."

Of the two species of *Antennularia*, one corresponds with our *Ant. ramosa*. The other species resembles the *Cymodocea simplex* of Lamouroux. It is however clearly an *Antennularia*, and the name of *Antennularia Cymodocea* is proposed for it, with the character,—"Ant. caulibus simplicibus: ramulis biseriatis, utrâque serie, alternantibus." Hab. Af. aust., Australia, &c.

With respect to the geographical distribution of these Sertularians, it may be remarked that of the nine species of *Sertularia*, six are British forms also; of the other three, one may be common to Australia, and no other locality is known for the remaining two. Of the five *Plumulariæ*, three are also members of the British Fauna; and of the two *Antennulariæ*, one is also British. Thus of the whole number 17, ten are European forms,—a circumstance calculated to excite much surprise. None of the South African *Sertulariadæ*, except *Sertularia operculata*, and perhaps *S. arbuscula*, occur among those which have come under the author's notice from Australia or New Zealand.

Of *Polyzoa*, there were noticed 15 or 16 species, viz. 1. *Cellularia*, 2 sp.; 2. *Flustra*, 2 sp.; 3. *Acamarchis*, 1 sp.; 4. *Catenicella*, 3 or 4 sp.; 5. *Serialaria* (*Amathia*), 3 sp.; 6. *Salicornaria*, 1 sp.; 7. *Elzerina*?, 1 sp.; 8. *Crisia*, 2 sp.

The species of *Flustra* are, first, *Flustra* ——?, distinguished by all the marginal cells having an avicularium imbedded in them. There appear to be two varieties of this species. The second species is the beautiful *Flustra bombycina*; it is usually parasitic upon sponges or other zoophytes, especially on *Sertularia polyzonias*. The species of *Acamarchis*, is that described by Krauss under the name of *A. tridentata*. It belongs to a group of *Acamarchis*, in which the species are distinguished by their containing a blue colouring matter, as is another set by the possession of a red colour, such as occurs in *Cellularia plumosa* of our seas.

The species of *Serialaria* (or *Amathia*) are—1. *Amathia biseriata* (Krauss); 2. *A. cornuta*; 3. *A. lendigera*; or at all events a species very much resembling that British form.

The *Salicornaria* is identical with our *S. farciminoides*, as is one of the *Crisiæ* with the British *C. denticulata*. The other *Crisia* is a peculiarly beautiful, pearly species, unlike any British form. The genus here doubtfully designated under the name *Elzerina* (Blainville), resembles *Salicornaria* in many respects, but is horny instead of calcareous. Two or three other species, referable to the same genus, occur in Australia, but the South African one does not appear to have been found there. Of the three or four species included under the name *Catenicella*, one will probably hereafter constitute the type of a distinct genus, but as it possesses many characters in common with the others, the separation is deferred. One of the species here called *Catenicella*, is most probably the *Menipea cirrata* of Lamouroux, or the *Cellaria cirrata* of Ellis and Solander, of which a figure is given in their work, which is copied by Lamouroux. Great confusion appears to exist in this genus up to the present time; but it would occupy too much space in this abstract to enter upon the consideration of the historical part of the subject. The genus is a very important one, especially as regards the relation of the South African Fauna with that of Australia and New Zealand, and may be thus defined :—

Polypidom growing from the base with a more or less distinct stem, consisting of a congeries of horny tubes. The branches dichotomous, composed of calcareous cells arranged in linear series, and arising, one from the upper and back part of another, a *flexible* joint intervening between them. At the dichotomous divisions of the branches, which take place after a variable number of cells, the duplication of the series is effected by one of the cells giving off laterally a second sessile cell, from the upper and back part of which, as in the parent cell, the subsequent cell and series arise. It is in respect of the mode of division of the branches, that the species above referred to differs from the others, and would appear to constitute a distinct generic form.

The openings of the cells are all on one face of the branch, and vary in different species in shape, &c., as does the sculpture on the cells, their form and size, &c. The cells are always furnished with lateral appendages or alæ, which in most species support longer or shorter spines, which apparently are readily detached; but in some cases the lateral appendages assume the form of cup-like cavities or are Avicularia. This genus appears to be in great measure confined to the southern hemisphere, and there is probably no species of it in the European Fauna. A species is described and figured in the great French work on Egypt (*Catenicella Savignyi*), but this may probably have been obtained from the Red Sea. It approaches very nearly to one of the South African species. There is also in the Mediterranean a Polyzoon, named by Audouin *Eucratea Lafontii*, and also figured in the work just cited, which however differs from *Eucratea* in having flexible joints and in other respects, and which would seem to be allied with that among the South African forms, which differs in its mode of division from the other true *Catenicellæ*.

The principal seat of this genus would appear to be in the Australian seas, for in the rich collection of zoophytes sent home from H.M.S. Rattlesnake, not less than sixteen distinct species of this genus occur, all differing however from the South African. And from New Zealand another species has been named by Mr. Gray *Catenicella bicuspis*, which is probably distinct from any of the Australian forms, though closely resembling one of them.

Examples of Exuviation, or the Change of the Integuments of Animals in the Crustacean Tribes. By Sir John Graham Dalyell, *Bart.*

All animals are invested by a skin, an external covering or integument of various quality. In general the skin simply expands with the growth of the subject which it invests, but where the integument is not susceptible of such enlargement, nature has provided effectual substitutes in its place. This is most favourably illustrated by the history of the crustacean tribes.

While occupied with the *Cancer Mænas*, the Shore or Harbour Crab, a dingy brown specimen, A, of medium size, with one limb white, was put outside the window on a summer evening, in a capacious glass vessel of sea-water. In the morning, a form exactly resembling its own, only somewhat larger, lay in the vessel. This was a new shell, exuviation having taken place in the night. The resemblance was complete; every organ, even the white limb, was seen in both. The natural colour of this species is green, or it is often variegated green and white, and is sometimes reddish.

Another specimen, B, was caught of smaller size, the opposite extremities of the limbs being only 13 lines asunder, its colour green, with three white patches on the back. In the course of little more than a year five exuviations took place at irregular intervals, the new shell and animal being successively larger on each. The third shell came in uniformly green, the white being entirely obliterated. The limbs expanded two inches and a half on the fourth exuviation.

As this subject was a male, a female of about the same size was introduced into its vessel soon after the fifth exuviation, but only after they were gorged with food, to avert hostilities. Both gave unequivocal symptoms of satisfaction. Their union followed, the breast-plate or (more properly) the apron of each being folded back. This female underwent several exuviations. Its shell was originally of a beautiful intermixture of green and white. On the first exuviation, the new shell appeared in perfect purity, with precisely the same colours distributed in the same manner. This shell subsisted 210 days. The male survived but a short time; nor did the union of the animals prove prolific.

Numerous other examples were afforded by the *Cancer Mænas*, all to the same purport. The observer must feed the subject of experiment frequently, that is, every day or every second day, and renew the sea-water as often. Nothing prognosticates exuviation unless abstinence for one or more days previously, and greater quiescence. The colours are alike vivid on exuviation, as if the animal were at large; but if it be a defective specimen, mutilated perhaps of both large claws, or of the eight limbs, all these ten organs will come in perfect and entire on the first subsequent exuviation, as an integral portion of the new shell. On the other hand, no subsisting shell which is mutilated seems ever to acquire a new limb. There is naturally a great disparity in the size of the claws of various genera.

It is difficult to explain either the formation and position of the new shell within the existing animal, or how it escapes on exuviation.

For a long time I concluded that the new parts were derived from the old, that a claw was generated within a claw, a limb within a limb, the eyes within the eyes; thence concurring in the prevalent opinion, that on exuviation each was withdrawn from the pre-existing organ as from a sheath. Nature seems to conduct her operations otherwise. But the means are most obscure.

The adult of the common Crab, *Cancer Pagurus*, is of a reddish brown colour, darker or lighter, the claws always tipped black; but some of the young are naturally of the purest white, which remains long unsullied. This is not incident to confinement, which has no effect on colour.

A young white specimen, C, was taken among others on September 29. The body might have been circumscribed by a circle, nine lines or three quarters of an inch in diameter, and the extended limbs by one and a half inch in diameter. Its first exuviation ensued on November the 8th; the second on the 30th of April following; the shell now produced subsisted until September 12, when another exuviation took place, introducing a new shell of such pure and transparent white, that the interior almost shone through it. All the shells were white, and somewhat larger successively. This last shell of September 12 subsisted until March 29, being 197 days, when it was evacuated by another exuviation, introducing its contents, D, to view. The new animal, as I must call it, D, had only the two claws; all its eight limbs were deficient. Resting on the breast, I did not at first discover the fact, but the creature presented a very strange and uncouth aspect. However, it fed readily and proved very tame, though helpless, often falling on its back, nor able to recover itself from wanting the limbs. I preserved this mutilated subject with uncommon care, watching it almost incessantly day and night; expecting another exuviation which might be attended with interesting consequences, I felt much anxiety for its survivance. My solicitude was not vain. After the defective shell had subsisted eighty-six days, its tenant meantime feeding readily, the desired event took place in a new exuviation on June 23.

What was now disclosed? Still another animal, E, came forth, and in the highest perfection, quite entire and symmetrical, with all the *ten* limbs peculiar to its race, and of the purest and most beautiful white! I could not contemplate such a specimen of Nature's energies restoring perfection, and through a process so extraordinary, without admiration. Something yet remained to be established. Was this perfection permanent, or was it only temporary? Like its precursor, this specimen, a very fine one, was quite tame, healthy, and vigorous besides. In 102 days it underwent exuviation, when the new animal, F, appeared in all perfection, with a shell of snowy white and a little red speckling on the limbs. Finally, its shell having subsisted 189 days, was succeeded by another, G, of equal beauty and perfection, the speckling on the legs somewhat increased. As all the shells had gradually augmented, so was this much larger than any. The limbs extended would have occupied a circle of four inches diameter. About a month after this last exuviation, the animal perished accidentally, having been two years and eight months under observation. This was a fine and interesting specimen, extremely tame and tranquil, always coming to the side of the vessel as I approached, and holding up its little claws as if supplicating food. Thus the perfection regained is permanent; nature preserves the symmetry she originally designed.

A weaker specimen of the *Cancer Mænas*, H, had been mutilated of both claws and six limbs by the preceding animal when first taken. Crabs are in general extremely contentious, many species waging a war, even to extermination, against each other. This mutilated specimen survived several weeks, and died apparently of abortive exuviation, not of its wounds,—when I thought the new animal to be produced might be discovered lying with the limbs folded over the breast.

Another small crab, I, having lost five limbs, including one of the claws, was diligently preserved. As reproduction is first announced by a papilla rising from the remaining stump in the mutilation of fleshy animals, I watched the several stumps here preserved, without adverting to the improbability of the same process when there was a casement of shell; yet I was so much influenced by what I had heard and read, that I began at length to believe papillæ actually perceptible; but in due time the illusion was dispelled by the appearance of the new animal with all its ten limbs perfect, on exuviation. No regenerating limb ever protrudes from the vacant stump. Under all these circumstances, it is evident that the new subject—the shell and animal—to be produced on exuviation, must be concentrated within the smallest possible bounds, lying with the limbs crossed over the breast in the original shell, which sunders or gapes between the hind pair of limbs, to allow its exit when mature.

Precisely the number of defective organs is presented by exuviation along with the rest. A specimen of the *Cancer* (or *Portunus*) *pusillus*, whose limbs expanded two inches between the opposite extremities, had lost both the claws. From this defect it fed itself with difficulty, for the claws of all crabs, lobsters, and such animals are employed just as the human hands. Both claws however appeared perfect in the new animal introduced on exuviation. The same occurred where only one pincer of the forceps of a claw was defective. Taking everything in view, therefore, the whole parts constituting the entire animal must be produced or reproduced within the original or subsisting shell; but generated or regenerated. The time and mode whereby this is effected, I must leave more skilful physiologists to determine.

The course of exuviation of the lobster-tribe may be conveniently followed in the *Crangon* or shrimp, which is easily kept and fed, and becomes very tame; also the process is frequent. The integument separates entire and is almost colourless.

The *Cancer Bernhardus*, the Soldier or Hermit Crab, is intermediate between the *Cancer* and *Astacus*. As only the upper half is invested by a shelly covering, its exuviation is limited in correspondence, there being nothing to separate from the lower, the fleshy portion. The peculiarities of exuviation by the other crustacean genera, being sought from themselves, will be found extremely interesting by the practical naturalist.

In as far as I have been able to ascertain, prolific females are exempt from exuviation during the period of gestation. The spawn or roe adhering externally to the shell would be endangered by such a process. This spawn, which is seen in beautiful variety, in colour and quantity, often resembles luxuriant clusters of currants or grapes, each capsule containing a fœtus, which is discharged on maturity, while the spawn still remains *in situ*. The young has no resemblance whatever to the parent.

The preceding facts, combined with many other observations, lead to the following conclusions:—

1. The crustacean tribes are invested by a rigid inexpansible shell.

2. As the existing shell cannot dilate to allow the increment of the animal, it is wholly cast off by *exuviation*, to make way for another, which is always of larger dimensions.

3. This exuviation, commencing at very early age, is repeated at irregular intervals during the progress of increment, each successive shell with its animal exceeding the size of its precursor.

4. The larger or new shell and animal is generated or regenerated within the existing shell, which opens for its exit when mature.

5. No enlargement of the new subject is sensible after production.

6. Whatever the mutilation may be which the existing shell and animal have undergone, the new subject is always produced entire and perfect by exuviation.

7. Prolific females are exempt from exuviation, that their spawn adhering externally may not be exposed to injury.

8. The young of many crustaceans, which bear no resemblance to the parent, attain symmetry and perfection through the medium of successive metamorphoses.

Notice of a Tissue spun by Caterpillars. *By* JAMES DENNISTOUN.

In the early part of this century there lived at Munich a retired officer, Lieutenant Hebenstreit, who amused himself by experiments on the means of giving consistency to the gossamer produced by caterpillars, which is occasionally seen blown about in flakes over the fields in Germany, and he was at one time sanguine of rendering it available as a material for ladies' dress. It is said that his plan was to prepare a paste of lettuce or other leaves beat up with butter, and, after spreading it thinly over a smooth surface of stone or wood on an inclined plane, he placed at the lower end a number of chenilles or caterpillars of the proper species. These animals gradually ascended the incline, devouring the paste, and depositing as they proceeded a sort of tissue until the whole surface was uniformly covered with it. He is reported to have produced open-work designs by drawing the pattern with a hair pencil dipped in olive oil before the animals began to work. These I never saw, but I have seen one veil on which were some letters exactly resembling a water-mark on paper, the secret of which I do not know. The inventor pursued his experiments with great secrecy, in the hope of turning his invention to valuable account; but finding this impracticable, it appears that he produced but very few specimens, which are now preserved in various museums on the continent. I have seen two besides my own, which I procured at Munich in 1837 after having advertised for it several months. The objections to using this tissue seem to be chiefly its exceedingly flimsy quality and its very adhesive properties, which render its management and preservation extremely difficult—attaching itself closely even to the smoothest surfaces, from which it can be separated only by the breath. My veil is about 42 inches by 24. One of $26\frac{1}{2}$ by 17 inches is said to have weighed only one grain and a half. Another containing nine square feet is mentioned as weighing $4\frac{1}{3}$ grains, while the same surface of silk gauze weighed 137, and of fine lace $262\frac{1}{2}$ grains. A notice of these tissues appeared in Chambers's Journal about ten or twelve years ago. It would seem that the art was in some degree known at an earlier period, and occasionally practised in convents, where coloured drawings on small bits of it are said to have been made. I have seen in all four of these on the continent, and two or three on which impressions from copper-plate had been taken—always of sacred subjects. One of the drawings is in my possession, about 7 inches by 5, executed apparently in the last century, and I have seen one dated about 1770.

On the European Species of Echinus, *and the Peculiarities of their Distribution.* *By* Professor EDWARD FORBES, *F.R.S.*

When the author published his account of the British Echinodermata, he laid great stress on the distinctive characters furnished by the sculpture of the spines in each species. In this communication he endeavoured to show that these characters are of the most certain kind, that they bear definitive relations to the more important features of the organization of the test, and that through them we are enabled easily to recognize even the most aberrant varieties of each species.

In the work alluded to, five species of *Echinus* were enumerated as British: viz. *E. sphæra, E. Flemingii, E. miliaris, E. neglectus,* and *E. lividus.* Although during the ten years which have passed since the publication of this list, the most active exploring researches have been carried on in our seas, only two additional forms have been brought to light.

One of these is the *Echinus Norvegicus* of Duben and Koren, a pretty species of small size, first observed on the Norwegian coasts, and since dredged by Mr. McAndrew off the shores of Zetland. The other appears to be identical with the *Echinus Melo* of the Mediterranean. It was discovered on the coast of Cornwall by

Mr. Peach. It exceeds all our other British species in size, and is nearly allied to *E. sphæra*.

The researches of Duben and Koren on the shores of Norway have now made us fully acquainted with the distribution of Echinoderms to the north of Britain. The works of Mediterranean naturalists, and the author's own researches, have afforded ample information respecting the southernmost European species. There remained to connect the Mediterranean and Celtic provinces, by an examination of the Lusitanian coast. Valuable materials towards filling up the gap have been procured by Mr. McAndrew, during his recent cruize on the Spanish and Portuguese shores, and submitted to the author for examination.

On comparison of all the materials thus brought together, it would appear that the species of the genus *Echinus*, inhabiting the European seas, indicate four principal types of distribution—1st. an arctic, to which *Echinus elegans* appears to belong; 2nd. a boreal, of which *E. Norvegicus* and *E. neglectus* are members; 3rd. a Celtic, of which *E. sphæra* and *E. miliaris* are the characteristic forms; 4th. a Lusitanian, of which *E. esculentus, E. lividus* and *E. melo* are members, and to which also the little Mediterranean *E. monilis* belongs. *E. Flemingii* is probably a member of this southern type.

On the Anatomy of Doris. *By* ALBANY HANCOCK *and* DR. EMBLETON.

The paper, which was illustrated by numerous drawings, contained a description of the different internal organs, and embraced several new points, namely,—

Some hitherto unnoticed modifications of the digestive organs.

A full account of the complicated organs of reproduction, and their varieties: these organs have long been matter of dispute.

A notice of an additional heart, having a portal character and driving along its artery, whose branches form a network with the hepatic twigs of the aorta, venous blood; thus a mixed current is sent to the liver for the secretion of the bile.

A description of a renal organ, on the walls of which the network of aortic and portal vessels is spread out before they reach the liver.

A new version of the course of the circulation of the blood in these mollusks, showing that the blood which is returned from the liver-mass, *i. e.* liver, renal organ and ovarium, is the only portion of that fluid that traverses the branchiæ before reaching the heart, the rest being returned from the other viscera and the skin directly to the auricle, and there mixed with that which has passed through the branchiæ.

Lastly, an account of a true sympathetic nervous system in *Doris* and other mollusks, consisting of plexuses of nerves and ganglia on all the viscera, a system quite analogous to that of the higher animals. Thus it appeared that the œsophageal circle of ganglia corresponds to the cerebro-spinal nervous system of the Vertebrata; the individual ganglia of the mollusk were then compared to their counterparts in the vertebrate cerebro-spinal axis so as to bring out their true signification.

From the whole paper it was evident that the mollusca are much more highly organized than has been supposed, and that as regards the organs of vegetative life at least, much more richly endowed than the Articulata have yet been shown to be.

On an Acarus *and a* Vibrio *that attack Grasses. By* JAMES HARDY.

Our indigenous grasses occasionally become diseased by the attacks of small animals, and the author described some that had not hitherto been observed. In the beginning of July his attention was directed to *Holcus lanatus* (meadow soft grass), in which many of the panicles were blighted. The causes of this were two:—in the one case the base of the shoot was either dissevered from the stem, or was becoming putrescent where in contiguity with it; and occasionally channels were eroded in the enveloping integuments, which were sometimes strewed with hard granules, apparently excrementitious. These were produced by an active yellow maggot, which the author suspected belonged to a *Chlorops*. In the second set of examples the panicles were quite soft and debilitated, and the branchlets were matted together by some action that had entirely exhausted them. On a close inspection, several small white spherical glassy bodies were perceived sticking amongst the florets, and closely invested by them. On extracting one of these, it was found to be a soft turgid animal, evidently an *Acarus*, but differing from most species of this genus, in being to outward appearance destitute of legs. This creature is about half a line in length. The author then proceeded to give a detailed account of its structure. Although in the later stages of its growth no legs are perceptible, the author had abundant opportunities of observing the young immediately after being hatched, when they were found to possess six very serviceable legs. The *Acari* are most abundant near the summit of the panicle, but they sometimes occupy the base only. The stem of the grass seems the principal object of their attack, and the drooping of the panicle the result of the arrest of the ascending sap, which they use for their own nourishment. The author had also observed this creature on *Holcus mollis*, or likewise *Avia cæspitosa* and *Phalaris arundinacea*. He proposed to call the species *Acarus graminisugus*. The author had also observed a new *Vibrio*. This was noticed on the sheep's Fescue grass (*Festuca ovina*), and some other grasses of the sea-coast. They are affected with several purple knots or swellings, which on being opened appear as if filled with bluish or purplish granules; but on closer examination, a little white annelide was observed coiled up, in channels winding amongst the granules. These were the *Vibriones*. Some of the knots contained only one, others half-a-dozen of these creatures. They are white, almost transparent, very minute, just visible to the eye, and slender-pointed at each end. This *Vibrio* differs from the one described by Mr. Bauer, and which produces the ear-cockles or bunt in wheat. The author therefore proposes to call this species *Vibrio graminis*. It is by no means unfrequent amongst the short grasses on the sea-coast, and occurs likewise inland, especially on *Agrostis alba*.

On the Genus Perodicticus *of* Bennett, *and its relation to* Stenops. *By* Prof. Van der Hoeven.

The *Lemur Pollo* of Gmelin, a species from the coast of Guinea, had hitherto only been known very imperfectly, the two specimens observed by the late Mr. Bennett and by the author of this notice having been both young and not having all their teeth. The author has had the opportunity of examining an adult specimen in the past year, and found the dentition quite similar to that of the genus *Stenops*. The tarsal bones were of the same shape as in *Stenops*, and the statement of Bennett, that the tarsus was elongated, is incorrect. It seems then that *Perodicticus*, the genus formed by Bennett on the *Lemur Pollo*, is not sufficiently distinct from *Stenops*, and could only be admitted as a *subgeneric* group, by those who are not willing to admit the fashion of many contemporary authors, who make genera for nearly every species. The tail and the short index of *Perodicticus* seem to be characters of an inferior and subordinate order.

On the Upper Jaw of the Iguanodon. By G. A. Mantell, *LL.D., F.R.S.*

Dr. Mantell exhibited and described a portion of the upper jaw, with seven teeth in place, of the Iguanodon, recently discovered in the Wealden of Sussex. Dr. M. laid before the Section specimens of the upper and lower teeth of this gigantic herbivorous reptile of various ages, and in different states of detrition from use, and explained the dental arrangement Dr. Melville and himself had inferred from the detached teeth, and which was confirmed by the fossil now exhibited, in which there were several mature molars in their natural position. Drawings and restored figures of the cranium and jaws were shown in illustration of the author's remarks; and the opinions of the comparative anatomists present were solicited as to the physiological inferences to be deduced from the anatomical facts described; especially relating to the muscles, prehensile tongue, and flexible lips, as indicated by the edentate character of the symphysial portion of the lower jaw, and the number and magnitude of the vascular foramina, &c., characters not present in any existing type of the class Reptilia.

A List of Zoophytes found in the Vicinity of Peterhead, N.B., with a Notice of some new to the British List. By C. W. Peach.

The author commenced by stating that when he went to Peterhead in December last, he took with him a paper of Mr. John McGillivray's, containing a list of the zoophytes found on the coast of Aberdeen; this list he had verified, with the exception of two, and he has added above as many more (including rare flexible kinds); the principal additions being calcareous, mostly *Lepralias*. He observed that many which are most abundant on the coast of Aberdeen, are either very rare or altogether wanting on the Cornish coast, and *vice versâ*. The list now contained 107 species, all of which he had carefully examined before admitting them to the list. The first new one which he mentioned is a *Cellularia* of great beauty, differing from all figured in Dr. Johnston's edition of the British Zoophytes, in the shape and arrangement of the cells having one tooth on the upper edge of each cell. The next is an *Actinia*, which, from its colour and markings, very much resembles a Carnation. He concluded by saying, that although hitherto the shores of Peterhead had been considered to be bleak and wild, and barren of specimens of Natural History, it is quite a California in naturalists' gold.

On a peculiar Structure in the Submedial Pair of Rectrices of Vidua paradisea. *By* H. E. Strickland, *F.G.S.*

When these feathers are in a young state, the barbs of both webs are united at their extremities to an intermediate filament, which becomes detached as the growth of the feather advances, and ultimately falls off. This filament is furnished on both sides with alternate tufts of "barbules," and these barbules possess hooked "barbicels," similar to those which exist on the distal side of the ordinary feather-barbs. By means of these hooks the filament embraces and clasps the barbs which are attached to its two opposite sides. This structure appears to be peculiar to the *Vidua paradisea*, and to the submedial rectrices only in that bird. Its object is probably the protection of the feather-barbs during the course of their development. But it is difficult to account for so complex a structure occurring in two feathers only, in a single species (so far as known) of bird. This singular structure was originally described and figured by the accurate Brisson (Orn. vol. iii. p. 123. pl. viii. f. 1.), but seems to have been wholly overlooked by later observers. Illustrative figures are given in Sir W. Jardine's 'Contributions to Ornithology,' 1850.

On the Dentition of the British Pulmoniferous Mollusca. By W. Thomson, *King's College, London.*

In this paper the author gave a detailed account of the number, form and arrangement of the lingual teeth of this order, his observations being founded upon an examination of more than fifty British species, both land and freshwater. His object was to show, that all the different teeth on a tongue are only modifications of one typical form, which is to be met with in the central longitudinal row of teeth. Also, that the direction of the transverse rows, that is, the mode of divergence of the teeth from the central line on either side to the margin of the tongue, is regulated by the nature and extent of these modifications. The result of his researches throws much new light upon the structure and affinities of this order of mollusca; and amongst other points of interest, it tends to establish, as truly generic, the groups known by the names of *Zonites* and *Zua*. The author places *Zonites* near *Vitrina*, and between *Limax* and *Helix*; he considers *Zua* as intermediate between *Helix* and *Limneus*, and *Pupa* (which scarcely differs from *Vertigo*) as the connecting link between *Helix* and *Zua*.

On the Application of Photography to the Compound Microscope. By Wyville T. C. Thomson, *Sec. R.P.S.*

The author stated that he had found it possible, by placing a sensitive plate, by means of a slide so constructed as entirely to defend it from the light, in the position of the *second* glass of the eye-piece of a compound microscope, to obtain with a low power a correct and delicate photographic picture of the microscopic field.

By means of the albuminized glass plates, the preparation of which has been brought to such perfection by Messrs. Ross and Thomson of Edinburgh, a transparent and very permanent negative picture is thus procured, from which any number of positive prints may be taken.

This process seems to be peculiarly adapted to the illustration of sections of recent and fossil woods, and other well-defined objects not requiring a very high magnifying power; for more delicate tissues the Daguerreotype seems to be preferable, as the silvered plates are more sensitive to the action of light.

Some dissections of insects, portrayed in both ways, were exhibited to the Section.

On the Birds of the Faroë Islands. By J. WOLLEY (*of Beeston*).

In illustration of the abundance of certain kinds of food, the phænomenon of the sudden rise of a compact shoal of small marine animals, probably crustaceous, was mentioned; which, on the authority of an intelligent native, has given origin to the belief in the existence of the huge flat sea-monster, the *Kraken* of Pontoppidan, called in Faroë *Kraka*, or *Teara-bue*. The particulars given by the Bishop, and those related by credulous eye-witnesses in the islands, are mostly consonant with this explanation. Such are the choice of particular localities, the seaweed-bank appearance, the birds hovering over it, and the fishes feeding upon its dung, with the calmness and heat of the weather; the latter also necessary for a sight of another of the sea-monsters, the *Soe-ormen*, for which the effects of electrical jets of air, little whirlwinds, or waterspouts, have undoubtedly been mistaken by some at least of Pontoppidan's witnesses.

In a list of thirty-six birds found breeding in 1849, there were the names of only two not known to breed in Britain, the Snow Bunting, *Emberiza Nivalis*, and the Purple Sandpiper, *Tringa maritima*, both of which frequent the tops of mountains. The Fulmar, *Procellaria glacialis*, about ten years ago began to establish itself on the cliffs of Faroë for the first time. The Whimbrel, *Numenius phæopus*, and the Great Skua, *Lestris catarrhactes*, the latter preserved at its two stations in Britain only by the constant care of the proprietors, are, from their numbers, most characteristic of the Faroë Isles. Reasons were given for not considering *Uria lachrymans*, Gould, distinct from *U. troile*. One occurs in about every ten Guillemots on the rocks of Sutherland, Caithness, Shetland, and Faroë. The methods of bird-catching are just as they were described by Luke Debes nearly 200 years ago.

Accidents in climbing for Guillemots with the ropes very rarely occur; but in catching Puffins, *Mormon fratercula*, which is done with a kind of landing-net on the slippery slopes, they are more frequent. Guillemots, and their congeners, young Cormorants, and some other sea-birds, are an important article of food, and when properly cooked, as at the houses of the clergy, are even a delicacy to English tastes. Several traditionary particulars respecting the Great Auk, *Alca impennis*, were collected. After many observations on the habits of the different birds, their relative numbers, their distribution in breeding stations, and the etymology of their several local names, Mr. Wolley concluded by deducing a lesson from the mode in which they are treated by the human inhabitants. Although numbers are caught at stated times, yet on the whole they rather increase than diminish, for they are not constantly annoyed as they are round the coasts of Britain. Both the established rights of the bird-climbers and the interests of our coast navigation, require that the sea-birds should be protected at their breeding-places, where they cannot or will not take care of themselves. In foggy weather they warn vessels of their approach to the dangerous headlands which they chiefly frequent. Already they are very greatly diminished in numbers, and the persecution is constantly increasing. On the Yorkshire cliffs slaughtering parties arrive by trainsful. All the birds will soon be destroyed or driven from our inhospitable shores, unless the Legislature or other powers should think the matter worthy of their attention, as it is to be hoped they will. The protection afforded to them in the vicinity of one or two lighthouses on the west coast, and also round the Bass Rock and Ailsa Crag, are pleasing exceptions to the general rule, and show what may be done.

Physiology.

Suggestions regarding the expediency of ascertaining the extent to which Infantile Idiocy prevails in the United Kingdom generally, and of inquiring into the Causes of its Prevalence in certain Districts, with a view to the adoption of some means of deliverance from it. By John Coldstream, *M.D.*

In all civilized countries there has been, within the last sixty or seventy years, a great and most satisfactory progress in the increase of efficient means for the treatment and care-taking of the insane and fatuous. Few applications of the results of modern science have been productive of so much social good, as those which have issued in the improved construction of lunatic asylums, and the treatment of their inmates. Still something is wanting to complete the agency which has been so successfully brought to bear upon these important objects. Hitherto but little provision has been made for *the proper treatment of congenital* or *infantile idiocy*. But, seeing that we are now able, from experience, to affirm that this widely-spread malady is, in many instances, susceptible of great mitigation, and even of cure, when early and properly treated, it becomes imperative upon the public authorities to provide adequate means for affording to those affected with it the best chance of relief. The success obtained by Dr. Guggenbühl at his establishment for the cure of young cretins, on the Abendberg in Switzerland (commended to the attention of Members of the British Association in 1845 by the late Dr. Twining), as well as that accorded to the labours of other physicians in Paris and Boston (Massachussetts), and latterly, the experience of the asylum for idiots at Highgate, all conspire to prove that attempts to rescue the fatuous from their deep degradation are very likely to be crowned with success.

It must be regarded as essential to the satisfactory commencement of a general scheme for the amelioration of idiocy, that exact information should be obtained regarding the *numbers* of children affected with the disease throughout the kingdom. No means exist at present for enabling us to determine these numbers. A special inquiry, conducted under the authority and at the expense of government (like any other survey for a national purpose), would alone suffice to bring out the statistical information sought for. Such an inquiry would, of course, require much delicacy of management. Regard must be had to the natural feelings of parents, otherwise the agents would often fail to obtain an accurate statement of the facts. In making the first move, any government commission that may be charged with the inquiry should assume the attitude of conveying information to the people on a subject which they must be presumed to be generally ignorant of. The commission would announce that it had been appointed for the purpose of making known the encouraging fact that some forms of idiocy, hitherto regarded as incurable, are amenable to proper treatment; and further, with a view to the future provision of some general system of means of treating those so affected, it had been charged to inquire into the extent of the disease in the several districts of the kingdom, the forms of it most prevalent, and the causes which seem to lead to it, particularly in so far as these may appear to be connected with some peculiarities in certain localities. An address to the nation at large, fully explanatory of these views and objects, might be followed up by the circulation, through each town and neighbourhood visited by the agents of the commissioners, of a shorter circular having the same object, and in addition, announcing the readiness of the appointed officers to visit whatever cases may be mentioned in the schedules, one of which would be left at each house and subsequently called for. It is not to be expected, that however kindly and courteously all this might be carried on, returns would be obtained of *all* the existing imbecile and idiot children in the land. But it is almost certain that but few parents would withhold the information sought for, if only they were assured that benefit to their offspring might result from the use of means (to which the inquiry would be announced as preparatory), and if they were given to understand that no *names* of parties having affected children would be published. At all events, it may be presumed no more thorough system of inquiry could be adopted in this country with due regard to the liberty of the subject.

As to the measures which ought to follow upon the completion of the proposed inquiry, these would naturally take their shape in part from the results of the inquiry. But we may conjecture with plausibility, that it would be found, that to do justice to the treatment of the affected children, four or five separate establishments in Scotland, and fifteen or twenty in England would be required. These ought to be situated in the vicinity of the districts most affected with the disease. They would fall to be supported, just as the lunatic asylums are, partly by the contributions of parish-funds for paupers, and partly by the fees of parents sending children.

The first element necessary to a right determination as to what ought to be done to meet the necessities of the case, is the obtaining of a clear view of the extent of the evil with which it is proposed to grapple; and this can be attained in no other way than by making an accurate statistical investigation.

Observations on Hysteria, Hydrophobia, and other Convulsive Affections, embracing an Analysis of the Phænomena of Water-dread. By JOHN DALZIEL, *M.D.*

Prefixed to Dr. Dalziel's dissertation is the following intimation:—

"[N. B. The original paper, of which this is substantially a copy, was written upwards of twenty years ago; and a brief notice of it was published in the Glasgow Medical Journal for November 1830.]"

Dr. Dalziel's paper obviously resolves itself into two distinct parts:—

I. The theory of convulsive affections; and II. The analysis of the corporeal and mental process undergone by the hydrophobic patient on the presence, &c. of liquids.

I. The theory of convulsive affections as regards hysteria and hydrophobia is expressed by Dr. Dalziel in the three following propositions:—

"1st. The globus hystericus, as well as the similar affection of the throat in hydrophobia, which is occasioned by the idea, &c. of liquids, is a spasmodic stricture of the glottis, whereby respiration is obstructed.

"2nd. Obstructed respiration, whether suspended or impeded, occasions *cerebral congestion*, as well as that feeling of '*general uneasiness*' designated 'sensation of suffocation,' which is an attendant on the diseases under consideration.

"3rd. Cerebral congestion and this 'general uneasiness,' separately or conjointly, may, especially in an irritable habit, occasion convulsion."

Convulsions from foreign bodies in the larynx do not, he argues, proceed directly from the local irritation, as the "current language of surgery" would indicate; but are induced indirectly by suffocation, &c. Convulsions from *local irritation elsewhere*, he conceives, flow from the same source,—violently obstructed respiration,—the aperture of the glottis being instinctively closed and the muscles of expiration called into vigorous action for the purpose of mitigating pain. By this process, he alleges, the pain is actually mitigated through means of the consequent "cerebral congestion," although the temporary relief is occasionally purchased at the expense of a convulsive or even an apoplectic attack.

We may insert here the practical inference Dr. Dalziel deduces from the preceding three propositions, viz. "that in the treatment of hydrophobia, the performance of the operation of bronchotomy is advisable, with the view, not only of warding off or palliating the convulsive paroxysm, but also of preventing other injurious effects of obstructed respiration, which will afterwards be specified." These we may mention are inflammatory affections of the lungs and brain, emphysema and spasmodic constriction of the muscles of the chest,—formidable accessories all.

II. Of the author's analysis of water-dread it is difficult to give an abstract. He assumes that it is more difficult, because it requires a greater degree of contraction of the muscles of deglutition, to swallow a liquid than a solid; and violent contraction of muscular fibre will induce spasm, in a state of health, much more when in an irritable state. Again, there being little relish for *food, it* will be swallowed with indifference, and hence *with ease*, while, there being urgent thirst, liquids will be swallowed with avidity, *especially water*. But the very preference of water to any other liquid is precisely the reason why, at a certain point in the progress of the malady, the swallowing of it excites convulsion, &c. Only now increase the thirst, and the mere presence of water will be sufficient to produce the effect. Yet, again, add to the feeling of thirst, or increase the irritability, and the very ideal presence of the tempting beverage will excite the muscles of the throat and effect the catastrophe:—a general miniature type this of many of the ills of life.

Of the Influences of Man's Instinct on his Intellectual and Moral Powers, i.e. *his Mental Functions. By* RICHARD FOWLER, *M.D., F.R.S.*

The body of an animal is the mortal coil, or rather congeries of coils, through which its vital and mental forces act. Each of these coils has an instinctive appetite for its appropriate object, the wants, appetites, emotions and passions, both of man and animals inferior to man, though instinctive and susceptible of control by the mind, and subject to the direct influence of the physical forces, gravitation, motion, chemical affinities, heat, light, electricity, and magnetism.

Now the most marked difference between man and other animals seems to be, that man has to contrive the means by which his ends are to be attained, whereas to animals the means of gratifying their instincts, wants, or appetites are instinctive. The spider requires no previous teaching to weave its web, and the Chinese fish (see 'Bell on the Hand') with unerring aim brings down a fly from some feet in the air with a drop of the water in which it swims. Shells, scales, fur, and feathers defend them from the elements, and more perceptive organs of sense are given to all for detection and pursuit of their prey. Man, urged by his wants to devise means for their gratification, is thus schooled and impelled to the cultivation and progressive improvement of both his intellectual and moral faculties, for the obstacles to be removed force on him the control of his own propensities and the conciliation of the aid of his fellow man. Our wants therefore may not be considered an evil, but rather as the Pertinens Interrogatio, suggesting search, and are thus the sources of all the arts and of a large portion of the sciences by which human life is gladdened, sustained, and informed.

The author shortly adverted to Outness, or the instinctive belief that all the objects with which we are surrounded are separated from us by apparent distances in space, while it is now known that this belief is not more than an instinctive inference (sustained indeed by concurrence of periodical returns of phænomena at the exact times calculated and perspective sketches of objects at different distances) from subjective sensation; for even of the forces by which all changes in objects and their relations to each other are affected, the mind has very direct perception; that this is really so, light and heat may be adduced as instances.

Of the travellers who meet at the half-way hut on the Andes, those who have descended feel over-heated, while those who are ascending complain of cold, though the actual temperature, as measured by the thermometer, is the same to both parties.

Analogous to this is light, as it is seen by persons in the passages to and from a diorama.

The hand that has been in hot water feels cold, while the other just out of cold water feels warm, when both are dipped into the mixture of the hot and cold water.

Again, all the physical forces are felt as different while passing in or out of our bodies, for instance, gravitation and motion, while ascending or descending in a swing; of heat and light, the instances given above may suffice. The operations of a surgeon inflict like wounds, whether pure air or chloroform has been respired; but how different to the feelings of the patient are these changes of the chemical affinities when continued or obstructed; buoyancy when pure air has access to the blood, faintness when chloroform is substituted! Is it not then demonstrable that what is perceived by the mind directly is not the objective excitors, but the subjective effects, notwithstanding our instinctive belief of the contrary?

On the still debatable subject of innate ideas, the author doubted whether we have any other than the mind's perception of our functional appetites in the various organs of the body (accompanied as they are with corresponding changes in the passage of the blood through the heart), and of the impressions made by the physical forces incessantly exciting all our sensational structures; hence every antecedent sensation is intuitively inferred to be the cause of the propensity felt for any action or object of desire, present or absent; for to be doing, in order to acquire something, is an incessant propensity in all animals.

On Pathological Cell-Development. By W. T. Gairdner, *M.D., F.R.C.P., Pathologist to the Royal Infirmary, Edinburgh.*

The object of the author in reading the paper was to demonstrate the existence in morbid fluids and structures (and more particularly in *pus*) of a number of cell-forms not usually described, and difficult of interpretation, either upon the theory of Schleiden, Schwann and Valentin, of *exogenous* cell-development, or on that of Barry and others, of *endogenous* growth. The author maintained that it was impossible in the case of the structures described, either to refer the formation of the cell-wall to the activity of a pre-existent nucleus, or to consider the latter as springing from the former. The only view which appeared to meet the case was, that the nucleus and cell-wall had each an independent power of organization, and that the one was superimposed on the other when they happened to be formed in juxtaposition. The author said that this was only one proof out of many which had been afforded by recent observations, that the cell-theory, at least in its original form, was not sufficiently comprehensive for the facts of modern physiology. [The paper was accompanied by drawings, without the aid of which the details would be unintelligible.]

On the Geometrical Basis of Beauty in general, and more particularly as applied to Architecture and the Human Form. By D. R. Hay, *F.R.S.E.* (*Communicated by* Professor Kelland.)

The basis of harmony in music is the fact that the ear is pleased with a mixture of sounds, when the vibrations which constitute them severally recur with a frequency expressed by some very simple arithmetical relations. Thus, when the notes C and G are struck together, a pleasing sensation is experienced, arising from the circumstance that the string which produces the one note makes two vibrations whilst the other makes three. On the other hand, if the notes C and C sharp, which vibrate nearly in the relative rapidity of 20 to 21, are struck together, the combination is exceedingly disagreeable even to the most uneducated ear. The first position laid down by Mr. Hay is, that the eye is influenced, in its estimation of spaces, by a simplicity of proportion similar to that which guides the ear in its appreciation of sounds. It may at first appear that this analogy between sight and hearing is not admissible, inasmuch as the eye judges of effects by passing from point to point, whilst the ear judges of them only by receiving them all at the same moment. This difficulty is obviated by two simple considerations; the one, that the standard of comparison is always present to the eye in ordinary cases*, which is equivalent to the key-note of a harmony being constantly ringing in the ear; the other, that all the faculties of man are from his birth under the influence of education, involuntary or constrained, by means of which their powers tend to become analogous. Thus the eye, the hand, and the ear are daily acquiring greater certainty in the estimation of intervals. Few persons are acquainted with the extent to which their faculties are capable of cultivation. In early life, necessity teaches us their simpler uses. The child is learning to judge, by muscular action, of distances and positions. Its hand soon finds the way to its mouth, and by degrees it can at once touch any part of the body, even in the dark; and there its education ceases. The blind fiddler, having heard none but the most simple performances, never ventures to quit the easiest position of his instrument, from ignorance of his possessing that sense of distance which, with a little cultivation, would enable him to trace his way to any part of the string. The appearance of a great *executant*, such as Paganini, proves to others that their faculties may be taught beyond what they have been accustomed to; and, although none may have his genius, many may acquire his art. And the same is true of our other faculties. The ear, perhaps, receives less involuntary education than any other faculty; but that it is capable of cultivation, so as to be able not merely to estimate sounds in succession, but with extreme accuracy to judge even of independent sounds, is well known to every musician. The involuntary education received by the eye usually enables it to form a tolerable judgement as to positions and relative magnitudes. Its estimate of the symmetry of an object is equally accurate with that formed, by a person unused to music, of the correctness or incorrectness of a note in the scale.

* It is usually four right angles, or the angles about a point.

Greater accuracy is the result of cultivation. An artist can detect errors in the proportions of a figure, which will escape an uneducated eye. From these considerations it appears, that whilst the ear is learning to judge of successive sounds with the same facility with which the eye judges of successive spaces, the eye, again, is acquiring the power of the estimation of spaces in combination, with that extreme accuracy with which the ear estimates a combination of sounds. And it is reasonable to conclude with our author, that simplicity of proportion, which is so necessary an element to the satisfaction of the one sense, should be an essential element to the complete gratification of the other. The next position laid down by Mr. Hay is, that the eye is guided in its estimate by direction rather than by distance, just as the ear is guided by number of vibrations rather than by magnitude. The architect well knows that one elevation of a simple building is more agreeable than another; but, on the application of numerical ratios to its measurement, he finds them to fail altogether. Artists, from the time of Albert Durer downwards, have measured the relative proportions of the human figure; but neither architects nor artists have, as yet, arrived at anything beyond the most vague and unsatisfactory inferences. This has arisen from their having taken length, and not direction, as their standard of comparison—from their having endeavoured to apply simplicity of linear, not of angular proportion. A picture frame, in which one side is half the other, is not of nearly so pleasing a shape as another in which one side is half the diagonal, or the angle which the diagonal makes with one side is half that which it makes with the other.

The basis, then, of Mr. Hay's theory is this, that a figure is pleasing to the eye in the same degree as its fundamental angles bear to each other the same proportions that the vibrations bear to one another in the common chord of music. Now, in music, the simplest divisions are by 2, 4, &c., which produce tonics; the next are divisions by 3, 6, &c., which produce dominants, and so on; and the chord is pleasing in proportion to the simplicity of the numbers which represent the vibrations of its constituent notes; and the same thing is true of the fundamental angles of a figure, &c.

On the use of the Bofareira (Ricinus communis *of Botanists*) *as a means adopted by the Natives of the Cape de Verd Islands to excite Lactation. By* J. O. McWilliam, *M.D., R.N., F.R.S., Surgeon to the Hon. the Board of Customs.*

The author, while engaged in an official investigation into the nature and history of a yellow fever epidemy prevailing on the island of Boã Vista in the Cape de Verds, had his attention drawn to a remedy commonly had recourse to there and in the other islands of the group, to accelerate and increase the flow of milk from the breasts of child-bearing women, in cases where that secretion was tardy in appearing, or deficient in quantity when it did appear. He also learnt, that on occasions of emergency this remedy could be successfully applied to a more important use, namely, to cause the secretion of milk in the breasts of women who are not child-bearing, or who have not given birth to or suckled a child for many years.

The leaves of a plant called in the language of the country *Bofareira*, but which in reality is the *Ricinus communis* of botanists, and occasionally the leaves of the *Iatropha curcas*, both belonging to the natural family *Euphorbiaceæ*, are the means by which these interesting, if not extraordinary results are produced.

In cases where the appearance of milk is slow, the breasts are fomented at short intervals, during two or three hours, with a decoction made from the fresh leaves of the *Ricinus*. The boiled leaves are also spread over the breast, and allowed to remain until milk flows upon the application of a child to the nipple. When it is required to produce milk in the breasts of women who have not given birth to or suckled a child for many years, in other words, when a ready-made nurse is suddenly wanted, the mode of treatment is somewhat more complicated.

The author, in giving the results of his own experiments with the *Bofareira* while at Boa Vista, among other cases alludes to one in which, according to Consul-General Rendall, a woman who had not borne a child for ten years, was on an emergency rendered capable of doing the duty of a nurse in the course of three days. He was also informed of similar cases by Mr. George Miller of San Nicolaõ, a gentleman of great talent and observation, many years resident in the Cape de Verds.

The author concludes his notice of this galactagogue of the Cape de Verds, by inviting a fair trial of its action in our more temperate regions, which, if found to be similar to that which it manifests within the tropics, will open an interesting field of inquiry as regards its hygienic, medicinal, medico-legal and other relations.

On the Reciprocal Relation of the Vital and Physical Forces. *By* George Newport, *F.R.S., F.L.S.*

In this communication, addressed in a letter to Dr. Lankester, F.R.S., one of the Secretaries of the Section, the author first drew attention to the views of Dr. Fowler, F.R.S., in a paper which had been read at a meeting of the British Association at Birmingham in September 1849, and an abstract of which is published in the Report of the Association for that year, p. 77. From this abstract it appears that Dr. Fowler advocates the view that the *vital forces* not only have reciprocal relations amongst themselves, but also with the *physical forces*, and that in the language employed by Mr. Grove with regard to the *physical forces*, they are *mutually correlated*, and are convertible the one into the other.

A writer in the British and Foreign Medico-Chirurgical Review advanced a similar theory in that Journal in January 1848, and during the present year a paper on the same subject by Dr. Carpenter, F.R.S. has been communicated to the Royal Society.

The author now showed, that so long ago as November 1845 a similar view had been advanced by himself in a memoir 'On the Natural History, Anatomy, and Development of the Oil-Beetle, *Melöe*,' read to the Linnean Society, but that the Council of the Society had omitted to publish this part of his paper in their Transactions when his memoir was printed.

The author's view had for its foundation, that *vital force* is derived *from without*; that its *degrees* or *kinds* have a close relation with the *physical forces*; and that, like the vital force, the *instinctive power* or *force* in animals is a change of form of these forces, in or through the organization of nervous structure. The *force* referred to in the author's paper read to the Linnean Society, in illustration of this view, was *light*. He had been led to the view he advanced through the results of some experiments on the effects of light on the *instinct* and habits of the young Melöe, as detailed in his paper, and through the discovery, then recently announced by Dr. Faraday, that light and electricity are the same principle, as Faraday and Matteucci had previously shown there is reason to believe is the case with electricity and the nervous function, and which seems to be confirmed by the recent labours of the latter philosopher, published in the Philosophical Transactions for 1850.

The author, after remarking that it was perhaps unnecessary for him to restate now, in support of the doctrine that the *vital forces* have a reciprocal relation with the *physical*, those circumstances which had already been mentioned, added, in support of the view advanced, the following facts relating to the evolutions of vital force in the embryo:—

Amongst insects there are some species of Canadian Perlidæ which undergo their transformations, and even pair at very low temperatures at the end of winter, when the ice begins to crack; they do so even in the crevices of decaying ice. This is the habit of *Capnia vernalis* and of *Brachyptera glacialis*. The ova, although thus deposited at a temperature but little above that of freezing, are produced at a time when diurnal warmth is increasing, because accessions of heat-force from without are required for the evolution of vital force within them, and to induce the formation of structure. The ova of the common earwig, *Forficula*, are rarely deposited at a temperature below 43° or 44° Fahr., and as both Degeer and the author have observed, the female attends to and incubates them during the whole period of development, turning and removing them from place to place according as the locality may happen to be of the required heat or moisture. The cells in the embryo or foundation layer of the impregnated egg grow by accessions of *heat* and moisture from *without*, acquire *gravity* through *chemical changes* promoted by *heat*, subdivide and multiply, and while the growth of the whole tissue is thus promoted by their individual influence, *vital force* is evolved in the whole as *motion*. Motion amongst individual cells is the invariable accompaniment of their growth and subdivision, and the reaction of the cells on each other is the commencement of motion in separate regions of the whole tissue, and also in the entire body of the embryo. Motion thus generated in individual cells during the earlier stages of formation of the embryo, through *heat-force* derived from without, becomes a fixed or inherent power, a *vital force* in one structure, muscular tissue, while the same force from without may be evolved as *light* in another. In the egg of the glow-worm, *Lampyris*, the cells in a portion of the foundation layer, instead of forming muscular or nervous tissue, retain to a great extent their primary individuality, and evolve their vital force as *light*. The author has seen light emitted from the luminous organs at the moment the embryo is escaping from the egg shell. To the objection that may be urged that this light may be simply that of combustion rather than a form of vital force, he remarks that the light of the glow-worm is excited to greater vividness, not only by increased temperature of the surrounding medium, and an acceleration of the respiratory and circulatory processes, as well as by immersion in oxygen, but also by mechanical irritation of the animal, and consequent excitement of *nervous force*. In this respect, then, the production of light by the glow-worm, he remarks, seems to bear analogy with the evolution of electricity through mechanical and other modes of exciting nervous force in the electrical fishes; and that force derived *from without* in the form of heat, seems thus to be converted through organization into *vital force*, and evolved as *muscular contractility*, *light*, *electricity*, or *nervous power*.

On the supposed relation of the Spleen to the origin of the Coloured Blood-Corpuscle in the Adult. *By* John S. Sanderson, *Emer. Pres. of the Royal Medical Society of Edinburgh.*

The inquiries, of which the results are detailed in the paper, were undertaken with a view of repeating and, if possible, verifying the results of several series of researches which have been brought forward by various continental physiologists as to the connexion of the spleen with the origin or disintegration of the coloured blood-corpuscle.

It had been maintained by Dr. J. Gerlach (Henlé and Pfeufer's Zeitschrift für Rationelle Medezin, band vii. s. 75, 1848; Handbuch der Gewebelehre, s. 216, 1849), as well as by Dr. Schaffner of Herrstein (band vii. s. 345 of the same Journal, 1849), that cells containing blood-discs in various stages of development were always to be found among the contents of the Malpighian corpuscles. On the other hand, it had been maintained by Prof. Kölliker (Ueber den Bau und die Verrichtungen der Milz; Mittheilungen der Züricher Naturforschenden Gesellschaft, 1847), by Dr. Ecker (Henlé's Zeitschrift, band vi. s. 261) as well as by Landis (Beiträge zur Lehre von den Verrichtungen der Milz, Zurich, 1847), that the special purpose of the spleen was the disintegration of the coloured blood-corpuscles, and that this was brought about by the aggregation of these bodies into rounded masses, and their subsequently breaking down into granular pigment, this process being effected with or without the enclosure of the masses in question in an apparent membrane, the seat of the process being, not the Malpighian sacculi or parenchyma, but the dilated veins of the organ. The conclusions which it is attempted to arrive at are—

1st. That cells containing blood-corpuscles never occur in the Malpighian sacculi of the spleen, and that the bodies which Dr. Gerlach described as such were more probably cells, which are here and there observed in that position, and which contain five or six round highly refractive nuclei, which resemble blood-discs somewhat in appearance.

2nd. That the structures described by Kölliker as cells containing blood-corpuscles are similar (as he himself believes) to the so-called "inflammation-globules," containing perfect blood-corpuscles which occur in the substance of the brain, and that they also correspond in nature and mode of production with the spherical cell-like bodies containing blood-corpuscles which occur in the *area vasculosa* of the cheek at an early period of incubation, and that all these forms are probably produced round masses of blood-corpucles in extravasated or stagnant blood.

3rd. That wherever extravasation or retardation of the circulation occurs, the changes described by Kölliker in the spleen will take place, and that, although from the frequency of these conditions in that organ the changes in question may be more frequently seen in it than in other structures, these changes bear no relation to the most important part of the function of the organ, viz. that which is performed by the constituent cells.

4th. That none of the cellular elements of the spleen are set free and normally enter the circulation as such.

On a Physiological Mode of resolving the Metaphysical Difficulties as to the Origin of the Notion of Space, of Motion, of the External, of Substance, &c. By WILLIAM SELLER, *M.D., F.R.S.E., President of the Royal College of Physicians of Edinburgh.*

The purpose of Dr. Seller's paper was to show that the metaphysical difficulties, as to the origin of the notions of space, of motion, of the external, of substance, &c., might be resolved physiologically on the two axioms, "that every sentient nervous filament is an independent instrument of sensation, and that every sensation involves an element of space, namely, the point of space where the organic change produced by the impression originates, that is, at the peripheral extremity of the nervous filament concerned;" that the infant thus comes to recognize the relative position of all the sentient points in the space occupied by the skin and muscular system, and that out of the element of motion besides involved in the sensation attendant on the contraction of every portion of muscular substance supplied with a sentient nervous filament, he finally comes to recognize the external contact of one part with another of the zone of space occupied by self, and the resistance of one part of self to the intrusion of another part of self; and that, having at length acquired the knowledge of the properties of the body itself as a piece of matter, he quickly obtains the notion of the external, because when an external body is touched it is distinguished by the negative property of affording no consciousness of being touched like that afforded by every part of self. The whole of the paper was not read, and therefore the entire view was not brought out.

On the Causes which advance or retard the appearance of First Menstruation in Woman, with a Synoptical Table showing the Mean Age of First Menstruation in 10,422 *Women in Hot, Temperate, and Cold Climates. By* E. J. TILT, *M.D., Senior Physician to the Paddington Free Dispensary for Diseases of Women and Children, and Physician to the Farringdon General Dispensary and Lying-in Charity.*

Whatever bears upon the theory of population is more than ever interesting, seeing that certain portions of the globe having become too densely populated, we are seeking to draught the overplus to far distant climes, to those wildernesses which have but seldom echoed the voice of man.

To ascertain the period of first menstruation in any variety of the human race, is to ascertain when its reproductivity becomes possible, a matter equally interesting to the physician, the philosopher, and the statesman; and it behoves them to know that this epoch varies under the influence of causes which for the most part have been insufficiently studied.

Dr. Tilt divides the modifying influences of the first establishment of menstruation into—

I. The extrinsic causes, such as climate, habitation, civilization.

II. The intrinsic causes, such as race, family, and national customs.

Dr. Tilt is of opinion that the action of the extrinsic causes is indubitable; and in proof of the influence of the first and most important cause, that of climate, he adduces the following carefully-made table, in which he has brought in striking opposition to such cases as we have been able to obtain from India, 3840 obtained from Denmark, and now for the first time made public; the sixteenth year in Denmark, the thirteenth in India, and the fourteenth in temperate climates, being the epoch at which this function generally begins.

Table of the Periods of First Menstruation of 10,422 Women of the Lower Classes, in Hot, Temperate, and Cold Climates. By E. J. Tilt, M.D.

GRAND MEAN OF ALL COUNTRIES, 14y. 4m. 18d.

Years.	Hot Climates. Number of Observations, 629. Mean Age, 13y. 0m. 16d.			Temperate Climates. Number of Observations, 5775. Mean Age, 14y. 4m. 4d.										Cold Climates. Number of Observations, 4018. Mean Age, 15y. 10m. 5d.			Years.
5	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	5
6	...	...	...	...	...	...	...	...	...	..	...	...	...	...	...	...	6
7	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	7
8	3	...	...	...	...	...	...	...	2	1	...	...	...	...	...	...	8
9	7	1	...	1	...	...	...	1	10	4	14	...	...	...	...	...	9
10	14	4	...	...	...	...	5	...	29	5	55	...	...	...	1	...	10
11	37	41	1	5	2	6	14	3	93	53	67	10	...	...	5	...	11
12	66	71	5	6	11	10	26	14	105	90	123	19	3	...	18	1	12
13	49	74	10	3	19	13	47	6	132	183	210	53	8	4	107	2	13
14	41	46	16	4	35	9	50	18	104	266	311	85	21	7	363	2	14
15	11	29	15	3	67	16	76	14	190	291	320	97	32	22	712	4	15
16	6	16	17	4	40	8	79	7	141	234	264	76	24	43	694	4	16
17	3	11	12	4	41	4	58	6	127	181	158	57	11	31	581	3	17
18	1	2	7	3	12	2	38	5	90	105	112	26	18	19	518	3	18
19	...	3	5	...	11	...	21	8	35	45	42	23	10	13	347	...	19
20	1	...	1	...	4	...	9	3	30	26	29	4	8	13	265	...	20
21	...	2	...	...	...	...	5	...	8	8	9	...	1	3	109	2	21
22	...	...	...	...	...	...	1	...	8	3	4	...	...	2	71	...	22
23	...	1	...	...	...	...	...	...	5	2	1	...	1	...	27	...	23
24	...	...	...	...	...	...	3	...	...	...	...	...	...	...	12	...	21
25	...	...	...	...	...	...	...	...	...	1	...	...	...	...	4	...	25
26	...	...	...	...	...	...	...	...	...	...	...	...	...	...	5	...	26
27	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	27
28	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	28
29	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	29
No. of Cases.	239	301	89	33	242	68	432	85	1111	1498	1719	450	137	157	3840	21	No. of Cases.
Mean Age.	y. m. d. 11 11 13	y. m. d. 12 5 23	y. m. d. 14 10 12[1]	y. m. d. 13 3 7	y. m. d. 14 10 14	y. m. d. 13 7 7	y. m. d. 14 11 19	y. m. d. 14 0 0	y. m. d. 15 5 9	y. m. d. 14 2 8	y. m. d. 14 3 4	y. m. d. 14 7 22	y. m. d. 15 2 5	y. m. d. 16 0 24	y. m. d. 16 0 13	y. m. d. 15 3 7[2]	Mean Age.

Country.	Race.	Authorities.	Indications.
Labrador.	Esquimaux.	J. Lundberg.	Mr. Roberton: Med. and Surg. Edin. Journal, vol. lxiii.
Copenhagen.	Gothic-Hindoo-Germanic.	Dr. Rawn.	Bibliothek fur Læger, list of 3429,—to which Dr. R. has added 411 cases taken by Professor Leog.
Christiana.	Gothic-Hindoo-Germanic.	Dr. Frugel.	A Government Report on Norway.
Gottingen.	Gothic-Hindoo-Germanic.	Osiander.	Denkwürdigkeiten für die Heilkunde und Geburtshülfe, 11 bre. bd. 2, sl. 1795, ms. 320.
Manchester.	Gothic-Hindoo-Germanic.	Mr. Roberton.	Mr. Roberton: Med. and Surg. Edin. Journal, 1832.
London.	Gothic-Hindoo-Germanic.	Dr. Lee and Dr. Murphy.	Dublin Med. Journal, No. lxxvii., 1845.
London.	Gothic-Hindoo-Germanic.	Dr. Guy.	Medical Times, vol. xii.
Paris.	Celtic-Hindoo-Romano-Germanic.	Brierre de Boismont.	De la Menstruation (Prize Essay), 1835.
Paris.	Celtic-Hindoo-Romano-Germanic.	Dr. Marc d'Espine.	Archives Gén. de Méd., Oct. and Nov. 1835.
Lyons.	Celtic-Hindoo-Romano-Germanic.	Petrequin.	These. Paris, 25th August 1835.
Marseilles, Toulon.	Celtic-Hindoo-Romano-Germanic.	Bouchacourt.	Art. Menstruation, 19th vol. of Dic., in 25 vols. (2nd edition.)
Madeira.	Hindoo-Germanic.	Dr. Dyster.	Ditto, vol. lxvi.
Corfu.	Hindoo-Germanic.	Dr. Tariziano.	Ditto, vol. lxii.
Jamaica.	Negro.	Rev. J. Elliot, and others. Mr. Bowen.	Ditto, vols. lviii. and lxix.
Deckan (Bombay).	Tamulian.	A. H. Leith, and others.	Ditto, vol. lxiv.
Calcutta (Bengal).	Hindoo-Gangetic.	Dr. Goodeve. Dwarikanauth dus Bossu.	Mr. Roberton: Med. and Surg. Edin. Journal, vol. lxiv.
Country	Race[3].	Authorities.	Indications.

[1] This average is deduced from too small a number of facts to counterbalance the contrary testimony of travellers.

[2] This average is likewise deduced from so small a number of observations that it cannot weigh against the opposing statements of travellers, amongst whom I shall mention Dr. M'Darmid, who informed Dr. Campbell that, in Esquimaux women, menstruation was often delayed till the 23rd year, then only appearing in the warmest months of the year, and as a mere show.

[3] I follow my friend Dr. R. G. Latham's nomenclature, as given in the late valuable work which has just issued from his pen ('Natural History of Man').

In proof of the influence of a town habitation in advancing slightly the period of first menstruation, Dr. Tilt quotes the results of M. Brierre de Boismont's careful investigation of the question, results which have since been confirmed by the statistical information obtained in Denmark by Dr. Rawn, as well as by Dr. Tilt's more recent investigations in London.

The author maintains that the influence of civilization stands second only to that of climate, and he founds this belief on his own unpublished observations, and on those already made public by M. Brierre de Boismont and Dr. Rawn, proving that luxurious living and habits render menstruation precocious, while this function is retarded by out-door labour and less sophisticated habits.

Thus far the tendency of Dr. Tilt's observations has been dogmatical; but in discussing what he calls the intrinsic causes which have been supposed to influence menstruation, his observations are rather of a suggestive character, for he considers such causes highly problematical and requiring further investigation.

Remarks on the Laws regulating the Development of Monstrosities, with illustrative Specimens. By ALEXANDER WOOD, *M.D., F.R.C.P.*

The paper first pointed out the importance of the study of teratology, in reference to philosophical anatomy, embryology, and natural history. It next adverted to the unity of type which exists throughout the whole of organized nature, and showed the use that had been made of that fact in laying down the laws of monstrous development.

The first law adverted to was that of anomalies from excess, of which examples in supernumerary fingers and toes were shown. The hereditary nature of these redundancies was adverted to, and it was argued from that, that there must be some original difference either in the spermatozoa or ovum, and that all the varieties of monstrosity could not be referred to changes taking place in the womb subsequent to impregnation. As examples of the second class, or those in which development was arrested, a case was shown in which the fingers were entirely deficient; also another specimen, where arrest of the development of the left inferior extremity was accompanied with eventration. From the concurrence of these two monstrous states, it was argued that in this case the arrest of development must have taken place about the commencement of the third month of uterine life. Another specimen of escape of the viscera from their cavities was shown in a cast of an encephalocele.

The last specimen exhibited was one of thlipsencephalus. The posterior bones of the skull were deficient, the brain existed in the most rudimentary state, its place being supplied by a vascular humour protruding externally, composed of hypertrophied pia mater, a congeries of blood-vessels, and a little watery fluid.

The paper concluded by arguing at some length against the tendency which at present existed to carry the theory of unity of type to an undue length. It contended against there being any real resemblance between the nervous system of the Articulata and that of anencephalous monsters.

A General View of the Morphology of the Muscular System. By M. ZAGLAS.

Comparative myology having already been sufficiently treated in the way of approaching the ultimate forms of the muscular masses of animals to one another, for finding their analogies in the same animal, as well as in the whole department of vertebrata, so as to allow almost no hope of thus coming to an insight of the connexions of this system extending to remote classes, recourse has been had to comparative osteology, and myology has been based on the osteogenesis. This way of treating myology, Prof. John Müller first indicated in his classical elaboration of the monography on myvinoids. Still comparative myology remains in a very unsatisfactory state. While occupying myself with dissections and thinking on the matter, I became strongly impressed by the idea that muscles must have, as well as other systems, their own morphological truths, and there must be a series of modifications in the muscular masses themselves, presented by the first appearances of a simple or elementary muscle, provided a generality of plan in their arrangement be existing. Such a series of modifications, connecting the simplest element with the most complicated, has been presumed to be probably the fittest means, if not the only, of reducing into one conception the almost simply diffused muscular masses of fishes and those of mammalia, so variously complicated in appearance, through intermediate terms safely appreciated. With these presumptions for a guide, and using the necessary impartiality in viewing facts, and patience suited to the intricacies which this system so often presents, the investigations have been pursued, and the results already obtained appear both satisfactory and promising. Such of them as would appear sufficient to indicate a thread of connexions between the two extremes in the disposition of muscles in vertebrata, and afford a general view of it, were intended for communication to the Section, and could be briefly summed up in the following statements.

A repetition of parallel membranes stretched between skin and skeleton, and corresponding in number with the segments of the latter, are met with in fishes and lower reptiles, where muscular portions, which fill their intervals with fibres parallel to the axis of the body, are called myocomata. The membranes descend from the back to the abdomen in waving or zigzag ribbons, having their concave and convex surfaces alternately turned forwards and backwards. The character of ribbons becomes soon lost by the membranes being found to protrude alternately on one side, and forwards or backwards according to the convexities of the angles; thus pouches being formed more or less long and funnel-shaped. The pouches, which are insinuated in one another, are met with gradually elongating, so as to stretch over several vertebræ, and in proportion as they do so, they become more and more obliterated at the bottom, which is effected through accretion of the side walls to a lamina, this lamina being then found to extend gradually as a crest on the upper wall of the pouch. In the Skates the whole pouch has become a lamina, receiving the muscular fibres on its flanks.

Before proceeding further, the divisions of the lateral masses of fishes in longitudinal direction must be taken notice of. Some fishes present no division on the mesial line of the side; others do, having thus a dorsal and an abdominal portion separated; in others the portions or longitudinal stripes are three, four, &c., according to the species. The number of the stripes does not correspond to that of the angles; but the distinction not only exists virtually, as it appears from real divisions in other fishes, but also if an angle be not comprehended between two divisions, another angle is formed. The greatest number of angles or series of pouches with real longitudinal separation from one another met with, is exhibited by *gymnetrus*, the amount being to above thirty-five. Thus the myocomata are divided in several collateral elements, recombining in their longitudinal succession to collateral series; and in proportion as the longitudinal series become independent, the myocomatical character of the masses disappears. These elements being anatomically so well defined and of great importance in the operations of nature to attain a higher development of the muscular masses, a term becomes necessary to designate them, as well as the longitudinal series; for the element, the term *myisk* has been proposed and made use of, and for a longitudinal series of myisks, that of *myostichia*. If several myisks of higher animals be ascertained to belong to one transverse set, the myocomata of fishes would evidently reappear.

We must now come back to the Skates. Their myisks begin from the bottom of a myostichial channel, and accosting the walls of the latter, they ascend to the surface of the myostichia, to be prolongated in a membranous expansion, bearing a mesial tendon, the prolongation of the lamina. The myisks of the Skate, as well as their tendons, being superposed upon one another, it has been made probable that this is effected by the lower walls of the pouches accreting to the bottom of the channel. The myisks stretching over several vertebræ, every corresponding segment of the channel will appear sending off fasciculi to several of them. In serpents and lizards, the fasciculi coming from one segment for the first time, appear depending on tendons, at first on one side only, then on both. The next step is found in myostichias of the same animals, and consists in the modification, that only one side of the channel gives off fibres to the myisks, while on the other side the corresponding walls of the pouches present mere membranes more or less blended with the channel wall, and help to constitute the vagina for the myostichia and its tendons. Birds and mammalia present no more essential modifications of the myisk, and the differences are reduced to atrophic, or aponeurotic appearance of the mentioned fascias or prolongation of the pouches. An illustration for the mammalia has been made on the sacro-lumbalis of the rabbit. The origins of the muscle from the ribs would correspond to the several fasciculi sent off from a segment to the several accosting myisks; with every innermost fasciculus of these organs a myisk begins, to end at the seventh rib anterior, at the outer side of the muscle, crossing the ribs in an oblique line, and receiving a fasciculus from every one.

ETHNOLOGY.

On the Language and Mode of Writing of the Ancient Assyrians. By the Rev. Dr. Edward Hincks.

Much interesting ethnological information has been already obtained from the Assyrian inscriptions that have been brought to light; and more may be confidently expected, as these inscriptions shall be more perfectly deciphered, and as new inscriptions shall be discovered. Apart, however, from all such information, the language and the mode of writing of the Assyrians are themselves two important ethnological facts. The language of the Assyrio-Babylonian inscriptions is generally admitted to be of the family called Semitic. It is in many respects strikingly like the Hebrew; but has some peculiarities, which were mentioned, in common with the Egyptian, the relationship of which to the Semitic languages has been already recognized. The mode of writing of the Assyrians differed from that of the Hebrew and all other Semitic languages, and agreed with the Egyptian, in that it was partly ideographic. Some words consisted entirely of ideographs; others were written in part phonetically, but had ideographs united with the phonetic part. As to the part of the writing which consisted of phonographs, Dr. Hincks maintained, in opposition to all other writers, that the characters had all definite syllabic values; there being no consonants, and consequently no necessity or liberty of supplying vowels. In proof that the characters had definite syllabic values, he handed about copies of a lithographed plate*, in which examples of various forms of words analogous to those existing in Hebrew were collected together. This use of characters representing syllables he considered to be an indication that, though the language of the Assyrians was Semitic, their mode of writing was not so. A second proof of the same position he derived from the absence of distinct syllables to represent combinations of the peculiar Semitic consonants Koph and Ain. From these facts he inferred that the Assyrio-Babylonian mode of writing was adopted from some Indo-European nation, which had probably conquered Assyria; and he thought it likely that this nation had intercourse with the Egyptians, and had, in part at least, derived its mode of writing from that most ancient people.

On the Sicilian and Sardinian Languages. By John Hogg, *M.A., F.R.S., Hon. Secretary of the Royal Geographical Society.*

The author, during a tour in Sicily, collected many words as spoken by the common people, and compared them with the corresponding Italian ones. Some of these he inserted in the present paper with specimens of Sicilian poetry. The proximity of Sicily and Sardinia, and their having been under the successive dominion of the like ruling powers, led the author, when in Sicily, to conclude that much *resemblance* existed between the languages of those islands: but he had not at that time any *data* of sufficient consequence to establish such a conclusion.

Mr. John Hogg considered that the "modern Sicilian" dialect, which some authors suppose to be the nearest to the Neapolitan and Calabrian dialects of the *Italian*, is in reality very dissimilar from them, and he then pointed out the chief differences.

The *three* principal dialects of the *Sicilian* were classed under these periods:— The *first*, from the *eighth* to the *eleventh* century† of the Christian æra, wherein

* See copy of this in Plate IV.

† The times specified in these divisions are to be taken as *nearly* fixing the respective periods; but they will be found sufficiently exact for general purposes.

Latin, but little corrupted, mixed with much Arabic, and some Greek, prevailed; the *second*, from the *eleventh* to the *fourteenth* century, in which the language agrees very well with the modern true *Italian*; and the *third*, between the *fourteenth* and *seventeenth*, or *eighteenth* centuries, when the "modern Sicilian," as now generally used, became corrupted or modified.

Sicily had the honour of giving birth to *Italian* poetry, as Petrarch distinctly asserted, and the great Dante made "Siciliana Favella" synonymous with modern *poetical language*.

The first important poet of that island, since the revival of letters, *Ciullo d'Alcamo*, composed his verses, in the twelfth century, in the earlier dialect of the *second* period, which is similar to and in fact was the parent of pure Tuscan.

Mr. John Hogg entered into a more detailed and critical notice of the *Linguaggiu Sicilianu*, or "modern" dialect of the last period; and he introduced many examples of words in the latter idiom compared with the Italian. Having remarked on the paucity of *prose* works in "modern" Sicilian, he gave several interesting specimens of *poetry* as written at this day; and added to each a literal translation in English.

The author afterwards brought forward in an historical sketch the different nations, which had chiefly effected by their respective languages the changes and alterations in the dialects of Sicily: he observed that *Sicilian*, as now spoken, reminded him of the style and pronunciation of *Doric* Greek, and suggested that it might perhaps be termed a *Doric* dialect of the *Italian*.

Next, Mr. J. Hogg separated, as Adelung had done, *Sardinian* into—I. the ancient *native* language, and II. the *foreign* language.

Having pointed out the distinctions existing between the *two* chief dialects, the *southern* and the *northern* idioms of the *native* Sardinian, he stated the existence of a Spanish dialect, the *Catalonian* or *Catalan*, in Alghieri and its vicinity; and a variety of the *Tuscan* in Sassari, and some other places, both being introduced or *foreign* languages.

According to Mr. Tyndale, the Sarde *native* language, or *Sardic*, especially that of the *northern* district, is the nearest of existing languages to pure *Latin*.

Mr. John Hogg then gave some notices concerning the material differences of the Sardinian idioms, and peculiarities of their grammatical structure, from that author's instructive work on Sardinia.

Having added some general examples of *Sardinian* as compared with Italian, the author inserted many sentences, and some specimens of poetry in the former tongue, together with English versions, in order to afford ample illustrations. And, as he had in the *first* part of this essay given *two* versions of the *Lord's Prayer* in dialects of the *Sicilian*, he followed out the same plan in appending *four* copies of that *prayer* in different dialects of the *Sardinian*, so that the former might be compared with the latter.

In both islands *Italian* is likewise spoken by the higher classes, whilst the lower only use the common Sicilian (*dialetto volgare*) and *Sardic* dialects.

The author said in this communication he had considered *Sicilian* and *Sardinian*, for the sake of convenience, as "languages," and not mere dialects of the Italian, because they will be found to branch out into several dialects.

On the Original Distribution of the Germanic, Lithuanic and Slavonic Populations. By R. G. Latham, *M.D., F.R.S.*

At the beginning of the proper historical period, *i. e.* when the parts in question were first known otherwise than from hearsay evidence, there were few or no Germans east of the Elbe; on the contrary, the whole population was Slavonic. This is generally considered to have been of recent origin, the previous population being German. The current reasons for this opinion lie in the fact of the parts between the Elbe and Niemen being parts of Tacitus' *Germania*.

The evidence of this, as well as of other classical works, is not sufficient to counterbalance the very opposite state of things in the ninth and tenth centuries; since to reconcile the undoubted Slavonic character of the populations at that time with the common interpretation of Tacitus, is to assume an unparalleled amount of migrations and displacements, and that on no evidence; but simply for the sake of the supposed fact they would account for.

The same applies to Bohemia, which was never more German than it is at present.

Reasons for believing that the *ante*-Germanic population of Jutland and *Goth*land were the *Guddons* of Prussia, and Lithuanians rather than either Celts or Finns, were also given.

Remarks on the Soukaneeah *Dialect of the Berber.* *By* Professor F. W. Newman.

The vocabulary sent home by Mr. Richardson contains near 150 single words, besides a few short sentences. Setting aside those which are mere Arabic (which are not many), the rest, with few exceptions, are found in recognized dialects of the Berber, and in fact are generally discernible in the Kabail or Algiers Berber. The words totally new to me (F. W. N.) seem to me under twenty in number; so there can be no question that the Soukaneeah is a genuine Berber dialect.

Its personal pronouns are nearest to those of the Ghadamsi, which is perhaps the same as the dialect which *Hodgson* calls Tuaryk; but in the plural there seems to be a clipping of the pronunciation, and the word for They (*Emdīn*, if I rightly read the MS.) is quite peculiar. In the Ghadamsi of Hemso di Gråberg there is equally great divergency from the standard Berber as to this pronoun.

The interrogative and demonstrative pronouns in general appear to approach closest to those of the Ghadamsi; so also do certain common verbs and words in which these dialects deviate more or less from the Kabail and from the Shilha.

In the numerals there is this peculiarity (unless the reporter has been misled), that for Five, they say *Fūsa* (a hand), and for Ten, *Ifāsen* (hands); which further leads to saying for Six, *Fūsa li dād* (hand to finger); Eight, *Ifāsen ghair sen* (hands without two); Nine, *Ifāsen ghair egīn* (hands without one). *Egīn*. one, is Ghadamsi.

Inquiry into the Evidence of the Existence of Primitive Races in Scotland prior to the Celtæ. By Daniel Wilson.

Dr. Prichard remarks in his Observations on the Indo-European Nations, introduced into his 'Natural History of Man,' "It would be an interesting question if there were any data likely to facilitate its discussion, whether the Arian nations found on their arrival in Europe the different countries already occupied by previous inhabitants, or vacant, and affording them a peaceful and undisputed admission" (p. 184). Ethnologists are now familiar with the labours of several zealous men of science on the continent, and especially of Professors Nillson and Retzius, to supply a distinct answer to this important inquiry. It is to be regretted that this branch of physical archæology has heretofore been so little esteemed in this country in comparison of the contributions afforded by philological researches to ethnology. Many points still remain in doubt which it alone can answer; and while the philological evidence affords valuable and precise information in regard to the diffusion of the Arian nations over Europe, it is a matter of very great importance, even in its bearing on this branch of the inquiry, to know whether the nomade Celtæ peopled for the first time the unoccupied wastes and forests of Europe, or superseded elder aboriginal races. Still greater is its value in relation to the other questions which demand a reply from the ethnologist, as to the origin of the human family from one or more stocks, and the migration from a common centre, or cradle-land, which, in so far as relates to the historic races, appears distinctly to coincide with the Mosaic history of the human race.

Philological research has not, as yet, thrown light on the Allophylian nations of Europe, nor is there much probability that it can do so; and from the general misapprehension by men of science in England, of the value of archæological investigations, they have been rendered nearly valueless as a means for the ascertainment of truths relating to primitive ethnology. On the continent, and especially in Sweden and Denmark, much has already been done in this department of inquiry, and not without valuable results. The conclusions arrived at by Professor Nillson of Lund, in regard to the primitive inhabitants of Scandinavia, have already been laid before the British Association. It is extremely desirable, however, that these should be compared with similar investigations carried on in other countries, both to test their general application, and to ascertain what evidence is recoverable in regard to the movements of the earliest nomade tribes of Europe.

Professor Nillson's conclusions may be thus briefly stated :—At a period prior to the latest geological changes in Sweden, while the *Bos primigenius* and other of the long extinct herbivorous animals existed in the country, it was possessed by a human population in a very low state of civilization, ignorant of the metallurgic arts, constructing their weapons and implements of horn and stone, and living chiefly by fishing and hunting. The skeletons of this aboriginal race still exist in the earliest class of Barrows. Their skulls are described by Professor Nillson as short (the *brachy-cephalic* of Retzius), with prominent parietal tubers, and broad and flattened occiput.

This was succeeded by a superior race, with a cranium of a more lengthened oval form, and prominent and narrow occiput.

The third race, which Professor Nillson considers as of Celtic origin, appears to have introduced bronze, the earliest working metal, into the country ; and the Celtic population is not supposed by him to have been displaced by the true Swea, or modern Scandinavians, till some time in the sixth century.

With relation to the primitive inhabitants of Britain, we know that a Celtic people appear to have existed here at the earliest period in which we have any authentic historical information respecting them. But history carries us back only a very short way, and its whole indications seem to point to the Celtæ as intruders within a comparatively recent historic æra; while the tumuli and primitive relics abounding in Britain and the whole north of Europe, furnish unmistakeable evidence of the presence of a human population at a much more remote period. Pursuing the mode of inquiry into the primitive races of Scotland which has already been successfully employed by continental ethnologists, the following Table of Cranial Measurements supplies data derived from an examination of thirty-nine skulls, a number too few to admit of the assumption of dogmatic conclusions, but sufficient at least for an initiatory step in this interesting inquiry in relation to the British aborigines. The system of measurement employed is chiefly that adopted by Dr. Morton in his 'Crania Americana' (Anatomical Measurements, p. 249). Four additional measurements are added, marked (*), as in some cases preferable, or supplying more certain data in the imperfect and decayed state of the skulls. The proportions of two Mexican skulls, described by Dr. Morton as superior specimens of the ancient race, are also inserted for the sake of comparison.

Of the crania in the annexed Table, it may suffice in this very brief abstract to state, that the direct archæological evidence, derived from the presence of rude stone weapons, the form of cists, the presence or absence of metallic weapons or implements, pottery, &c., seem to justify the order of classification.

The conclusions which these data appear to suggest are, that the earliest primitive Scottish race differed entirely from the earliest Scandinavian race as described by Professor Nillson, being rather *Dolicho-cephalic*, or perhaps more correctly *Cymbo-cephalic*,—to adopt a term which I venture to suggest as most appropriate to the peculiar *boat-like* shape of the crania. These are long and equally narrow in the forehead and occiput; while the whole head, when seen *in situ*, is small in proportion to the skeleton.

The second race decidedly corresponds with the *Brachy-cephalic* of Retzius, though in the few examples I have been able to obtain the cerebral development appears considerably greater than in the primitive race of Scandinavia. Nearly all ethnologists are agreed in assigning to the true Celtic type of cranium an intermediate form, shorter than the true *Dolicho-cephalic*, and longer than the *Brachy-cephalic*. This conclusion is confirmed by the examples adopted in the Table of Measurements, with the exception of No. 27, a so-called typical Celtic skull, in the Edinburgh Phrenological Museum, introduced here for the sake of comparison.

Even after obtaining the proper crania it is difficult to determine the most trustworthy elements of comparative proportion. The relative proportions of the parietal diameter; and of the inter-mastoid line, measured from the upper root of the zygomatic process, when compared with the longitudinal diameter, will be found to afford some of the most striking elements of comparison and classification. Another interesting basis of comparison appears to consist in the relative proportions of the parietal and vertical diameters. The following laws would seem to be indicated :—

In the elongated *Dolicho-cephalic*, or *Cymbo-cephalic* type, the parietal diameter is remarkably small, being frequently exceeded by the vertical diameter. In the second, or *Brachy-cephalic* class, the parietal diameter is the greatest. In the Celtic crania they are nearly equal; and in the Mediæval or true *Dolicho-cephalic* crania the parietal diameter is again found in excess.

Not the least interesting of the indications which this course of investigation seems to establish in relation to the primitive races of Scotland, are the evidences of the existence of primitive British races prior to the Celtæ; and also the probability of these races having succeeded each other in a different order from the primitive colonists of the north of Europe. Meanwhile, however, these data, and the conclusions derived from them, are produced chiefly with a view to induce more extended research. A much greater accumulation of evidence is requisite to establish any absolute or certain conclusions; and this can only be obtained by a general interest in the inquiry leading to the observation of such where the researches of the archæologist, or the chance operations of the agriculturist afford the desired means.

One or two other indications, however, bearing on the same subject, may here be adverted to, as well meriting further attention. One characteristic feature in the skulls of various tumuli is the state of the teeth. It is rare to find among them any symptoms of irregularity or decay. In a tumular cemetery at North Berwick, however, the teeth of the skulls, though sound, were worn in most cases completely flat, like those of a ruminating animal. Dr. Thurnam remarks the same to have been the case with the teeth in those found in the Anglo-Saxon cemetery at Lamelhill; and it is also observable in an under-jaw found along with other remains of a human skull, an iron hatchet, and several large boars' tusks, in a deep excavation on the south bank of the Castle Hill of Edinburgh. This peculiarity in the teeth of certain classes of ancient crania is of very general application. The inferences to be drawn from such a comparison are of considerable value, in the indications they afford of the domestic habits and social life of a race, the last survivor of which has mouldered underneath his green tumulus perchance for centuries before the æra of our earliest authentic chronicles. As a means of comparison, this characteristic appearance of the teeth manifestly furnishes one means of discriminating between an early and a still earlier, if not primæval period; and though not in itself conclusive, it may be found of considerable value when taken in connection with the other and still more obvious peculiarities of the crania of the earliest barrows. We perceive from it at least that a very decided change took place in the common food of the country, from the period when the native Briton of the primæval period pursued the chase with the flint, lance and arrow, and the spear of deer's horn, to that comparatively recent period when the Saxon marauders began to effect settlements and build houses on the scenes where they had ravaged the villages of the older British natives. But the social state in the British Isles was a progressive one. Whether by the gradual improvement of the aboriginal race, or by the incursion of foreign tribes, who were already familiar with the fruits of agricultural labour, the wild pastoral or hunter life of the first settlers was exchanged for one more suited to call forth the social virtues; the increase of the population, either by the ingress of new tribes, or by the numerical progression of the first settlers, would of itself put an end to the possibility of finding subsistence by means of the chase. Thus, it might be from the inventive industry which privations force into activity that new wants were first discovered, and new tastes were created, and satisfied by the annual harvests of golden grain. The ploughshare and the pruning-hook divided attention with the sword and the spear, which they could not supplant, and the ingenious agriculturist devised his oaken querne, his stone-rubbers, and at length his simple yet effective hand-mill, which resisted, during many centuries of change and progress, all attempts to supersede it by more complicated machinery.

There is only one other point to which I would wish to advert, in reference to the archæological evidence which we possess referable to the British Allophylian races, and to which I venture to hope ethnologists will be induced to devote more attention than they have hitherto done. The term Archaic very fitly applies to the period in relation to its arts. The ornamentation employed in the pottery found in barrows consists almost, without exception, only of improvements on the accidents of manufacture. The same indefinite and archaic character prevails throughout our primitive ornamented relics, which are by no means rare. In the pottery, for example, the incised decorations are characterized by great variety, and an obvious progress is traceable; but in no single instance is any attempt made at the imitation of a leaf, or flower; of animals, or of any other of the most simple natural objects. The same is the case with the most beautiful gold and silver ornaments, and the decorated bronze weapons. It is curious and noteworthy to observe this entire absence of all imitation in primitive British arts, because it is by no means a universal or even very general characteristic of the arts of Allophylian nations. The relics recovered from the sepulchral mounds of the great valley of the Mississippi, as well as in the regions of Mexico and Yucatan, display, along with the weapons and implements of stone, silex, and obsidian, numerous rude indications of imitative skill. The same is the case with the modern Polynesians. What I would specially note in connection with this is, that both in the ancient and modern examples, the presence of imitative arts accompanies the existence of idols, and the abundant evidences of an idolatrous worship. So far as we yet know the converse holds true in relation to the primitive British races; and as Dr. Prichard has already attached so marked an importance to the contrasting creeds and modes of worship and polity of the Allophylian and Arian nations, I venture to throw out this suggestion as not unworthy of further consideration.

Another peculiarity in which all the earlier races appear to differ from those of Teutonic origin is of a purely physical nature. In the tumuli we find the weapons and implements buried with the deceased, and wherever these have been obtained sufficiently perfect to admit of positive conclusions being drawn, they show that the hands of the earlier British races must have been extremely small, when compared with those of very moderate stature in our own day. This however is also, though in a less degree, a characteristic of the pure Celt, in contrast to the Saxon, or other later colonists of the British Isles. It is curious that we possess the most indisputable evidence of the same characteristic having pertained to the primitive temple-builders of the new world. Mr. Stephens remarks, in describing the well-known symbol of the red hand, first seen by him at Uxmal, "Over a cavity in the mortar were two conspicuous marks which afterwards stared us in the face in all the ruined buildings of the country. They were the prints of a red hand, with the thumb and fingers extended, not drawn or painted, but stamped by the living hand, the pressure of the palm upon the stone. There was one striking feature about those hands; they were exceedingly small. Either of our own spread over and completely hid them." This also I think is worthy of note, I have examined primitive British swords and daggers, the handles of which would be straitened for the grasp of many a delicate lady's hand.

Table of Measurements of Scottish Crania.

	Number.	Crania.	Longitudinal diameter.	Parietal diameter.	Frontal diameter.	Vertical diameter.	Intermastoid arch.	Intermastoid arch from upper root of zygomatic process.	Intermastoid line.	Intermastoid line from upper root of zygomatic process.	Occipito-frontal arch.	Occip.-frontal arch from occipital protuberance to root of nose.	Horizontal periphery.	Length of head and face to foramen magnum.	Length of head and face to occipital protuberance.	Zygomatic diameter.	Facial angle.
			in. twf.	in. twf.	in. twf.	in. twf.	in. twf.	in. twf.	in. twf.	in. twf.	in. twf.	in. twf.	in. twf.	in. twf.	in. twf.	in. twf.	in. twf.
	i.	Mexican	6 8	5 5	4 6	6 0	15 6	....	4 4	....	14 6	....	19 9	....	....	....	80 0
	ii.	Mexican	6 4	5 7	4 5	5 4	14 6	....	4 5	....	13 5	....	20 2	....	....	....	78 0
Primitive Dolicho-kephalic or Kumbo-kephalic.	1	Cist, Aberdeenshire	7 0	5 4½?	4 9?	4 10	13 11	11 5	3 6½	4 8½	13 9	12 0	20 4	16 2	14 6	....	80 0
	2	Cist, Fifeshire	;	4 8	4 4	5 3	13 2	11 0	4 1	4 10	14 0	11 11	19 6				
	3	Cist, Cockenzie (East Lothian)	6 11	5 3	3 11	5 0	....	12 0	....	4 8½	14 4	11 4	19 0	17 0	14 2		
	4	Cist, Cockenzie	7 0	4 11	4 4	5 3	13 8	11 4½	4 1	4 10	13 10	11 3	16 7½	16 0	13 6		
	5	Cist, Cockenzie	6 6	4 1?	4 11	4 2?	13 2	11 3	....	4 8	13 11	12 0	19 0	16 0	14 7		
	6	Cist, Stonelaws (East Lothian)	7 3	5 4	4 6	5 2	14 3	11 9	4 4	5 0½	14 8	12 3	20 8½				
	7	Cairn, Fifeshire	7 5	5 2	4 5	5 2	14 3	12 0	3 7	4 10½	14 3	12 3	20 7½	....	....	5 0½	
	8	Tumulus, Newbattle	7 9	5 6	4 9	....		12 3	....	5 6	15 6	....	21 3	18 6	....	5 3	
	9	Tumulus, Montrose	7 3	5 8	4 3½	4 9	14 0	11 9	3 8½	5 0	14 2	11 9	20 7	17 0	14 6		
Brachy-kephalic.	10	Cist, Montrose	7 0	6 1	5 3	5 8	15 9	13 1	4 4	5 9½	15 2	13 3	21 0				
	11	Moss, Kilsyth	....	5 7½?	4 4	5 5	14 6?	12 2?	4 1	....	....	....	21 0?				
	12	Moss, Linton	6 6	5 1	4 1	4 9	13 5	11 3	3 9	4 6	13 6	11 9	18 7½				
	13	Moss, Linton	6 7	5 0	4 1	4 11	13 4	11 3	3 10	4 6	13 8	11 10	19 7				
	14	Cist, Ratho (West Lothian)	6 10	6 0	5 1	5 6	15 7	12 11	4 2	5 7	14 11	13 0	20 0				
	15	Cist, Linlithgow (West Lothian)	7 2?	5 6	4 9	....	14 10	12 7	4 6	5 5	....	....	20 6	....	....	4 7	80 0¾
	16	Roman Shaft, Roxburghshire	7 3	5 4	4 6	5 4	14 7½	12 0	5 3½	5 6	14 4	12 9	20 6	16 11	15 4	5 4	79 0
Celtic.	17	Tarbert, Kintyre	7 9	5 0	4 10	5 6	14 9	11 11	4 0	5 4	15 5	13 6	21 3	18 1½	16 3	5 1½	74 0
	18	Sea-shore, Argyleshire	7 6	5 1	4 6	5 1	14 8	11 3	3 11	5 3	14 6	12 11	20 4	17 0	15 6	5 5	80 0
	19	Harray, Hebrides	7 3	5 3	4 5	5 4½	14 5	12 4	3 11½	4 9	14 9	12 9	20 10	17 5	15 5		
	20	Iona, Hebrides	7 5	5 6½	5 0½	5 6	14 11½	12 3	4 0	....	14 9	12 6	20 10				
	21	Iona, Hebrides	7 3	5 6½	4 4	5 6	14 8	12 0	4 1	5 3	14 5	12 10	20 2	17 2	15 6	4 10?	
	22	Iona, Hebrides	7 2	5 7	4 5	5 6	14 9	11 10	4 3	5 6	14 4	12 6	20 0				
	23	Iona, Hebrides	7 3½	5 7	4 6	5 2	15 0?	12 4	....	....	14 8	12 6½	19 10½				
	24	Iona, Hebrides	7 2	5 5	4 6	....	....	....	....	....	....	12 10	20 7				
	25	Knockstanger, Caithness	7 8	5 6	4 3½	5 3	14 4	11 8	4 7	5 6	14 6	12 7	20 11				
	26	Inch Columb Kill, Ireland	7 9	5 7	5 3	5 6	15 7	13 3	4 0½	5 4	16 4	14 4	21 11	....	....	5 0	
	27	Celtic Type (?), E. P. S.	7 11	5 5	4 9	....	....	12 0	....	5 1	15 5	13 9	21 6	18 0	16 3		
Mediæval.	28	Tumular Cemetery, N. Berwick	7 6½	5 9	4 7	5 6	15 2	12 3	3 11	5 2	15 0	12 3	21 5	....	....	5 0	
	29	Tumular Cemetery, N. Berwick	7 0	5 7	4 0½	4 8	13 8	11 4	3 6	4 9	....	12 3	19 9				
	30	Tumular Cemetery, N. Berwick	7 3½	5 10	4 11	5 7	15 5	12 3	....	5 9	15 0	13 0	21 7				
	31	Castle Bank, Edinburgh	7 6	5 4	4 11	....	14 3	12 0	4 3	5 5	....	12 6	20 1				
	32	Flodden Hall, Edinburgh	7 6	5 4	8	5 2	14 6	12 2	4 2	5 1	15 6	....	20 11				
	33	Old St. Giles's, Edinburgh	7 3	5 6	4 4	5 1	14 0	11 9	4 2½	5 5	14 4	12 0	20 2½	17 2	14 10	5 1	75 0
	34	Old St. Giles's, Edinburgh	7 6	5 6	4 7	....	14 7	12 0	4 1½	5 1	15 0	12 10	20 8				
	35	Old St. Giles's, Edinburgh	6 11½	5 6	4 4	5 0	14 5	12 0	3 7½	4 9	14 0	11 9	19 10				
	36	Old St. Giles's, Edinburgh	6 6	5 3	4 2	4 11	13 3	11 3	3 10½	4 10	13 3	11 0	18 7				
	37	Old St. Giles's, Edinburgh	6 11	5 9	4 9	5 1	15 2	12 0	4 0	5 7	14 0	12 2	20 5	....	....	5 1	
	38	Old St. Giles's, Edinburgh	7 3	5 7	4 6	5 4	14 7	12 1	4 0	5 0	14 7	12 7	20 2				
	39	Constitution Street, Leith	7 0	5 9	4 9	5 3	14 6	12 5	3 10½	5 0½	14 3	12 5	20 3				

STATISTICS.

Account of the System of Croft Husbandry and the Reclamation of Waste Lands, chiefly by Spade Culture, adopted at Gairloch in Ross-shire since 1846, *and its results as illustrating the conditions under which the labour of Paupers and Criminals may safely be made productive. By* W. P. Alison, *M.D., V.P.R.S.Ed., Professor of Physic in the University of Edinburgh.*

The objects of this paper were to establish, chiefly by statistical evidence, the following propositions:—

1. That where the system of *petite culture* practised in Belgium had been introduced in the arable lands in Ross-shire, *i. e.* stall-feeding of stock, collection and œconomical management of manure, proper rotation of crops, and careful cultivation of small crofts by the spade, the result had been almost exactly the same as in Belgium, viz. that a family of five persons could be maintained on such land, in comfort, on a croft of five or six acres, and pay a rent of £10 per annum to the landlord; and that the reclamation of arable but waste lands for this purpose could be effected in a very few years by the population now in their neighbourhood under due regulations as to instruction and inspection.

2. That great tracts of such land, now absolutely unproductive, exist in Britain, and at least 1,500,000 acres in Ireland, known by official surveys to be at least equal to that in Belgium, requiring only a small outlay of capital for draining, &c., and large outlay of labour, to make them equally productive as that in Belgium or the best of that at Gairloch.

3. That the objections made to the productive employment of paupers or criminals on such land, however just where applicable, are in most such cases distinctly inapplicable; those objections being,—1. That pauper farms generally prove failures, and are a loss instead of a profit to the parish. 2. That the employment of paupers in any productive employment interferes with the labour market, and injures independent labourers. To the first objection the answer made is, that it is not necessary, in order to establish the importance of productive employment of paupers, that they should produce a *profit* for the parish; they may be very usefully employed even in a merely œconomical view, if they only effect *a saving* to the rate-payers; who must feed, clothe and lodge them and their families whether they employ them or not. To the second objection it is answered, that lands on which no work has been done within the memory of man, are not in the labour market, and any productions raised on them are a clear addition to the wealth of a country, and no injury to any other labourers; and that all that sound political œconomy requires is, not that the labour of paupers (or of criminals) should yield no remuneration, but only that such remuneration as it does yield should be a clear addition to the resources of a country, not the substitution of the produce of their labour for that of independent labourers.

4. That great numbers of able-bodied destitute poor have been maintained in the workhouses in Ireland since 1846 in absolute idleness, and at a great expense to the rate-payers there and to Britain likewise; that many have died in Ireland of the effects of destitution, and great numbers more have wandered thence and caused expense and carried disease wherever the English language is spoken; who might have been employed in reclaiming these waste lands with a *saving*, if not a *profit* to those who have thus supported them; examples having been recently furnished by the experience of several English unions, particularly Chorlton and Sheffield, of the reclamation of waste lands by pauper labour, with a decided saving to the parishes, even within a very few years.

5. That when landed proprietors, as in Ireland, have their land occupied by a redundant and destitute population, for which they are legally bound to make some provision, their natural resource—as the best authorities, *e. g.* Mr. Mill, Sir R. Kane, and Mr. Nicholls, Poor Law Commissioner in Ireland, agree—ought to be the establishment of the *petite culture* as in Belgium, and as imitated at Gairloch; and that any law which impedes the sale of portions of their property for that purpose is truly a suicidal law, injurious to all the interests of the country.

6. That a poor law providing for the unemployed able-bodied, rightly worked, may

be *of the most direct and essential use* in Ireland, or in any other country, in bringing the waste lands "and idle hands" together, and aiding the general establishment of this kind of husbandry:—1. Because numbers of the able-bodied paupers in every union may be employed immediately in reclaiming and then cultivating such lands, taken possession of in default of payment of rates, or purchased or rented for this purpose, as has been done at Sheffield and at Chorlton. 2. Because such operations, carried on in every union in Ireland, under the direction and control of such experienced agriculturists as Government may easily obtain for the purpose, may become a normal school for instructing owners and occupiers of land in a system of cultivation which requires little expenditure of capital even from the first, but some knowledge of the subject, and especially constant attention and industry, such as the examples of Gairloch as well as of the English unions show, may gradually be enforced among the people by the owners of the land or their agents, when themselves duly sensible of its advantages.

Some Statistics respecting the Sale of Encumbered Estates in Ireland. By Prof. Hancock.

The questions the author proposed to illustrate by his statistics were,—1st. Did it appear that any necessity existed for establishing the cheap, simple, and expeditious forms of procedure of the Encumbered Estates Court in lieu of the proceedings previously required in the Courts of Chancery and Exchequer? 2nd. Was there any evidence of the parties most interested having confidence in the proceedings of the Court? 3rd. At what rate of purchase had the estates been really sold? 4th. To what causes were the differences of prices of the different classes of estates to be ascribed? As to the first question, it appeared, that of cases transferred from the courts of equity to the Encumbered Estates Court, no less than 89 cases had been pending in Chancery or Exchequer for 10 years; 40 cases for 20 years; 26 cases for 30 years; 13 cases for 40 years; 8 cases for 50 years; 5 cases for 60 years; and 1 case for 70 years. The result of this delay was to make the bulk of these estates bankrupt. It appeared that the estates owed the following sums:—

	Encumbrances.	Possible price.
5 cases, pending 60 years,	£202,602	£176,760
8 .. .. 50 years,	339,051	258,480
13 .. .. 40 years,	476,124	341,480
26 .. .. 30 years,	635,699	444,250

In only two of the 26 estates would the proprietors receive any part of the purchase-money, and they would get only £18,000, leaving £422,000 to pay encumbrancers having charges to the amount of £635,699; so that the encumbrancers must lose upwards of £200,000. The effect of the rapid sales of the encumbered estates was not to ruin puisne encumbrancers, but to make manifest the ruin that the dilatory proceedings in equity had produced. As to the second question, it appeared that out of 1003 petitions presented up to June last, 155 had been presented by the owners themselves, relating to a rental of £180,000, subject to encumbrances amounting to £2,892,000. As to the third question, it appeared that 25 sales of fee simple had produced £125,176, or a nominal rental of £7872; or, making an abatement of 20 per cent. on a real rental of £5658, being 22 years' purchase. That 13 sales of leases for lives renewable for ever had produced £22,930 on a gross nominal rental of £2285, subject to a head rent of £278; making an abatement of 20 per cent. to get the real rental of £1814; and taking 30 years' purchase of the head rent as added to the purchase-money, this gave an average of 17 years' purchase. That 14 sales of long terms of years produced £33,155 on a nominal rental of £4195, subject to a head rent of £768, which gave an average of 16½ years' purchase. That 6 sales of estates subject to annuities produced £57,285, on a nominal rental of £1014. In these cases, as the ages of the annuitants were not given, it was impossible to ascertain the rate of purchase. As to the fourth question, the difference of price of the land in fee and the leaseholds arose partly from renewal fines and the reservations and covenants in the leases, but was chiefly caused by the circumstance that in the case of leaseholds the Commissioners gave parliamentary title not to the land, but to the lease only; and consequently, parties buying leaseholds ran a risk of losing their purchase if it should turn out that the original lessor had no right to grant the lease, or if there was any technical defect in the lease. It followed, therefore, that the Encumbered Estates Court was absolutely necessary; that the owners of land had shown great confidence in it; that the land of Ireland was not depreciated, as it had brought 22 years' purchase; that the system of giving a parliamentary title had prevented any depreciation from complication of title; that the want of a complete parliamentary title in the case of leaseholds had caused a depreciation to the extent of nearly five years' purchase in their sale; and that this depreciation could be removed by wise legislation.

On the Cost of obtaining Patents in different Countries. By Prof. HANCOCK.

The author proposed to direct attention to a table showing the cost of obtaining patents in different countries. The principal points in the table worth noticing were,—1st. That the cost of obtaining copyright for designs, under recent legislation, was from £1 to £15, being less than in any country in the world. 2nd. That the cost of obtaining a patent in England was £110, being greater than in any other European state. 3rd. That the cost of obtaining a patent in Ireland was £135, being greater than in any other country in the world. 4th. That the cost of obtaining a patent for the entire British dominions was £375, being three times the cost of a similar privilege in any other collection of territories under one government in the world. He then proceeded to inquire whether there was any good reason for maintaining the great cost of obtaining patents in Great Britain, and proposed the following questions for consideration:—1st. Should separate patents be required for each portion of the United Kingdom? 2nd. Was the expense of English patents caused by wise arrangements, for affording to the public facilities for searching for previous inventions? 3rd. Was the great expense of British patents caused by arrangements for affording security to the inventor in the enjoyment of his property? 4th. From what causes did the cost of British patents arise? 5th. What were the benefits which patents of invention conferred on the community? 6th. By what means could the cost of obtaining British patents be diminished? He showed that if the system of having one registration for the United Kingdom, like that for registration of designs, were extended to patents, the cost of obtaining patents would be at once reduced from £376 to £110; that the cost of obtaining patents in Great Britain did not arise from arrangements for affording to the public facilities for searching for previous inventions, nor for affording security to the inventor. He then proceeded to point out the causes of the great cost of British patents to be,—1st. The prolix and complicated forms of procedure for obtaining patents. 2nd. The fees to the Attorney General and other public officers on these forms of procedure. 3rd. The stamp duties on patents and on the specifications required from patentees. It seemed very unwise to require the intervention of a Master in Chancery, a Secretary of State, an Attorney General, and a Lord Chancellor to the issue of a document that was a simple certificate of registration. The system of paying public officers by salaries instead of fees had been generally recognized, but not extended to the case of patents. The tax on patents was unequal, being the same no matter what was the value of the invention. The tax was also imposed at the time most inconvenient for the inventor to pay, namely, before he had derived any profit from his invention. The benefits arising from the granting of patents were threefold:—1st. Securing a reward to the inventor; 2nd, securing to the public a disclosure of the process used; and 3rd, encouraging the inventive genius of the community by forcing inventors to make really new discoveries. The means of reducing the cost of obtaining patents were threefold:—1st. By having only one patent for the United Kingdom. 2nd. By adopting for all inventions the simple process of granting certificates of registration of designs, instead of the prolix and complicated forms now required in obtaining patents. 3rd. By substituting for all inventions the moderate fees and stamps on the registration of designs for the official fees and stamps or patents.

On the Causes of Distress at Skull and Skibbereen during the Famine in Ireland. By Prof. HANCOCK.

This district suffered more than any other during the famine in Ireland. Was the distress entirely caused by the potato failure? This depended on the question, What was the state of the Skibbereen district before 1846? The *Times* Commissioner had visited it in 1845, and described the people as being then in the most abject state of destitution. Hence it followed that the real sources of the calamities which the people suffered were the distress and wretched system of agriculture which prevailed before the famine. Had the people not been reduced to the verge of starvation,—had their wages not been at the lowest point consistent with human existence before that time,—the failure of the potato would, as in other districts, have caused privation only, and not death. The next inquiry was, To what causes are the wretched agriculture and consequent distress before 1845 to be ascribed? To solve this question, Mr. Mill had started the theory that peasant-rents fixed by competition was the foundation of the œconomic evils of Ireland. He proposed to test Mr. Mill's theory, and to contrast with the conclusion to which he had been led, that the state of the law respecting land was the cause of distress,—the facts respecting this district he had collected from a petition in the case of the late Lord Audley, in the Encumbered Estates Court. The Audley estate included a large tract of land lying between Skull and Skibbereen. The entire of this estate was held by a middleman, whose lease would expire in 1854, so that in 1845 and 1846 no occupier had any interest exceeding nine years in the land; so that neither middleman nor occupiers were able to improve the estate. As to interest of the head landlord, it appeared that as far back as 1829 the incumbrances on the Audley estate had far exceeded its value, being £25,000 on a rental of less than £600 a year; that they increased rapidly, so as to amount to £89,400, exclusive of interest and law costs, at Lord Audley's death in 1837; and that the interest and law costs increased the charges against the property in 1846 to the enormous amount of £167,300, on a rental of £577 a year. It appeared that from Lord Audley's death in 1837, to the present hour, instead of there being one landlord to deal with the property, there were eighty encumbrancers, whose consent was necessary to enable anything to be done. Hence the folly of speaking of competition in such a case when this state of the property rendered real competition impossible. The œconomic evils of Ireland, in his opinion, did not arise from peasant rents fixed by competition, and consequently those evils could be removed by having peasant rents fixed by law. Of those causes that were within human control, the chief cause of distress in Ireland, he thought, was the state of the law with regard to land. The laws respecting property in land, he stated, were defective in these particulars:—1st, in opposing impediments to the free sale of land, and encouraging instead terminable leases; 2nd, in denying security to the capital of tenants, by providing that, in the absence of contracts, improvements shall not belong to the improver; 3rd, in impeding the search for encumbrances, by maintaining a complicated and defective system of registration of debts and charges affecting land; and 4th, in the want of simple, cheap and expeditious forms of procedure for the enforcement of debts and contracts affecting land.

On the Geographical Distribution of Disease, as indicating the Connexion between Natural Phænomena and Health and Longevity. By A. KEITH JOHNSTON, *F.R.S.E.*

In this paper, which was illustrated by maps and diagrams, the author gave general views of the distribution of endemic disease over the globe, showing, by means of colours, the regions visited by particular diseases, and the proportionate amount of mortality occasioned by each among natives and Europeans. He explained, by means of diagrams, the effect of climate in the production and extension of disease, as exhibited in the moist and marshy districts of tropical regions; that, for example, remittent fever increases progressively with the increase of temperature from north to south, as strikingly shown by the returns of health in the army of the United States of America. He stated, that in order to judge of the effects of climate, it is necessary to compare the amount of sickness and mortality among the indigenous population of a country with that of strangers to the soil; that in India the average amount of mortality among European troops is nearly three times as great as among natives. He then drew attention to the remarkable difference between the health of the army as compared with that of the navy, and with the civil population of a country. After adverting to the successful means that have been adopted for the prevention of disease and the greatly increased value of human life thence resulting, he intimated his intention of following up the important inquiries now commenced with a special view to the subject of life assurance.

Remarks on the present Condition of the City and Neighbourhood of Malaga, and on the Preparation of Raisins. By A. Milward.

The author describes in succession the main points of interest in the history, geological constitution, climate and agriculture, and enters fully into the cultivation of the Vine, and the trade which this supports. The condition of the people is also investigated. The detailed information thus given cannot be fairly represented by an abstract.

Mortality of the Provident Classes in this Country and on the Continent. By F. G. P. Neison.

In the present contribution it is intended to exhibit the rate of mortality which prevails among the wealthy, the middle and the provident classes of this country, and of the continent.

England and Wales are the only portions of the United Kingdom in which public mortuary registers are kept, and, consequently, in which the rate of mortality of the whole population can be accurately measured. In the other divisions of the kingdom, the rate of mortality is known only inferentially, and not by direct observation, and nowhere do the public records afford the means by which to determine the duration of life in particular classes of the community. There are, however, other sources from which much information may be derived.

In the year 1843, a report was made, by a committee of actuaries, on the mortality among the persons assured by seventeen of the principal assurance companies of this country, and these persons may be fairly considered to belong to the middle and upper classes of society; and at various periods since the year 1824, inquiries have been made into the rate of mortality among the members of friendly societies, including the more industrious and prudential of the working and the labouring portion of the people. One important result derived from these investigations is, that while the mortuary registers show a certain rate of mortality for the whole population of England and Wales, the evidence furnished by the facts constituting the other body of information clearly proves the mortality of the middle and upper classes to be above, and that of the industrious working classes to be below, the ratio for the country generally. This conclusion forms an important consideration in all sanitary inquiries, and, by an obvious inference, determines in what class or section of the people the excessive rate of mortality prevails. For other reasons, however, it is a subject of first importance to understand clearly the rate of mortality among the middle and upper classes.

The Journal of the Statistical Society contains a valuable body of evidence on this question, which goes to prove, that among the peerage, the country gentry, and the professional classes, the rate of mortality is higher than that of the country generally, and, as already remarked, the report by the committee of actuaries shows, that among the lives assured by the public companies of this country, the mortality is also not less than that of the general population.

In support of the results derived from this latter body of facts, there is abundant collateral proof; but it has been thought desirable to test them, if possible, by facts originating in quite an independent source, and, with this view, an analysis has been made of the experience of some of the life assurance offices in Germany, one of which, the Gotha Society, the largest in the world, had, in the twenty-one years ending January 1850, assured 22,063 lives; and there were, in the beginning of this year, subsisting assurances on no less than 15,471 of these lives.

Column 3 of the following table shows, that if the rate of mortality in the Society had been the same as among the male population of England and Wales, the total number of deaths would have been 3196·59, while the expected mortality by the tables of the Society was 3194; but the actual mortality had been 3144. It is

TABLE I.

Ages.	Number exposed to the risk of Mortality for a whole Year.	Number of Deaths that would have happened according to the Mortality of England and Wales.	Sum of the Deaths.	Actual Deaths in the Society.	Sum of Actual Deaths.
		Males.			
15—25	1,912	15·6	...	8	
26—30	8,788	87·7	103·3	71	79
31—35	20,403	216·9	320·2	189	268
36—40	29,642	343·0	663·2	304	572
41—45	32,846	433·2	1096·4	366	928
46—50	29,540	460·8	1557·2	440	1368
51—55	23,420	453·2	2010·4	450	1818
56—60	16,846	426·0	2436·4	481	2299
61—65	10,276	357·0	2793·4	412	2711
66—70	4,477	221·5	3014·9	271	2982
71—84	1,734	181·8	3196·7	162	·3144
	179,884	3196·7		3144	

therefore evident that the average rate of mortality for the whole population of this country does not, for the whole term of life under observation, differ in any important degree from the rate assumed for the basis of the Society's calculations; and it is further evident that the rate of mortality among the general population of England and Wales approximates near to both classes of results.

In the following Table will be found the rate of mortality according to various series of observations. The results in column 2 are deduced from columns 2

TABLE II.

Ages.	Rate of Mortality per cent. according to the					
	Gotha Life Office.	England and Wales. Whole Population.	Friendly Societies. Rural, Town and City Districts. England and Wales.	Peerage.	Government Annuitants.	Assurance Societies in England.
		Males.	Males.		Males.	
15—25	·418	·815	·679	·507	1·37	·738
26—30	·808	·998	·732	·788	1·38	·814
31—35	·926	1·063	·798	·949	1·18	·892
36—40	1·026	1·157	·887	1·130	1·40	·991
41—45	1·084	1·319	1·038	1·533	1·40	1·125
46—50	1·490	1·560	1·281	2·118	1·49	1·426
51—55	1·921	1·935	1·696	2·581	2·32	1·909
56—60	2·855	2·529	2·244	3·212	2·92	2·639
61—65	4·009	3·474	3·030	4·322	4·08	3·784
66—70	6·053	4·947	4·614	5·764	6·17	5·563
71—84	9·343	10·482	8·584	8·155	11·43	11·147

and 5 of Table I., and therefore represent the rate of mortality experienced in the Gotha Life Office. And it will be seen, that throughout the whole of life, the mortality is almost always less than among the peerage or the males of the government annuitants, and not differing widely from the results for the whole male population of England and Wales, and those for the lives of the assurance societies in England, but the mortality is much above that experienced by the members generally of friendly societies in England and Wales. A consideration of the peculiar features and constitution of those humble provident institutions, will fully explain the reasons of this increased longevity among the industrious and provident portion of the working classes of this country; and those desiring to enter fully into this part of the question, will find it treated of at length in 'Contributions to Vital Statistics.' Column 4 in the preceding table represents the rate of mortality as observed among the male members generally of friendly societies throughout England and Wales; but if reference be made to Appendix A. of the Report of the Select Committee of the House of Lords appointed to consider certain matters connected with Provident Associations, Session 1847–48, paper No. 126, some interesting examples will be found of remarkable differences in the rates of mortality and sickness in those societies. In a very able paper by Mr. Farr, in the second edition of M'Culloch's 'Statistics of the British Empire,' it is stated that there is reason to believe that further inquiries will show, that not only sickness, but mortality will increase in friendly societies generally; and the results of a recent investigation among the members of Odd Fellow Societies appear to support this opinion, in so far as respects mortality. Recently a careful examination was made into the rate of mortality among the members of one of the learned societies of the metropolis, composed exclusively of the members of the medical profession, and the results are strikingly corroborative of the general principle which seems to regulate the mortality of other classes, namely, that the humble but industrious working classes, whose prudential habits lead them to become members of these societies, are subject to a less rate of mortality than any other, and that the higher the class of society over which the observations extend, until the peerage, or highest class of all, is observed, in which there is less of the regular and healthful daily exercise essential to the condition of the industrious workman, the greater the rate of mortality; and for intermediate classes, a varying degree of mortality is observable, following pretty closely the scale of their position in social rank.

The results of this inquiry will be found in detail in the following table:—

TABLE III.

Year of Membership.	Number exposed to risk.	Died.	Mortality per cent.	Mortality per cent. England and Wales.	Average Age.
1— 4	2198·0	9	0·409	·998	25—30
5— 9	2190·5	14	0·639	1·063	31—35
10—14	1353·5	20	1·477	1·157	36—40
15—19	811·5	11	1·355	1·319	41—45
20—24	578·5	8	1·383	1·560	46—50
25—29	410·0	17	4·146	1·935	51—55
30—34	200·0	7	3·500	2·529	56—60
35—39	74·0	6	8·108	3·474	61—65
40—44	18·0	4	2·222	4·947	66—70
	7834·0	96	1·225		

For the whole period under observation, it is therefore evident that the rate of mortality is somewhat higher than among the general population of England and Wales.

From the facts brought forward, it therefore appears that the duration of life in the German States of Europe, among the higher provident classes, embracing the principles of life assurance, is fully equal to that among the like classes in this country, and the value of life amongst those classes approximates closely to the rate of mortality for the general population of England and Wales; but among the humbler provident classes who enrol themselves members of friendly societies of this country, there is experienced a prolonged duration of life above all others.

With the view to determine whether any and what law prevailed in relation to the period which has elapsed from the date of assuring to the date of death among those persons dying in the years 1839–49, distinguishing the age at the time of being assured, a detailed abstract has been made of each policy, classifying those together of the same age at the date of assuring, and at the same time setting forth the period elapsing until the day of death, and thence arriving at the average period which elapsed from taking out their policies till the day of death, for those entering the Society at different ages. The following table shows the results arrived at:—

Table IV.

Period elapsed from the date of Assuring, till Death, of those dying among the Assured, during the Years 1839–49.

Age.	No.	Duration of Life.		Duration of Life to each Person.		Duration of Life.		Duration of Life to each Person.	
		Years.	Months.	Years.	Months.	Years.	Months.	Years.	Months.
15—19	4	26	...	6	6	26	...	6	6
20—24	27	200	11	7	5	1246	6	6	6
25—29	164	1,225	7	7	6				
30—34	311	2,547	...	8	2	5758	2	8	4
35—39	384	3,211	2	8	4				
40—44	383	3,815	7	10	...	7533	9	9	9
45—49	388	3,718	2	9	7				
50—54	393	3,876	9	9	11	7064	2	9	8
55—59	342	3,187	5	9	4				
60—64	68	710	2	10	5	770	2	10	3
65—67	7	60	...	8	7				
Total	2471	22,778	9	9	3				

In which it will be seen, contrary to what would generally be expected, that the period which has elapsed from the date of the policies to the date of death is less at the younger than the older ages; so that, if such a law were found generally to prevail, it would follow that a Life Office would find the deaths taking place among the younger lives more immediate than among the older class of lives. Whether this unexpected and apparently anomalous result may arise from the fact that, at the earlier ages, the deaths take place from acute and rapidly-fatal diseases, and at the advanced periods of life they happen from chronic and lingering causes, is not clearly borne out by the present body of facts; but that such is very probably the case, will appear from a consideration of the following figures, derived some time ago from the experience of friendly societies in Scotland, from which very accurate and interesting returns were received and carefully analysed; from which it appeared that at the term of life 31–35, there is 116 weeks' sickness to each death, and the rate goes on increasing to the period 76–80, in which the amount of sickness is 319 weeks to each death.

The following condensed abstract will assist in giving a general view of the results thus arrived at:—

Ages.	Average duration of each Attack of Sickness.			
	Ending in final recovery.	Not ending in Death, but among those afterwards dying.	Immediately preceding Death.	Among those Dying, including the attacks Immediately preceding Death, and others.
11—35	4·372	11·442	14·907	10·830
36—50	5·131	7·228	12·006	9·276
51—60	11·717	8·711	34·851	18·789
60 and upwards	45·034	7·178	16·226	11·372
Total	8·636	7·788	45·173	23·932

It is hence obvious, that having regard to the ages of persons, the duration of any attack of sickness is a most important consideration in calculating the chances of recovery. If another element, the frequency of a series of attacks of sickness, were introduced (but the details it would here be out of place to discuss), the value or the duration of life of invalids might be calculated with even more precision than the expectation of life of the general community; and if the analysis were carried one step further, and the same classification adopted as in the preceding abstracts, only keeping the sickness peculiar to each disease by itself, a series of results would be arrived at, furnishing elements of the greatest value in the estimation of the value of life among persons who have suffered or are suffering from disease. Notwithstanding the immense pecuniary interests at stake by life offices, no inquiry or investigation of this kind has ever been undertaken by them, and the preceding and other collateral collections of facts, it is believed, are the only sources of information so analysed which anywhere exists. From the specimens now furnished from the records of friendly societies, the very remarkable aids which they must afford in estimating the value of peculiar classes of lives, by confining fluctuations within known limits, must be evident. The trouble and expense of collecting such data is very great, but still the information itself is of tenfold value to the life institutions of the country.

Attention is next directed to the following table, which is somewhat analogous in its character to Table IV., only that the element of age, with a view to its more simple application to practical purposes, is excluded. From the register of deaths for the years 1840–49, an abstract has been made of those which have taken place in the first, second, third, and every subsequent year, from the date of the policies, and the results constitute the following table:—

Table V.

Year.	Deaths among the assured after the lapse of the following number of years from the date of assurance.																				
	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	Total.
1840	11	14	14	9	17	9	13	15	17	8	5	13	..	..	..	..	..	..	..	..	..	143
1841	14	9	11	10	10	11	14	14	23	15	7	8	18	..	..	..	..	..	..	..	..	164
1842	6	8	13	17	14	17	15	20	14	14	24	10	5	21	..	..	..	..	..	..	..	198
1843	9	13	5	19	16	10	14	7	14	16	15	20	13	8	24	..	..	..	..	..	..	203
1844	4	11	10	9	9	8	14	15	13	7	19	19	26	10	8	18	..	..	..	..	..	200
1840 to 1844 ...	44	53	53	64	66	55	70	71	81	60	70	70	62	39	32	18	..	..	..	..	..	908
1845	11	13	9	8	5	17	12	21	10	11	8	20	25	16	16	12	24	..	..	..	..	238
1846	7	13	3	8	20	10	11	15	21	9	14	9	14	18	16	9	8	24	..	..	..	229
1847	14	14	15	16	8	12	12	18	12	15	19	18	18	20	25	19	6	7	25	..	..	293
1848	7	14	12	14	17	17	16	15	18	14	23	21	21	11	16	23	27	17	7	29	..	839
1849	4	13	14	14	8	19	14	13	15	17	13	17	16	22	15	24	17	22	8	14	38	837
Total ..	87	120	106	124	124	130	135	153	157	126	147	155	156	126	120	105	82	70	40	43	38	2344
Order of mortality..	6	9	8	10	10	12	13	15	18	11	14	16	17	11	9	7	5	4	2	3	1	

On referring to Table IV., it will be found that the average period which had elapsed from the date of the policies to the day of death was nine years and three months; and in the preceding table it will be also seen, that the greatest number of deaths has taken place in the ninth year after the date of the policies, the oldest policy being then about twenty-one years. During the five years, 1840–44, it is curious to observe, that the greatest number of deaths was also among policies of nine years' standing, although the oldest policy was then of sixteen years' duration only; and it is still further to be observed, that during the five years, 1840–44, about one-half of all the deaths took place in the first eight years of the policies; but for the ten years, 1840–49, one-half of all the deaths happened in the first nine years, the oldest policies being, in the latter case, of five years' greater duration. At the same time it will be seen that the number of deaths per annum has gone on increasing, from 143 in 1840, to 337 in 1849; in the former year the number of persons assured being 10,234, and in the latter 15,036; so that, although the number of persons assured increased about 48 per cent., the deaths increased to the extent of 136 per cent. The numerals on the top of the table show the duration of the policies, and those in the bottom line of the table show the order in which the deaths have taken place, from the minimum, in the twenty-first year, to the maximum in the ninth year. It is obvious that the solution of the results here presented will be derived from the law of mortality exhibited in Table I., the number of persons assured in each year, and the ages of those persons, and that any fluctuation whatever taking place in any one of these elements must disturb the above results.

In the following table will be found an abstract of the number of deaths which have taken place at the various periods of life from different diseases, and at the same time setting forth the average period which has elapsed, in years and months, from the date of effecting the policies to the date of death:—

TABLE VI.—Deaths in the Gotha Life Office

Causes of death.	Ages.											
	Under 20.		20—24.		25—29.		30—34.		35—39.		40—44.	
	No.	Average duration.	No.	Average duration.	No.	Average duration.	No.	Average duration.	No.	Average duration.	No.	Average duration.
		yrs. ms.		yrs. ms.		yrs. ms.		yrs. ms.		yrs. ms.		yrs. ms.
All causes	1	1 5	3	2 3	37	3 2	113	3 6	217	5 2	278	6 8
Specified cases	1	1 5	3	2 3	37	3 2	113	3 6	217	5 2	278	6 8
I. Zymotic diseases	..	..	1	0 2	10	2 5	38	2 11	60	5 5	64	7 2
SPORADIC DISEASES.												
II. Dropsy, cancer, and other diseases of uncertain or variable seat	..	..	..	..	2	2 9	9	3 2	18	4 10	38	7 7
III. Tubercular diseases	..	..	1	1 2	9	4 0	38	4 1	54	5 2	74	4 8
IV. Diseases of the brain, spinal marrow, nerves, and senses	..	..	..	..	6	2 10	5	3 3	22	4 6	29	7 7
V. Diseases of the heart and blood-vessels	..	..	..	..	1	1 6	1	1 1	7	4 9	6	10 11
VI. Diseases of the lungs and of the other organs of respiration	1	1 5	1	5 5	4	2 8	9	3 8	26	4 10	29	6 7
VII. Diseases of the stomach, liver, and other organs of digestion	..	..	..	..	1	2 3	3	3 0	14	5 8	25	7 8
VIII. Diseases of the kidneys, &c.	..	..	..	..	..	..	..	..	5	6 7	2	6 2
IX. Childbirth, diseases of the uterus, &c.	..	..	..	..	..	..	3	1 6	..	..	..	..
X. Rheumatism, diseases of the bones, joints, &c.	..	..	..	..	1	7 7	..	..	2	6 3	1	1 1
XI. Diseases of the skin, cellular tissue, &c.	..	..	..	..	1	3 5	..	..	..	..	..	..
XIII. Debility	..	..	..	..	..	..	..	..	..	..	..	..
XV. Age	..	..	..	..	..	..	..	..	..	..	..	..
XVII. Violence, privation, cold, and intemperance	..	..	..	..	2	4 2	7	3 11	9	5 8	10	6 11

In this table it will be found that the causes of death are unspecified in 8 only out of the 2471 cases recorded. The results herein given are so novel, but yet so varied, that it will be impossible to discuss them fully within the limits of this paper, and the most obvious will therefore be only brought under consideration. In Table IV. preceding, it was seen that, measuring the period which elapsed from the date of effecting the policies to the date of death, the interval was less for young lives than for older ones; and here, by adopting the opposite test, of measuring the interval from the date of death to the date of assuring, the same law is found to prevail, although in a more remarkable degree; and this difference is evidently owing to the circumstance, that all deaths among policies of long standing must necessarily be included in the more advanced periods of life in the above table, but included in younger periods of life in Table IV. However, as the same law shows itself in both classes of results differing only in degree, the greater weight is thereby given to the unexpected principles disclosed, and should lead those connected with the management of life offices to the serious consideration of the financial questions which so obviously arise out of the results. The following shows the results for six of the principal classes of disease:—

Of the diseases in Class I., namely, the zymotic and sporadic diseases, it will be seen that the duration of the assurances on the lives falling by this class of disease is less at every age than the average from all causes, except at the term of life 35–44; and it will likewise be seen, that for all ages taken collectively, the duration of the policies lapsing from this disease is less than the average duration of all policies.

The same observation does not apply to Class II. Under age 40, the duration of the policies is less than the average; but in the term of life 40–54, greater; the succeeding ten years again less; and in the term 65–74, greater; but for all ages collectively, the duration of policies becoming claims on account of death from this group of diseases, is five months greater than the average.

In group III., which includes the tubercular diseases, it will be seen, that for all ages under 60, with the exception of the quinquennial term, 40–44, the period elapsed from the date of assuring to the date of death is above the average of the period connected with the deaths from all causes, showing that, for those ages, the deaths of this from all Causes, and the average Duration of the Policies.

Ages.																	
45–49.		50–54.		55–59.		60–64.		65–69.		70–74.		75–79.		80–85.		All ages.	
No.	Average duration.	No.	Average duration.	No.	Average duration.	No.	Average duration.	No.	Average duration.	No.	Average duration.	No.	Average duration.	No.	Average duration.	No.	Average duration.
	yrs. ms.		yrs. ms.		yrs. ms.		yrs. ms.		yrs. ms.		yrs. ms.		yrs. ms.		yrs. ms.		yrs. ms.
313	8 2	334	8 10	363	9 8	355	10 10	271	12 4	139	14 9	42	16 6	5	19 3	2471	9 1
312	8 2	330	8 11	361	9 9	355	10 10	270	12 4	139	14 9	42	16 6	5	19 3	2463	9 1
67	7 7	64	8 9	66	8 8	59	10 1	43	12 3	20	13 5	9	16 1	2	19 6	503	8 4
49	8 10	46	8 10	66	9 2	72	8 9	47	13 0	25	15 0	8	15 7	..	..	380	9 6
66	8 9	67	9 6	54	11 4	49	11 7	20	12 0	5	13 7	..	..	..	..	437	8 0
45	8 2	58	9 2	63	9 6	62	11 8	53	12 4	26	14 7	6	17 2	..	..	375	9 2
11	7 9	10	11 3	19	7 10	12	11 8	2	15 6	..	..	..	..	..	..	69	9 0
28	6 5	33	6 0	34	11 2	32	11 2	89	11 11	13	12 11	2	15 11	..	..	251	8 7
20	6 11	26	9 8	37	10 9	41	10 3	25	12 4	12	15 8	3	17 10	..	..	207	9 1
4	11 1	6	7 11	3	7 3	10	12 8	8	11 7	2	10 10	..	..	..	..	40	10 0
5	9 5	1	8 9	..	..	1	10 0	..	..	..	..	..	..	..	..	10	7 1
5	10 4	2	8 0	1	10 10	1	14 1	..	..	..	..	..	..	..	..	13	8 9
1	9 5	1	7 2	..	..	1	19 7	1	9 3	..	..	..	..	..	..	5	9 9
..	..	..	..	1	6 11	..	..	3	14 10	..	..					4	14 4
..	..	..	..	..	..	6	10 10	24	12 4	35	14 11	14	16 7	3	19 1	82	44 2
11	8 11	16	10 5	17	7 11	10	13 10	5	9 10	..	..	..	..	..	..	87	8 10

class, which consist chiefly of phthisis, must be induced by a disease slow in its operation, and in that respect differing from the characteristic of group I. In respect to one term of life, 40–44, the deaths taking place therein, from this group of diseases, have followed very rapidly on the date of the lives being assured, and so remarkably so as to reduce the average, at all ages collectively, from this disease, more than one year below the average from all causes. At the term of life 40–44, the period elapsed in the deaths from all causes is 6 years 8 months, but in the group of tubercular diseases it is only 4 years 8 months; and this would appear to be a true feature of the disease, for the greatest number of deaths have taken place at this term of life; at the other terms of life, when the opposite feature prevails, up till age sixty, the result is

TABLE VII.

Average Period elapsed from the Date of Assuring to the Date of Death, among persons dying at the following ages.

Disease.	25 to 29.		30 to 34.		35 to 39.		40 to 44.		45 to 49.		50 to 54.		55 to 59.		60 to 64.		65 to 69.		70 to 74.		75 to 79.		All ages.	
	Years.	Months.	Years.	Months.	Years.	Months.	Years.	Months.	Years.	Months.	Years.	Months.	Years.	Months.	Years.	Months.	Years.	Months.	Years.	Months.	Years.	Months.	Years.	Months.	Years.	Months.
All diseases	3	2	3	6	5	2	6	8	8	2	8	10	9	8	10	10	12	4	14	9	16	6	9	1
I. Zymotic diseases	2	5	2	11	5	5	7	2	7	7	8	9	8	8	10	1	12	3	13	5	16	1	8	4
II. Dropsy, cancer, and other diseases of uncertain or variable seat	2	9	3	2	4	10	7	7	8	10	8	10	9	2	8	9	13	..	15	..	15	7	9	6
III. Tubercular diseases	4	..	4	1	5	2	4	8	8	9	9	6	11	4	11	7	12	..	13	7	..	..	8	..
IV. Diseases of the spinal marrow, nerves, and senses	2	10	3	3	4	6	7	7	8	2	9	2	9	6	11	8	12	4	14	7	17	2	9	2
VI. Diseases of the lungs and of the other organs of respiration	2	8	3	8	4	10	6	7	6	5	6	..	11	2	11	2	11	11	12	11	15	11	8	7
VII. Diseases of the stomach, liver, and other organs of respiration	2	3	3	9	5	8	7	8	6	11	9	8	10	9	10	3	12	4	15	8	17	10	9	1

constantly above the average. On referring to the details of group III., it will be found that these peculiar results are due wholly to the deaths from phthisis, and therefore the preceding observations are strictly applicable to that disease only.

Group IV. contains the diseases of the nervous system, and it will be seen that the results do not differ widely from those for all causes; and the same remark applies to the deaths from apoplexy, which form a large proportion of this section.

On referring to group VI., which represents the other diseases of the lungs and the organs of respiration, it will be seen that, with the exception of the decennial term of life, 55–64, the deaths take place in a shorter time after the date of assuring than in the average of the deaths from all causes, and in the aggregate of all the ages the difference is six months. These results are due chiefly to the deaths from pneumonia, which constitute 229 out of the 251 deaths of this group. And it will further be seen, that the deaths from asthma have taken place at a prolonged period beyond the average.

In regard to the diseases enumerated in group VII., it will be found that, on the average, they agree in their results with the deaths from all causes; and that in the different quinquennial terms of life the results are in some instances above, and in others below the average.

If attention be now directed to the rate of mortality from the various specified causes given in Table VI., it will be found that, for all ages taken collectively, the greatest mortality has resulted from zymotic diseases, or those forming group I.; and next, tubercular diseases, or group III., which are here separated from the other diseases of the lungs and organs of respiration, which form a distinct class in group VI. The rate of mortality from the zymotic diseases does not differ widely between ages 31–50, but from that age upwards a rapid and uniform rate of increase takes place: in group II., including dropsy, cancer, &c., there is a uniform rate of increase from the younger to the older ages. In the class of tubercular diseases, there is not much difference in the rate of mortality from between ages 31–50; but in the next three quinquennial terms of life there is a gradual increase. In group IV. there will be observed a very great difference between the rate of mortality at the younger and more advanced ages; of the 375 deaths in this group, 274 consist of deaths from apoplexy. The results of group VI. resemble in their relation those in connexion with group III. Group VII., it will be observed, resembles the results of group IV. in having a very low rate of mortality at the earlier ages, and increasing rapidly at the more advanced terms of life.

The preceding remarks have been made on six only of the principal groups of diseases, and the following condensed abstract of the results may be interesting. The Roman numerals represent the diseases as grouped in the preceding table.

Diseases arranged according to the Order of their Intensity at the following Ages.

31—35.	36—40.	41—45.	46—50.	51—55.	56—60.	61—65.	66—70.	70—80.
I. }	I.	III.	I.	III.	I. }	II.	IV.	II.
III. }	III.	I.	III.	I.	II. }	IV.	II.	IV.
II. }	VI.	II.	II.	IV.	IV.	I.	I.	I.
VI. }	IV.	IV. }	IV.	II.	III.	III.	VI.	VI. }
IV.	II.	VI. }	VI.	VI.	VII.	VII.	VII.	VII. }
VII.	VII.	VII.	VII.	VII.	VI.	VI.	III.	III.

In the above, it will be seen that, at the earlier ages, the intensity of the zymotic diseases, and also tubercular disease, is greatest; but at the more advanced, a gradual falling off will be observable in the class of tubercular disease. In the term of life 56–65, tubercular disease stands fourth in the order of intensity, and in the term 66–80, last in order. Again, with respect to Class IV., which consists, to a great extent, of deaths from apoplexy, it will be observed that, in the period of life 36–50, it stands fourth in the order of intensity; but that in each of the three succeeding quinquennial terms of life it gradually advances one step in the order of intensity, until, at the term 66–70, it is highest in intensity. This assimilates strictly with preceding results, however, with regard to the class pulmonary diseases, or diseases of the respiratory organs; that not only, in the abstracts just referred to, and in the earlier reports of the Registrar-General, included in group III., but also group IV.; and if the results be viewed in accordance with this arrangement, the diseases of the respiratory organs will be found to take precedence of all others between ages 31–70, and in the term of life 70–80 they will stand fourth in order.

With the view to show the relative intensity of the various groups of disease at different terms of life amongst different populations, the following abstract is given from results deduced from facts presented in the reports of the Registrar-General :—

Group of diseases classified.	Mortality per cent.—Ages 41—50—for the different classes of disease in the			
	Gotha Life Office.	Division of East Kent.	Metropolis.	Twenty-four Towns.
I.	·279	·166	·119	·259
II.	·186	·190	·270	·242
III.+VI.	·419	·520	·962	·989
IV.	·159	·299	·237	·177
VII.	·095	·109	·118	·143

Statistics of Criminal and Civil Justice under the Bombay Government for the Years 1844, 1845, 1846 *and* 1847. *By* Colonel Sykes, *F.R.S.*

The author, from official tables, showed the working of the several courts in the respective years in the administration of criminal and civil justice. It will suffice to give a general view of the work done, the condensed nature of the reports of the proceedings of the Section not permitting details.

Criminal Justice.

	1844.	1845.	1846.	1847.	Total of 4 Years.
Persons under trial	60,504	63,025	67,563	72,495	263,587
Convicted and punished by magistrates and assistant magistrates	4,678	4,824	5,325	6,719	21,546
Ditto by district and village police officers	23,763	26,278	28,645	28,867	107,553
Acquitted	26,414	26,063	27,887	32,068	112,432
Discharged on security	1,235	1,335	1,732	1,159	5,461
Imprisoned in default	136	94	95	59	384
Banished zillah or district	58	44	45	89	236
Committed to the sessions court	3,022	3,308	2,730	2,485	11,545
Deaths and escapes	32	1,035	60	33	1,160
Depending	1,166	44	1,044	1,016	3,270
Total	60,504	63,025	67,563	72,495	263,587

The above table embraces all offences whatever, from petty police cases to atrocious crimes; and though the number of offenders appear to have increased annually, the serious offences have gradually diminished; as is shown by the committals to the sessions courts, which only have jurisdiction in serious matters. The latter class of offences, it would appear, amount only to about 4·3 per cent. of the total offences. The convictions in the minor cases (including those sent to the session court) were a fraction more than 51 per cent., the acquittals to a fraction more than 44 per cent., and a fraction less than 5 per cent. were otherwise disposed of. Of the minor convictions 16·7 per cent. of the work was done by the European magistrates and assistants, and 83·3 per cent. by the native authorities. Of the 11,545 serious cases committed in four years to the sessions courts, presided over by European judges, there were 5924 convictions, 4072 acquitted, 38 deaths and escapes, and 1511 were transferred to the highest criminal court, the Sudder Faujdarry Adawlut. Of this number 323 were acquitted and 1188 found guilty. Of these 131 were condemned to death, 273 to transportation, and the remainder to various terms of imprisonment. As the population under the Bombay government is said to be about eight millions, the atrocious cases tried to conviction amounted therefore only to 0·015 per cent. of the population during the four years 1844, 1845, 1846 and 1847.

Civil Justice.—The general results were as follows :—

Statement of Original Suits on the File of the Adawlut Courts, Bombay.

	On the File, January 1st, 1844.	Instituted during 1844.	Decided on the merits.			Adjusted.	Decided by European Agents.			Decided by Native Agents.				Total number decided.	In arrears 31st December 1844.	Aggregate value of the Suits decided.	Number of cases on the File for one year and under.	From one to two years.	Beyond two years.
			On Trial.		Dismissed on default.		By the Judges.	By Agent and Assistant Agent for Jaghirdars.	By the Assistant Judges.	By Principal Sudder Ameens.	By Sudder Ameens.	By Moonsiffs.	By Punchaeet.						
			Decreed wholly or in part.	Dismissed.												Rupees.			
1844.	9,319	74,863	45,338	3,870	4,228	20,229	13	933	44	4,518	13,406	56,143	49	75,106	9,076	3,503,394 4 11	8,904	142	30
1845.	9,076	77,062	46,245	3,522	3,665	20,151	10	771	36	4,399	12,692	56,229	86	74,223	11,915	3,954,619 14 3	11,668	192	55
1846.	12,384*	83,858	48,166	3,804	3,666	22,470	10	855	21	4,774	13,755	60,019	70	79,504	17,188	4,001,849 8 1	16,735	373	80
1847.	17,188	80,984	51,245	5,652	3,874	22,120	15	888	68	6,494	14,649	63,178	48	85,340	12,832	4,243,187 0 0	...	...	...
Total	48,417	316,767	190,994	16,848	15,433	84,970	48	3447	169	20,185	54,502	235,569	253	314,173	...	15,703,050 11 0	...	...	...

* 919 suits were brought on the list from the Colaba State, not included in the preceding year.

From the table it would appear that in four years 3664 original suits were determined by European agency, and 310,509 original suits by native agency; the former giving a per-centage of 1·17, and the latter 98·83 per cent. There were 1664 appeals from the European agency, or 45·4 per cent. of the original suits decided, but only 25 per cent. of them were reversed. The appeals from the decisions of the native judges were 12,790, or 4·1 per cent.; the reversals were 4309, or 33·8 per cent. The European judges only [with the exception of the principal Sudder Ameens] deal with appeal cases, and the greater number of appeals against their decisions in original suits is probably owing to the greater amount at stake upon which they decide, than in the suits before the native judges. During the four years there were only three farmers in jail at the instance of government for arrears of land-tax.

On the Prevalence and Mortality of Cholera in the Indian Armies.
By Cuthbert Finch, *M.D., R.E.I.C.S.*

Dr. Finch prefaced his paper by remarking that there exists in this country very exaggerated opinions as to the frequency and fatality of spasmodic cholera in India.

The scope of his paper was to show that the disease was neither so frequent nor so fatal in the East as is generally believed in this part of the world. With this view Dr. Finch had prepared tabular statements of the absolute number of sick and deaths from cholera and per-centages of sick and casualties from this dire disease to strength, and to sick from all other diseases, and to deaths from all other causes in the Madras and Bombay armies for the year 1847, drawn from the latest returns received in this country. The returns for 1847 from Bengal have not yet been received at the India House.

From these tabular statements, it appeared that in the Madras Presidency in 1847—

Of European troops the strength was	11,429
Cases of sickness from all other diseases	18,585
Cases of sickness from cholera	31
Deaths from all other diseases	323
Deaths from cholera	22
Per-centage of cases of cholera to strength	·271
Per-centage of deaths to strength	·192
Per-centage of cholera to all other diseases	·167
Per-centage of deaths from cholera to deaths from all other causes	6·81
Of native troops the strength was	67,950
Cases of sickness from all other diseases	51,728
Cases of sickness from cholera	227
Deaths from all other diseases	805
Deaths from cholera	78
Per-centage of cases of cholera to strength	·334
Per-centage of deaths from cholera to strength	·114
Per-centage of cases of cholera to all other diseases	·438
Per-centage of deaths from cholera to deaths from all other diseases	9·689

In the Bombay Presidency, during the year 1847—

Of European troops the strength was	8,736
Cases of sickness from all other diseases	18,509
Cases of sickness from cholera	45
Deaths from all other diseases	285
Deaths from cholera	24
Per-centage of cases of cholera to strength	·515
Per-centage of deaths to strength	·274
Per-centage of cases to all other diseases	·243
Per-centage of deaths to deaths from all other diseases	9·195
Of native troops the strength was	43,930
Cases of sickness from all other diseases	43,313
Cases of sickness from cholera	253
Deaths from all other causes	369
Deaths from cholera	100
Per-centage of sick of cholera to strength	·575

Per-centage of deaths from cholera to strength	·227
Per-centage of cases of cholera to sick of all other diseases . .	·587
Per-centage of deaths from cholera to deaths from all other diseases	27·1

A summary of these per-centages show, that of the European force, 11,429 strong, stationed in the Madras Presidency during the year 1847, there were attacked by cholera only ·271 per cent., little more than one man in 400; and of whom died ·192 per cent., less than one man in 500.

Of the European troops, 8736 strong, serving in the Bombay Presidency in 1847, there were sufferers from cholera ·515 per cent., or one man in 200; of whom died ·274 per cent., or about one man in 400.

Of the Madras native army, consisting of 67,950 men, the sick of cholera to strength was ·334 per cent., or about one man in 300; of whom died only ·114 per cent., or one man in 900.

Of the Bombay native army, comprising 43,930 sepoys, the ratio of sick to strength was ·575 per cent., or little more than one man in 200; but the loss occasioned by the disease did not exceed ·227 per cent., not amounting to one man in 400.

These results demonstrate, that though epidemic cholera is still a frequent and fatal disease in the Indian armies, it is neither so prevalent nor so mortal as it is generally believed to be; and show, that military service in India does not necessarily entail so great a risk of life from this disease as is generally supposed in this part of the globe.

On the Progress of Glasgow, in Population, Wealth, Manufactures, &c. *By* John Strang, *LL.D.*

The steady progress and growing importance of almost all the manufacturing and commercial cities of Great Britain, since the conclusion of the last war, may be considered as admitted facts, and have no doubt tended much to alter and improve the whole social condition of the country. In the rapidity of its progress, perhaps no city has rivalled, far less surpassed Glasgow, the commercial metropolis of Scotland. This has chiefly arisen from this city being, if I may use the expression, *cosmopolitan* in its commerce and manufactures. Glasgow unites within itself a portion of the cotton-spinning and weaving manufactures of Manchester, the printed calicoes of Lancashire, the stuffs of Norwich, the shawls and mouselines of France, the silk-throwing of Macclesfield, the flax-spinning of Ireland, the carpets of Kidderminster, the iron and engineering works of Wolverhampton and Birmingham, the pottery and glass-making of Staffordshire and Newcastle, the ship-building of London, the coal trade of the Tyne and Wear, and all the handicrafts connected with or dependent on the full development of these. Glasgow also has its distilleries, breweries, chemical works, tan-works, dye-works, bleachfields, and paper manufactories, besides a vast number of staple and fancy hand-loom fabrics, which may be strictly said to belong to that locality. Glasgow also, in its commercial relations, trades with every quarter of the globe, and its merchants deal in the various products of every country. It hence appears, that one branch of manufacture or trade may be dull while another may be prosperous; and, accordingly, Glasgow does not feel any of those universal depressions which so frequently occur in places limited to one or two branches of manufacture or commerce.

Although Glasgow may be justly said to be one of the most ancient cities in Scotland, it is at the same time one of the most *modern* of the towns of Great Britain. It was a place of some consideration at the commencement of the twelfth century, when the foundation of its cathedral was laid; and yet, at the commencement of the nineteenth century, it had given proofs only of progress equal to those of many other towns in the empire. From that time, however, its rise has been most striking, and in order to bring this more palpably into view, the following statistical comparisons have been prepared, which will at once prove the rapid and steady advance of this growing community.

Population.—As a first and great proof of the city's progress, let us advert to the statement of its increasing population; and here we find it to be as follows:—

In 1801	the population was	. . . .	77,385
1811	"	. . . .	100,749
1821	"	. . . .	147,043
1831	"	. . . .	202,426
1841	"	. . . .	282,134
1850	"	estimated at	367,800

From these figures it appears that the population has nearly quintupled in 50 years, and doubled itself in 20 years. In fact, the annual increase of the city has been found to be as nearly as possible at the rate of 3⅜ per cent., or at present about 12,000 per annum.

This great increase, it need scarcely be stated, arises almost entirely from immigration. In illustration of this let us look to the following facts. The mortality during 1849 (including the cholera) was 12,883; and the rate of mortality to the estimated population of that year was (exclusive of still-born) 1 in 28·5. With respect to the number of births during the same period it is impossible to speak with accuracy; but a pretty close approximation of these may be arrived at from the fact, that by the census of 1841 the children found living at that time under one year old amounted to 2·96 per cent. of the whole population; and assuming that Glasgow was in similar circumstances in 1849 to what it was in 1841, the annual births ought to have amounted (including those who died from 1 day to 12 months) to at least 12,000, or 1000 less than the deaths. The evident conclusion to be drawn from this, then, is—that the great increase of the population of Glasgow, even during periods of less mortality than 1848 or 1849, depends almost entirely on immigration.

While the population has thus increased, it may reasonably be supposed that the means of accommodating that population has increased along with it, and this plainly appears to be the case when the following comparative table is considered:—

Gross number of Dwelling-Houses, Shops, Warehouses, and other possessions, within the parliamentary boundary of Glasgow, in 1845 and 1850.

Years.	Under £4 Rent.	At £4 and under £10 Rent.	At £10 Rent and upwards.	Gross number of distinct Possessions.	Gross Rental.
1845.	16,399	29,849	18,780	65,028	£866,150
1850.	...	...	...	76,034	£1,017,362

It thus appears that even during the last five years the distinct possessions have increased 11,006, and the rental £151,212!

Streets and Sewerage.—But perhaps the best illustration of the extension of Glasgow may be drawn from the two following facts:—1st, that in 1800 there were within the district now embraced by the parliamentary city only 30 miles of streets and roads, whereas at present the formed and paved streets alone extend to 96 miles; and 2ndly, that while in 1800 there was little or no sewerage in the city, there are at present 42 miles of main sewers, 21 miles of which have been formed during the last six years—the cost of making these sewers averaging £1200 per mile.

River and Harbour.—The question next occurs, what have been the chief stimuli to this great population being concentrated at this peculiar spot? To which it may be answered, that in addition to the circumstance of Glasgow being placed in the centre of one of the richest mineral districts in the kingdom, she possesses a river and harbour which art and capital have, within a very few years, made perfectly safe and navigable. In fact, this city possesses an inland navigation and a stream harbour unequaled, perhaps, in Europe. Let us see within how short a period this has been accomplished. We find that about the beginning of the present century the depth of the river Clyde was scarcely 5 feet, and there were few or no vessels to be found at its port, and these consisted of craft drawing merely a few feet of water, none certainly exceeding 30 or 40 tons burthen. In 1820, the average available depth of the Clyde, at high water during neap tides, was 9 feet, which admitted vessels drawing 8½ feet. In 1840 the depth was increased to 14 feet; and in 1850 the average available depth at high water of neap tides is 16 feet. At spring tides there is an additional depth of about 2 or 3 feet; which renders the greatest depth attainable, irrespective of the increased depth created by land floods or strong westerly winds, 19 feet. The river has also been, during the past ten or twelve years, gradually increased in breadth; and, for more than a mile below Glasgow Bridge, the water-way is now three times its former width. With respect to the harbour, the change has been equally marked during the last fifty years. In 1800, the whole quay was restricted to a space not exceeding a few hundred feet, and occasionally exhibited no vessel larger than a coal barge or a herring wherry. At present the quayage extends to about 10,000 lineal feet, while hundreds of the largest-sized ships belonging to the mercantile marine of this and foreign countries are seen ranged three and four deep along its breast. At present, loaded vessels of 1000 tons register come up easily to the harbour of Glasgow, and are abreast of the quays in one tide; while steam-ships of 2000 tons have been built on the banks of the river, near to the city, and their machinery fitted up within the harbour.

The following are the numbers of the sailing and steam-vessels which arrived at the harbour of Glasgow, with their registered tonnage, during the years ending July 1828, 1840 and 1850.

Tonnage during the years ending July 1828, 1840 and 1850.

Year.	Under 40 Tons.	40 to 60.	60 to 80.	80 to 100.	100 to 150.	150 to 200.	200 to 250.	250 to 300.	300 to 350.	350 to 400.	400 to 450.	450 to 500.	500 to 600.	600 to 700.	700 & Up.
1828.	2117	2847	4605	1399	213	20	14	1	0	0	0	0	0	0	0
1840.	3256	4286	3945	2975	922	326	171	284	81	73	63	18	69	3	0
1850.	4319	2245	2894	3204	733	517	321	128	213	145	110	34	151	15	23

The whole tonnage arriving at the harbour of Glasgow during the same period was as follows:—

	Sailing Vessels. Tons.	Steam Vessels. Tons.
1828	214,315	481,946
1840	271,942	894,387
1850	392,033	873,159

From this statement it appears, that while there is a slight falling off in the steam trade in 1850—which is easily accounted for from the railways seriously interfering with the coasting trade—the increase of the tonnage of sailing vessels arriving at the port, and amounting to nearly one-half more in ten years, illustrates in a striking degree the steady progress of Glasgow.

But if further evidence were wanting from this source, it is only necessary to glance at the following abstract of the amount of dues collected at the harbour during the following four different periods; and when doing so, it must not be forgotten that during the last ten years the dues were considerably reduced on certain articles, both of export and import.

	£	s.	d.
In 1800 the Revenue of the Clyde Trust was . . .	3,319	16	1
1820 ,, ,, . . .	6,328	18	10
1830 ,, ,, . . .	20,296	18	6
1840 ,, ,, . . .	46,481	1	9
1850 ,, ,, . . .	64,243	14	11

Hence it is plain that the increase of revenue has been since the commencement of the century nearly twentyfold, and during the last 20 years fully threefold!

It may well be conceived that this great river and harbour improvement, and this immense increase of revenue, have not been obtained without a great outlay of capital, which also testifies to the progress of Glasgow. Up to a late period of the last century there was but little money laid out in improving the river, and, strange to say, about the year 1770, the city corporation, who were the guardians of the Clyde, were not at all clear (as appears from the city records) about the propriety at that time of aying out one hundred pounds to remove a shoal a little below the bridge of Glasgow, and hinted to the Merchants' House that they would require their assistance in this great work; whereas, from the period when their successors commenced really to deepen the river and improve the harbour, they have expended little less than two millions sterling! That the expenditure has been judicious, and of the greatest advantage not only to the city but to the whole country, has already been fully demonstrated in the results.

Customs duties.—The next striking index to the progress of Glasgow, will be found in the amount of duties levied at its Custom-house. The following table shows not only the amount received at various periods, but also the gradual increase of Glasgow shipping.

Amount of Customs Duties collected, and of Ships (Glasgow property) registered.

Years ended.	Duties. £ s. d.	No. of Ships.	Tonnage.	Remarks.
Jan. 5, 1796	125 13 0½			
„ 1801	469 13 6½			
„ 1806	1,323 7 11¼			
„ 1812	3,124 2 4¼	35	2,620	Glasgow ships required to be registered at Port-Glasgow or Greenock till 1819, and it continued optional to do so till 1824.
„ 1815	8,300 4 3¾	59	4,829	
„ 1820	11,000 6 9	85	6,604	Glasgow made a Bonding Port for particular articles in 1817 and 1818, and in 1822 extended to all articles except tobacco and tea.
„ 1825	41,154 6 7	111	14,084	
„ 1830	59,013 17 3	233	40,978	Glasgow made a Port of Importation of East India goods in 1828.
„ 1835	270,667 8 9	297	54,335	Glasgow made a Port for Importation and warehousing of tobacco ip 1832, and of tea in 1834.
„ 1840	468,974 12 2	351	71,878	
„ 1845	551,851 2 5	472	111,620	
„ 1850	640,568 7 9	507	137,909	

In examining the foregoing table, it should be remembered that the rise of revenue between 1840 and 1850 gives but an inadequate idea of the increase of business or of consumption, seeing that during the course of these ten years many serious fiscal changes had occurred calculated to lessen the revenue*.

The result of this table, however, is, that in spite of all drawbacks, the Customs of Glasgow have, in the course of less than 50 years, increased from £469 13*s*. 6½*d*. to £640,568 7*s*. 9*d*.; and its registered shipping, which previous to 1812 was nothing, is now 507 vessels of 137,909 tons!

The Post-office.—The next index to the progress of Glasgow which I would adduce, is the state of the *Post-office*, and this is limited to the last ten years. From the following return, which has been obtained from that establishment, it appears that the increase has been at least commensurate with the increase from the Customs.

Number of letters delivered by the Glasgow post-office during the week ending 21st July:—

1840	54,522
1850	111,504

Money orders issued and paid during the quarter ending 5th July:—

		No. of Orders.	Amount. £ s. d.
1819—	Issued	2,644	3,596 19 6
	Paid	2,000	2,466 0 8
	Total	4,614	6,063 0 2
1850—	Issued	16,708	29,752 9 0
	Paid	17,517	33,851 0 2
	Total	34,225	63,603 9 2

Number of officers employed:—

	Clerks.	Stampers.	Newspaper Sorters.	Letter Carriers.
1840	13	3	2	28
1850	31	6	3	51

From the above statement it appears that the letters delivered in Glasgow have been more than doubled in ten years, while the cash passed through the Money-order office has been increased tenfold. The business done in one year in this department amounts to about a quarter of a million sterling.

* In 1842 Sir Robert Peel's new Tariff came into operation; in 1846 the duties on sugar were reduced; in 1847, duties on corn suspended; in 1849, duties on corn reduced to 1*s*. per quarter; in 1846, duties on foreign spirits reduced; and in 1848, duties on rum reduced.

Cotton Trade.—Let us now look to only two of the staple manufactures of Glasgow, viz. cotton and iron, as a further illustration of its progress; and first, let us take only two departments of the cotton trade—cotton-spinning and power-loom weaving.

The first steam-engine in Glasgow connected with cotton-spinning was erected in 1792; but it was not till the beginning of the present century that any considerable quantity of yarn was spun in Scotland. At the present moment the extent of this trade may be imagined, when it is stated that the number of spindles employed in cotton-spinning connected with or dependent on Glasgow, amounts to about 1,800,000, and that the cotton consumed will amount to nearly 45,000,000 lbs. or 120,000 bales.

The power-loom was first introduced to Glasgow in 1793, by Mr. James L. Robertson, who brought two from the hulks on the Thames. In the following year forty looms were fitted up at Milton; and in 1801, Mr. John Monteith had 200 looms at work at Pollokshaws, near Glasgow. In 1831, the power-looms in or dependent on Glasgow had increased to 15,137; and in the present year the power-looms belonging to the city, or connected with it, number about 25,000, producing the daily average of 625,000 yards of cloth.

Iron Trade.—Although the cotton manufacture, in all its various combinations, was to a certain period justly regarded as the staple trade of Glasgow and neighbourhood, it is problematical whether or not the iron trade may not now be looked upon as equally important. From a document furnished me by Mr. Barclay, who lately published a pamphlet on the statistics of the Scotch iron trade, I find that the number of smelting furnaces around Glasgow in 1830 was only 16, each producing an average of 2500 tons of pig-iron per annum, or a total of 40,000 tons; whereas, during the year 1849, there were 79 furnaces, each producing about 6000 tons, or 475,000 tons per annum, showing an increase of more than ten times the amount in the course of less than twenty years*. The manufacture of malleable iron in Scotland is of more recent date, not having been properly commenced till 1839, and no note of the quantity made having been kept till 1845, when it appears the production was estimated at 35,000 tons. At present there are in operation five malleable iron-works near Glasgow, and one in Ayrshire, making the number at work in Scotland six, while the production at present is estimated at 80,000 tons, or more than double in five years.

Gas.—There is nothing connected with a great and growing city which marks its progress more palpably than its consumption of gas. By merely glancing over the annual returns of each of the various gas companies of the empire, it were at once easy to predicate, with some degree of accuracy, the progress of its various towns. Previous to 1817, Glasgow was dependent, like all other places, on oil or candle for light. During that year the first gas-light company was instituted, which was followed by another company in 1843. On the 15th September 1818, the streets were first lighted with gas, and immediately thereafter it began to be used in dwelling-houses and factories. The street lamps lit with gas in 1835–36 numbered 2888, and in 1840, 3301; whereas at this time (1850) they amount to 7358. The present annual cost paid by the police for lighting the city streets is £3913 7*s.* 3*d.*, irrespective of what is paid by the bridge and harbour trustees for the bridges and harbour. In 1840 the quantity of gas consumed in Glasgow and suburbs, irrespective of that burned by a few manufacturers who made their own gas, was 173 millions of cubic feet; whereas at present the consumption, irrespective of the gas made at one public work, amounts to 441 millions of cubic feet!

Water.—The next great point in the city's progress to which we would call attention is the supply of water. Prior to the year 1806, Glasgow was but indifferently provided with water. It depended at that time wholly for its supply on twenty-nine public wells (the greater number of which still remain), a few private pumps, and what could be drawn from a spring at Willow-Bank, and which was carted to the city and sold from door to door. About that period, however, the Glasgow Water Company was formed, which was soon followed by the Cranstonhill Company. These companies, now united, have, up to 1850, expended on their works and in laying pipes, £440,047 6*s.* 10*d.*; and derived last year, say from May 1849 to May 1850, a revenue of £31,093 9*s.* 7*d.* The daily supply of water by this company amounts to 9,673,000 gallons, of which a portion is raised to the height of 245 feet. This company now limits its supply to the north side of the Clyde, the population of which may

* In 1849 the blast furnaces in Scotland were 113 in blast, and 31 out of blast; the quantity of iron produced is estimated at 690,000 tons.

be taken in round numbers at 300,000, and deducting one-sixth part for the supply of factories and public works, leaves upwards of eight millions of gallons for private consumption, which amounts to about 27 gallons per day for every inhabitant. In 1846 another company was established to furnish water by gravitation, which, however, limited itself to the supply of the south side of the city, the population of which may be taken in round numbers at from 60,000 to 70,000. This company at present furnishes about 3,000,000 gallons per day, and after deducting the consumption by public works, affords at the rate of about 28 gallons daily to each inhabitant. The total quantity of water sent into Glasgow per day by these companies amounts to upwards of 12,000,000 gallons!

It were easy to multiply what may be called the bright salient points of the progress of Glasgow, but it is time now to advert to one or two of the dark spots—those social shadows which are almost invariably found amid large accumulations of houses and people; and first of all, let us look to that constant companion of the progress of wealth in great cities—poverty.

Poor.—In 1784 the assessment for the poor of Glasgow, which was then limited to the old burgh, was £1082. In 1816, a year of considerable mercantile distress and of dear corn, the sum expended on the poor within the same extent of territory was altogether £12,387 16*s.* 9*d.*; and in 1850 the poor of the same locality cost no less a sum than £47,787 7*s.* 10*d.*, or four times as much in the course of little more than thirty years. The present cost of the poor throughout the whole municipal city, which includes two whole parishes and a portion of two others, is estimated at upwards of £80,000 a-year.

Pauper Burials.—One of the most striking and alarming features connected with the management of the poor in Glasgow is the amount of pauper burials. Prior to the close of last century, such an occurrence as a person being buried at the public expense was almost unknown. During the last two years, however, the pauper burials were as follows:—

1848	4042
1849	3577

That so large a number of pauper burials should have taken place in Glasgow bespeaks either, at the time, a great degree of poverty, or an increased unscrupulousness respecting alms among the labouring population; while the fact that twenty-six per cent. of the whole burials within the Bills of Mortality should have been paid during 1849 from parochial or charitable funds, exhibits a sad picture of the condition of the working-classes, and if continued would loudly demand a most searching inquiry into the causes of such a fearful increase of pauperism, and of the remedies which should be adopted to meet and resist it*.

Police Crime.—Let us next look at another dark point of a city's progress, the amount of crime. The following return, which I have just received from Mr. Smart, the chief Superintendent of Police, at once exhibits the nature and extent of this:—

Number of Persons brought before the Magistrates of Glasgow, in the Police Courts of Glasgow, during the year 1849.

	Men.	Women.
1. Offences against the person	241	37
2. Offences against property, committed with violence	209	52
3. Offences against property, without violence	2,590	1,642
4. Malicious offences against property	128	72
5. Forgery and offences against the currency	26	22
	3,194	1,825
6. Drunk and disorderly	6,823	1,547
7. Drunk and incapable	1,688	200
	†11,705	3,572

* It is but fair to state, that during these two years fever and cholera both frightfully prevailed, and cut off a vast number of the labouring classes who had no relatives in the city, and also hundreds of poor Irish who fled to Glasgow before the famine fever in Ireland.

† These figures do not give a correct view of individual crime, seeing that the same per-

Cost to the community, of the criminal portion of the city police for 1849, £21,816 19*s.* 2*d.*

Amount of fines levied in the various police-offices within the city, £3583 1*s.* 4*d.*

Prisons.—As a corollary on crime we now turn to the prisons of Glasgow. Previous to 1810, the Tollbooth, or prison, like many others in Scotland, was indifferent enough. At that time a new jail was erected near the river, at the west end of the Green, and the old one was removed. There was also at that period a bridewell or house of correction. In the year 1820, the cost of these establishments to the Corporation, who then paid for the prisons, was £1058 4*s.* 11*d.*; whereas, in the year ending June 1850, the gross cost of the prisons of Glasgow was—

	£	s.	d.
	10,321	15	10½
Less, received for work	1,671	14	6
Net cost	8,550	1	4½

The average daily number was 717. The gross cost per head was £14 7*s.* 10¾*d.* Average earnings, £2 6*s.* 7½*d.* Net cost per head, £12 1*s.* 3½*d.*

The following was the state of the prisons of Glasgow during the year ending June 1850:—

	Males.	Females.	Both.
Number of criminal prisoners (male and female) in confinement on 1st July 1850	470	285	755
Number received during year ended 30th June 1850	2549	1572	4121
Total number in confinement	3019	1857	4876
Average daily number	418	299	717
Number of civil prisoners on 1st July 1849 . . .	17	1	18
Number received during year ended 30th June 1850	183	11	194
Total number in confinement	200	12	212
Average number of debtors	15	1	16
Total number who have passed through the prison, criminal and civil	3219	1869	5088

Local Assessments.—And now, to conclude this dark side of our picture, let us state the cost which the progressive city we have been illustrating is obliged to pay annually for the alleviation of poverty, for the suppression of crime, and the maintenance and cleansing of the streets. It is as follows:—

Police	£50,933	
Statute-labour	15,648	
		£66,581
Prisons		8,049
House of refuge		3,283
Poor-rates in the municipality:—		
City	*£66,250	
Barony	25,000	
Govan	7,644	
Gorbals	2,363	
		101,257
		£179,170

When this large annual local burden is added to the government taxes in the shape of property and income-tax, cess and assessed taxes, it must appear quite plain

sons may have been several times committed during the year. The same remark is applicable to the prisons.

* This sum, although laid on, was not realised, being levied according to the means and substance mode, occasioning many disputes and objections to payment. Perhaps not more than £15,000 or £16,000 was required.

that without great capital and indomitable industry such a load could not long be sustained.

Concluding remarks.—Notwithstanding all the drawbacks above hinted at, Glasgow still seems destined to advance in a ratio as prodigious as heretofore. At this moment a new town is being added to its western and northern boundary; streets, squares and crescents rise on every hand: a dozen of new spires, surpassing in architectural beauty the steeples of the old established kirk, formerly the monopolist of such structures, are shooting up in every direction, to give character and beauty to the city. The ancient bridge, which, previous to the erection lately of Hutcheson's and the Glasgow bridge, was for nearly six centuries the only communication between the north and south sides of the Clyde, has been just swept away to make room for a granite structure, equal in breadth to London Bridge. The deepening-machine and the diving-bell are daily labouring to maintain and increase the depth of the river. A thousand minds are nightly dreaming either of new combinations of forms or of colours to meet the growing taste of an advancing world, or are devising new mechanical appliances to diminish labour and ease mankind of toil. The manufacturer is still increasing his spindles and his looms, the merchant is still looking out for new products and new markets, while hundreds are flocking from all quarters of the land, full of hope or of enterprise, to join the already congregated crowd of eager competitors for labour or for gain. And yet, amid all this restless enterprise and activity, philanthropy is not asleep, for we find her engaged in raising lodging-houses for the industrious, retreats for the poor and the aged, houses for the houseless, hospitals for the sick, and schools for the ragged and the neglected; and, in fine, ministering to the sorrows and alleviating the miseries of the diseased and the unfortunate.

MECHANICAL SCIENCE.

The Astronomer Royal exhibited specimens of some spare castings for the pivots of the large transit-circle now in preparation at the works of Messrs. Ransomes and May, Ipswich, for the Royal Observatory, Greenwich. These castings had been broken for the purpose of showing the *chilled* structure; and the Astronomer Royal, in exhibiting them, alluded shortly to the construction of the instrument, and to the connexion of its general arrangement with the use of chilled iron for the pivots. The instrument is in form like a transit instrument carrying two large circles (one for graduations, the other for clamping): the axis is 6 feet long, consisting of two cones whose bases are attached to a cube of 20 inches; the telescope is 12 feet long, carrying an eight-inch object-glass; the circles are 6 feet in diameter. To carry an instrument of these dimensions (weighing about a ton) hard pivots are evidently indispensable; but the Astronomer Royal had been taught by experience to put no trust in the connexion of pivots of one material with an axis of another material; and he would therefore scarcely have ventured on the construction of an instrument of this magnitude, unless he had been able to find a material which, in different parts of the same flow of metal, could be made soft and easily workable in one part, and hard in another. It was at Mr. May's suggestion that cast iron was adopted, the pivots being "chilled." This process (which, as the Astronomer Royal believed, was either invented or was first extensively introduced by the senior Mr. Robert Ransome, for the purpose of hardening one side only of cast-iron plough-shares, so that in their wearing they may always preserve a sharp edge) consists in casting the iron in a mould of iron which is heated to a degree known by experience to be the most favourable for hardening the cast. [In the specimens which were produced, the pivots were hardened to the depth of about half an inch, and to this depth the iron is so hard as to be scarcely touched by a file.] The axis, including the central cube, the two cones, and the two pivots, was formed in two casts (their line of separation bisecting the cube). Each of these was cast in a mould, of which all that included the semi-cube and the cone was of sand, while that part which included the pivot was of iron. The joining surfaces were planed, and the cones were turned, in the usual way, but the pivots were ground with emery; and after overcoming some difficulties, a very perfect form had apparently been given to them. In alluding to this part of the operation, the Astronomer Royal took occasion to express his strong disapproval of the practice (so universal among engineers) of turning and boring with the axis of the lathe or borer horizontal. The difficulties in the shaping of these pivots appeared to have arisen entirely from the action of the weight of the iron transversely to the axis, and were overcome at last only by the use of counterpoises with friction-wheels: in all probability they would never have presented themselves if the boring and turning had been effected with the axis vertical.

The axis being thus made of cast iron, it followed almost as a necessary mechanical consequence that the telescope tubes and the circles should be made of cast iron. It had been matter of serious anxiety to ascertain whether the rusting of the iron, which might be expected at the contact of the iron with the band of silver on which the divisions were to be cut, would be so great as to endanger the firmness of the silver band. An experimental circle had therefore been cast and turned, and a silver band had been inserted; and this circle had been exposed to wet in every possible form, till the whole was covered with such a mass of rust, that the band, in some places, could scarcely be seen. On clearing off the rust, it was found that the surface touching the silver was nowhere affected.

On a Register Hygrometer for regulating the Atmospheric Moisture of Houses. By J. G. Appold.

This instrument, with a variation of one-quarter of a degree in the hygrometric state of the atmosphere, opens a valve capable of supplying ten quarts of water per hour, conveying it on to the surface of warm pipes covered with blotting-paper, by which the water is evaporated until the atmosphere is sufficiently saturated, and the valve thereby closed.

A lead pencil attached registers the distance the hygrometer travels, and thus a sheet of paper moved by a clock would show the hygrometric state of the atmosphere at any period of time.

The author presented a drawing and description of the apparatus.

On an improved Door Spring. By George Beattie, *Edinburgh.*

The motive power is the pressure of the atmosphere acting on one side of a piston, the other side being a vacuum. In applying this pressure to shut a door, about 2 lbs. to the square inch is lost by the friction of the machinery. The pressure of the air acts simply as a counterbalance on the piston, the resistance being uniform throughout the travel of the door when opening it, and when shutting the door the regularity of motion and avoiding of slam is obtained by means of a stream of oil being made to discharge from a cylinder through a large or small aperture, according to the speed required. Fluids being almost incompressible, the oil will not pass through the aperture beyond a given rate, which is in proportion to the size of the aperture and the quantity to be discharged, and the power of the cylinder the vacuum is formed in to press it through. There is nothing in the machinery employed liable to break or get out of order. The construction was minutely described.

The President, Sir David Brewster communicated the substance of a note addressed by Dr. Jules Guyot to the Abbé Moigno claiming the priority of the invention of the tubular bridge. Dr. Jules Guyot had taken out patents in France in 1844 and 1845, and one in England in 1846, for a tubular girder consisting of a number of hollow rectangular parallelopipeds or cells, formed either of bars or frames (*chassis*) of iron united by pins, or formed of one piece of cast iron. This was no doubt an anticipation of Mr. Stephenson's idea of a tubular bridge, as stated in 1846 to the Committee of the House of Commons; but Mr. Stephenson afterwards founded his claim to that invention upon his bridge at Ware, erected about October 1843, previous to Dr. Guyot's patent. Sir D. Brewster, however, states that a tubular girder bridge had been erected in 1840 or 1841 by Mr. A. Thomson over the

Pollock and Govan Railway near Glasgow, who had thus anticipated both Mr. Stephenson and Dr. Guyot.

On some proposed Improvements in Valves, Stopcocks or Stoppers for regulating the Passage of Fluids, by the Use of Flexible Substances. By GEORGE BUCHANAN, *F.R.S.E., Civil Engineer.*

The author adverted to the great importance of this subject in practical mechanics, affecting essentially all the arrangements for the supply of water to our cities and dwellings, and for the regulating and feeding of our water cisterns, our ordinary boilers for hot water as well as the boilers of steam-engines, and also in the safety-valves and other valves of steam-engines, and in gas-works ; a wide field, but only into a small portion of which he meant to enter at present. Considering however the skill and perfection already attained by our engineers, and the many improvements introduced by eminent scientific and practical men, he might well feel diffident in bringing before the Association anything out of the usual course of practice, and could only plead the important and interesting nature of the subject, should the views not prove of practical value in themselves.

The first improvement, and which applies to all valves of the lifting kind, conical or flat, and to the stoppers of bottles, consists in the introduction and use of a flexible substance, as vulcanized India-rubber, to form one of the bearing surfaces of the valve; and this not as a washer in the usual way, but in the form of a distended membrane, stretched across the mouth of an opening or cavity formed in the centre or round the circumference of the lid of the valve. This opening or cavity is of larger diameter than that of the valve orifice, so that when the orifice is brought to press against the membrane, this latter presents, by its smooth and even surface and by its tension and great elasticity, the means of producing with facility a perfect contact with the metallic glass or other surface, to the exclusion of the fluid, and sealing the orifice by simpler means than any hitherto in use. The cavity behind the membrane may be either open or shut; if open, the pressure against the orifice of the valve in closing is resisted by the membrane, but in such a way that the elasticity and tension of all its parts are brought into action; different from the case of a washer, where the narrow bearing surface is only affected, compressing a thin ring of the soft material against the metal, while here the pressure is diffused over the whole surface, every particle of which is brought into play, and the substance thereby less liable to tear and wear and derangement. If the cavity behind the membrane be shut, then the pressure of the valve orifice is resisted, both by the elasticity of the membrane and by the confined air behind, presenting a sort of cushion of resistance, and along with the air, water or other fluid, is sometimes introduced as a fluid cushion.

The bearing surface should be narrow, and so far indeed as the contact is concerned and the exclusion of the fluid, it may be reduced to a very thin edge; for Mr. Buchanan had found by various experiments that it is not so much the breadth of the surfaces in contact as their mutual pressure, on which the effect of excluding the fluid depends; and the narrower therefore the surface is made, the greater is the intensity of any given pressure.

Such is the principle of this first improvement upon valves, and so far as experience had gone the result was very satisfactory. He had found the vulcanized India-rubber to retain its form and tension for a long period unimpaired. If applied loosely, the form was liable to change by pressure, but in the form of a distended membrane it retained its form and elasticity in a surprising manner, and this both with air and water. With hot water and steam of a moderate pressure, he had also reason to think it would answer, but had not tested it for sufficient length of time to speak decisively. The distension of the membrane he had contrived to produce in a very simple manner, by joining round the circumference of the membrane or disc previous to distension another similar disc with an opening in the centre, or else a thickish ring, and then by applying a metallic ring of larger diameter than the membrane the required distension was easily effected.

Mr. Buchanan then illustrated the application by various experiments and models, and its peculiar adaptation in all cases of regulating the level of fluids where the operation to be effected depends on a nice balance of forces; and he had applied it successfully in this way as a ball-cock or regulating valve for cisterns, and also for hot water boilers under various forms, and all having the advantages of the valve running full-bore till the cistern be filled, when it closes at once, and also the surfaces not adhering by contact.

In all these cases, the membrane, at least the bearing surface, is not subjected to the full pressure of the fluid in the pipes; it is under a balance of forces, and the only force acting is the preponderating one necessary to close the valve.

He also showed the peculiar adaptation of this valve to the water metre, an instrument of great importance, but which had hitherto failed, he believed, entirely for want of a sufficient delicacy and permanence in the action of the valves; also the application to another important case, viz. the feeding of steam-engine boilers, which he illustrated by drawings and a regulating apparatus, consisting of valves and float in a small vessel or cistern separate from the boiler, and which he had found to act with excellent effect. He also showed the application to annular valves, a form of great value, and which had been already introduced with success in pump-work, combining a large area of discharge with a small lift in the valve.

The second improvement introduced by Mr. Buchanan, and involving another leading principle, consists in the application of the flexible substance, not merely as the bearing surface or lid of the valve orifice, but as a medium by which the pressure of the fluid, either water, steam or others flowing in the main pipes, is by a very simple arrangement brought to bear upon the flexible substance, and communicate this pressure to the lid of the valve so as to close it at once and effectually, and by means greatly simpler and requiring less mechanical power and arrangement than any hitherto in use, and by which valves and corks of the largest dimensions, and either of the membrane kind or of any other description, can be worked by the opening or shutting of a very small orifice. This principle Mr. Buchanan illustrated by drawings, showing the mode of applying the pressure, and by experimental models of cocks and valves, the effect of which appeared extraordinary and capable of extensive application, and whereby there appeared to be introduced a new principle of action for working hydraulic and other kinds of machinery with a degree of ease and facility not hitherto attained.

Mr. Palmer Budd made a Communication in continuation of his paper, published in the Transactions of the Association for 1848, "On the Advantageous Use made of the Gaseous Escape from the Blast Furnaces at Ystalyfera."

He explained how he had applied the œconomy described in 1848 to all the furnaces at the Ystalyfera works, so as to dispense with the fuel and labour before employed to heat the blast and raise the steam for the engines. As to effect this the distance to which the gaseous escape had to be carried was increased, he had found it advantageous to drop into the furnace at the charging place a funnel or hopper of sheet iron, of a depth sufficient to shield entirely the mouths of the horizontal flues conveying off the escape. By this appliance there was about a foot of space clear of material, at the entrance of the flues; and the difficulty that sometimes arose in high winds was obviated, and the flues themselves were protected from the lodging of any portion of the materials thrown into the furnace. He found in practice that as long as there was a free ascending column through the furnace, this iron hopper was not injured from heat; and that the only danger of injury was during and after stoppages of the furnace, when the ascending column was faint and not sufficient to oppose the descent of the atmosphere.

Mr. Budd noticed the introduction of his plan into the Scotch furnaces, and pointed out the great advantages that might be derived from the great abundance of the gaseous escape from them, from the nature of the fuel used, and stated that the waste heat from one furnace in Scotland would probably heat the blast and raise the steam for three, leaving the top escape of two-thirds of the furnaces disposable for other purposes, which he pointed out.

On the Hyperbolic Law of Elasticity of Cast Iron. *By* Homersham Cox, *B.A. Jesus College, Cambridge.*

By the formulæ ordinarily used, the elasticity of a uniform iron rod subject to direct extension or compression is represented as proportional, up to a certain limit, to the extending or compressing forces. It appears however from experiment, that for equal increments of extension the increase of tensile force is continually less and less. The decreasing ratio of the elastic force to the corresponding extension or compression, indicating what is sometimes termed *defect of elasticity*, was noticed by Leibnitz, James Bernoulli and others* very soon after Doctor Hooke announced the first-mentioned law, which is known in England by his name.

If the extending weight (ω) be considered such a function of the extension (e) as to be capable of being expressed by a convergent series ascending by integral powers of e, Dr. Hooke's law, by which $\omega = Ae$, where A is a constant (called the "modulus of elasticity"), may be considered as stopping at the first term of such a series. To correct the errors of Dr. Hooke's formula, the step which suggests itself most obviously is to add on another term of the series; so that,

$$\omega = Ae - Be^2, \quad \ldots \quad (1.)$$

where B is another constant; or dividing by e,

$$\frac{\omega}{e} = A - Be. \quad \ldots \quad (2.)$$

And as the ratio of ω to e decreases as e increases, the second term on the second side of the equation is necessarily negative.

Such a formula is compared with experiment in a valuable paper by Eaton Hodgkinson, Esq., Appendix to the Report (1849) of the Royal Commission "appointed to inquire into the application of Iron to Railway Structures." But on examination it will be found that the differences between the results of the formula and experiments are not + and — promiscuously, but themselves follow a certain order.

Eight formulæ are given for extension of different kinds of iron; and we observe in all, without exception, that one-half, and generally more, of the results come together in the middle of each series of experiments with errors having the same sign, and are preceded and followed by errors affected by the contrary sign. The formula cannot, however, be considered satisfactory until the errors be affected by the + and — signs promiscuously and without regular sequence. From the general character of these errors, it may be inferred by sufficient analytical reasoning that a formula involving the first three powers of the extension would possess much greater accuracy† than one involving only two powers, if the constant coefficients were properly chosen.

All these formulæ, however, lead to excessively complicated results when applied to investigations respecting the deflection of beams. They have moreover the serious inconvenience, that, from the expression for the weight in terms of the extension to find conversely the extension in terms of the weight, it is necessary to solve quadratic and cubic equations involving very large numerical coefficients.

The formula about to be proposed is far more accurate than the formula (1,), and has greatly the advantage of simplicity of computation from it. It can be applied with great facility to obtain the extension from the extending force, or the latter from the former. It has also this advantage, that, when applied to the theory of beams, it leads to an expression similar in form to itself, from which, with the utmost readiness, the deflection can be computed from the transverse pressure, or the latter from the former.

If α and β be empirical constants, it will be found that the relation of ω to e, for a rod of a unit of length and a unit of sectional area, may be nearly expressed by the equation

$$\frac{\omega}{e} = \alpha - \beta\omega \quad \ldots \quad (3.)$$

This is the equation to a rectangular hyperbola of which e and ω are the co-ordinates parallel to the asymptotes, and referred to an origin at a point in the curve.

The proposed formula therefore exhibits the Hyperbolic Law of Elasticity according to the nomenclature of James Bernoulli, who (*loc. cit.*) represents the relation of the tension to the extension by a curve which he calls the *Linea tensionum*.

Similarly, the formula (1.) may be termed the *parabolic formula*, for it is the equa-

* Acta Eruditorum of Leipsic, 1694.

† A formula involving four powers is given in the Report in one case; but its accuracy is little greater than that of the formulæ of two powers, as the constant coefficients have not been chosen by a method which gives the minimum error.

tion to a parabola of which ω and e are co-ordinates, measured from a point in the curve itself, perpendicular and parallel to the axis respectively.

Tables* are given in the original paper in which the hyperbolic and parabolic law are compared together, and with the results of experiments; and it is shown that the former has the advantage of having a mean error between one-third and one-fourth of the error of the parabolic formulæ. The same comparison is extended to the deflection of beams, for which formulæ of similar forms are adopted.

Taking the "hyperbolic" formula for direct longitudinal compression (c) of a rod of a unit of length and a unit of sectional area by a direct force ω to be

$$\frac{\omega}{c}=\gamma-\delta\,\omega,$$

and the "hyperbolic" formula for central deflection (f) of a rectangular bar by a transverse pressure (ω) applied perpendicularly at its centre to be

$$\frac{\omega}{f}=\epsilon-\zeta\,\omega,$$

the paper proceeds to show that the following equation is very nearly correct where the deflection is of small magnitude compared with the length of the beam :—

$$f=\mathrm{P}a^3\div\left(\mu d^3(\alpha+\gamma)-\frac{27}{16}\,\mathrm{P}da\,\frac{\alpha\beta+\gamma\delta}{\alpha+\gamma}\right),$$

where P is half the deflecting pressure, d half the thickness of the beam in the direction of that pressure, μ the breadth, and a half the length.

The breaking weight of rectangular beams is then found in terms of the constants α, β, γ, δ; and the resulting expression is, as far as its form is concerned, found to be similar to that ordinarily used for determining the breaking weight of rectangular beams.

From the formulæ for direct tension and for deflection may be obtained (by substituting in them the numerical values of α, β, ϵ, ζ, deduced from experiment) the numerical values of γ and δ by means of the connecting equations last given.

This method seems to give more accurate results than the experiments on direct compression detailed in the Report, which are so irregular as evidently not to be trustworthy. They were made by compressing bars enclosed in tubes of which the sides resisted the flexure of the bars. This lateral resistance had of necessity great effect in sustaining the external force applied to compress the bars, and was probably the principal cause of the vitiation of the results.

The numerical values of the constants for compression are obtained in the original paper from several independent experiments, and agree with each other in a very satisfactory manner. It is however to be observed, that a great desideratum exists for perfecting the "hyperbolic" or any other hypothetical law of elasticity, namely a knowledge of those variations of the strength and elasticity of cast metal which depend on the *magnitude of the castings*. It is greatly to be desired that this want of experimental data may not long remain unsupplied.

On the Water Sirene. By Professor John Donaldson, *Edinburgh.*

Professor Donaldson explained, that in regard to the vibratory movement of fluid masses, it had long been known that when solid bodies are brought into collision under water, the liquid is agitated directly in all the points where it touches the solid vibrating bodies—acquiring thereby an undulatory movement, producing sound, heard of course at a greater or lesser distance, corresponding to the violence of the shock. It was also known, that by a direct shock, the normal vibrations of discs, and longitudinal vibrations of rods, threw water, mercury and other liquids, into an undulatory or vibratory motion; and it had therefore been very generally supposed, that the shock of solid bodies is essential to the production of an undulatory or vibratory movement in fluid masses. But the Baron de la Tour found that sounds could be produced under water without the percussion of solid bodies, by throwing the water into rapid undulatory motion, by the play of the sirene, the instrument about to be described.

* These tables and the analytical investigations were presented before the Cambridge Philosophical Society, Nov. 1850.

Fig. 1.

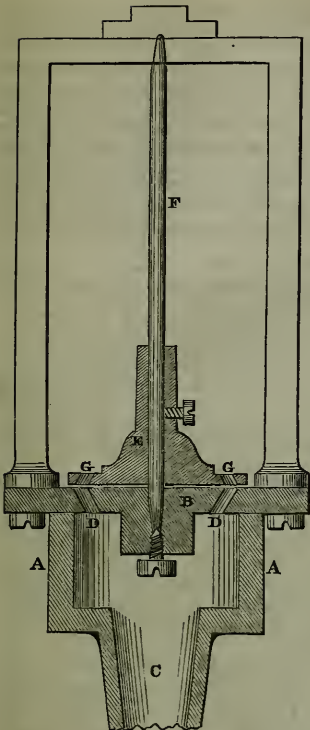


Fig. 2.

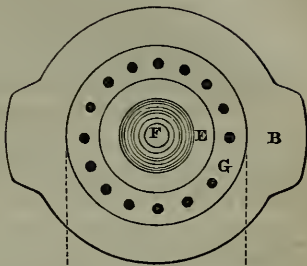


Fig. 3.

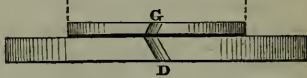
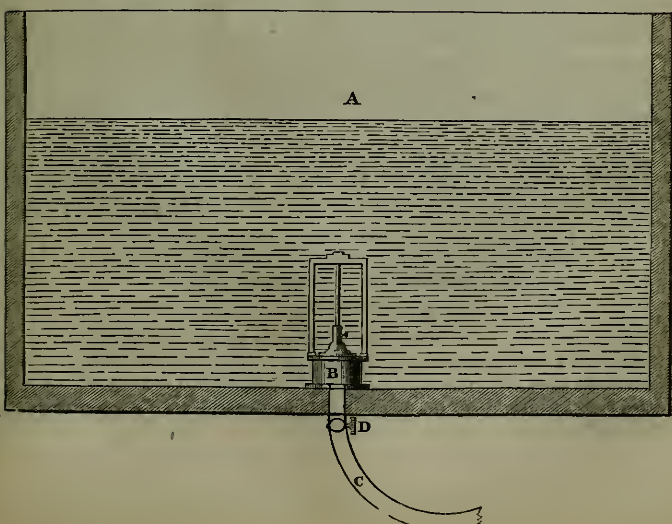


Fig. 4.



The construction of this instrument, and the method employed, may perhaps be more easily understood by an examination of the annexed figures.

Fig. 1 is a vertical section of a sirene intended to act on the air. A is a cylindrical brass box, about two inches in diameter and one inch in height, and having a closed top, B, about a quarter of an inch thick, with a perfectly plane upper surface highly polished. In the bottom of this box there is an opening for the introduction of the tube or "porte-vente" C, by which wind is forced by bellows into the box. Openings, D, are pierced angularly through the top B, as also represented in the plan of the top and revolving disc, in fig. 2, and in the side elevation of the same parts, fig. 3. These holes—16 in number—are disposed in a ring, and are equidistant from each other. They are each of the same size, and the spaces between them are slightly larger than the holes themselves, in order that when the revolving disc E is in motion, its corresponding ring of holes, G, may be quite cut off from any communication with the box A.

The revolving disc E has a long boss upon its upper side for adjustment upon the vertical spindle F, which runs in a jewelled centre at the top in the upper part of the guide-frame, and at the bottom has an adjustable screw-centre in the box A. The holes G in this disc correspond in every respect with those in the top of the box A; they are pierced however at an opposite angle, in order that the pressure of the upward currents or jets from the box beneath may cause the disc to revolve*. The two surfaces of the disc and top of the box are highly polished, and are so adjusted as to cause no perceptible friction, and yet to work close enough to prevent the escape of air from between them. This is difficult to accomplish in practice, and the beauty and accuracy of the surfaces produced by the French makers of these instruments are very remarkable.

When air is forced into the box A, the jets issuing from the holes D, impinge on the oblique surfaces of the corresponding holes in the disc E, and thus cause it to revolve at a rate proportioned to the pressure.

Now, let it be supposed that one hole only was pierced in the box, and one in the disc, the air in its passage would force round the disc, and during its revolution the wind within the box would be prevented from passing to the air without the box, until the hole in the disc came round to the hole in the box, when the wind would rush through as before and thus keep up a regular rotatory motion, causing a stroke or pulsation on the atmosphere at each revolution.

When these pulsations are perfectly regular, and attain to a rapidity of thirty-two in a second, a musical note will be obtained appreciable to most ears, although a very grave note. As the pulsations become more rapid the notes become more acute. The greater the number of holes the more rapid the pulsations.

Having concluded his explanation of this air-sirene, the Professor described the plan he had adopted in using it under water. In the diagram, A is a large square cistern, the sides of which are of strong plate glass, and the bottom of mahogany in a very strong frame. The sirene, B, made as already described, is firmly fastened down in the bottom of the cistern, a piece of caoutchouc being interposed between the surfaces to prevent the movement of the sirene from acting on the bottom of the cistern.

The details of the instrument are analogous to those of the air sirene, except that the holes in the box and disc are larger and only 8 in number. The actuating water is brought by the gutta-percha tube C, from a reservoir elevated about 30 feet above the cistern, through a hole in the bottom into the box B, governed by a stop-cock D.

On turning the cock D, the water in the reservoir rushes into the cylindrical box, forces its way through the holes pierced in the upper part of the box, which strike those pierced in the disc, and thus keep up a rotatory motion.

It must be observed, however, that unless the cistern be filled so as to completely cover the sirene, the water forced through the revolving disc will strike the air; for although it is a jet of water that is cut off by the rotation of the disc till the hole in the disc comes round towards the hole in the box, yet nevertheless it is the

* Strictly, the section, fig. 1, ought not to show any angularity in the holes, as the angle is in relation to the circumferential line of the disc, but they are so drawn to make the movement quite clear.

atmosphere which receives the shock or pulsation. But if the water completely cover the sirene so as to be an inch or more above the revolving disc, then it is the water in the cistern which receives the shock or pulsation.

The pressure of the water flowing from the reservoir causes the disc to revolve under water, and the small streams of water which are forced through the holes pierced in the box are cut off in their transit by the movement of the disc, until the holes in the disc correspond to those in the box, when the water again rushes through and is again stopped, thus keeping up a continuance of regular alternations. The slight shocks or pulsations thus created in the water produce musical tones of singular purity, which become even purer and more and more sustained as the water flows into the cistern. It is also remarkable, that the gravest tones thus produced under water are far more readily appreciated, that is, recognised as musical, than tones produced by a similar number of vibrations in the atmosphere.

On a Wrought Iron Tubular Crane, designed by William Fairbairn, *C.E., F.R.S.* (*Communicated by* Sir David Brewster, *K.H., D.C.L., F.R.S. &c.*)

The author presented a plan, side view, and transverse section of the tubular cranes which he had designed, and which were now in process of construction for the Keyham Dockyards, near Devonport.

These structures exhibit additional examples of the extension of the tubular system, and appear to indicate the numerous advantages which may yet be derived from a judicious combination of wrought iron plates, and a careful distribution of the material in those constructions which require security, rigidity and strength.

Drawings of this new principle of crane having been submitted to the Admiralty, six cranes were ordered for the new docks, each of them to sweep a circle of 65 feet diameter, and to lift 12 tons to a height of 30 feet from the ground. The projection or radius of the jib is therefore 32 feet 6 inches from the centre of the stem, and its height 30 feet above the working platform. It is entirely composed of wrought iron plates firmly riveted together, and so arranged that the upper side is particularly well adapted to resist tension, and the under or concave side, which embodies the cellular construction, to resist compression. The form is correctly that of the prolonged vertebræ of the bird from which this useful machine for raising weights takes its name; it is truly the neck of the crane, tapering from the point of the jib, where it is 2 feet deep by 18 inches wide, to the level of the ground, where it is 5 feet deep and 3 feet 6 inches wide. From this point it again tapers to a depth of 18 feet under the surface, where it terminates in a cast iron shoe, which forms the toe on which the crane revolves. The lower or concave side, which is calculated to resist compression, consists of plates forming three cells and varying in thickness in the ratio of the strain; and on the other hand, the convex or top side, which has to bear the pull or tension due to the suspended weight, is formed of long plates connected together by the system of "chain riveting," which Mr. Fairbairn first applied in the great tubular bridges in Wales. The sides are of uniform thickness throughout, the joints being covered with T-iron intervening, and externally with strips or covering plates $4\frac{1}{2}$ inches wide. This arrangement of the parts and distribution of the materials constitute the principal elements of strength in the crane. The form of the jib, and the point at which the load is suspended, are probably not the most favourable for resisting pressure. It nevertheless exhibits great powers of resistance, and its form as well as the position may safely be considered as a curved hollow beam, having one end (A) immoveably fixed, the force being applied to the other end (C). Viewing it in this light the strengths are easily determined; and taking the experiments herein recorded, we may deduce from the formula $W=\frac{AdC}{l}$ that it would require a load of 63 tons to break the crane. With 20 tons the ultimate deflection was 3·97—·64, permanent set=3·33 inches, the deflection of the jib due to a load of 20 tons. The following experiments were made at Keyham Docks on the 8th and 9th of November last.

November 8th:

Weights laid on in tons.	Deflection at the point of the jib in inches.	
2	·32	
3	·50	With 5 tons suspended the crane was turned completely round, without any alteration in the deflection.
4	·65	
5	·90	
6	1·05	
7	1·20	
8	1·35	
9	1·50	
10	1·70	

With this weight the crane was again turned round; the deflection in 8 minutes increased to 1·85 inch, when it became permanent, after sustaining the load during the whole of the night, a period of about 16 hours.

On November 9th the experiments were resumed as follows:—

11	2·05
12	2·22
13	2·40
14	2·60
15	2·80
16	3·00
17	3·20
18	3·50
19	3·73
20	3·97

On again turning the crane round with a load of 20 tons, there was no perceptible alteration in the deflection, and the permanent set after removing the load was ·64 inch.

From the above experiments, it appears that the ultimate strength of the crane is much greater than is requisite in either theory or practice; and although tested with nearly double its intended load, this was still far short of its ultimate power of resistance, which by calculation is five times greater than its nominal power.

The advantages peculiar to this construction of crane, are its great security, and the facility with which bulky and heavy bodies can be raised to the very top of the jib without the least risk of failure. It moreover exhibits, when heavily loaded, the same restorative principle of elasticity so strikingly exemplified in the wrought iron tubular girders. These constructions, although different in form, are nevertheless the same in principle, and undoubtedly follow the same law as regards elasticity and their powers of resistance to fracture.

Reference to the figures.

Fig. 1 is a side view of the crane with a portion of the side removed from A to the foot, in order to show the cast iron cylinders built in the masonry, the rollers which encircle the body of the crane and support the stem vertically, with its rollers and bearings acting against the interior recess of the large circular plate *a*. Between the plate and the frame attached to the crane is a double ring which contains the rollers, giving a rotatory motion to the crane in any direction. Immediately above the rollers is a platform, 12 feet in diameter, attached to the stem, on which the men stand to work the crane. This platform also enables a man, by turning a handle at *b*, to move the crane round in any direction at pleasure.

Fig. 2 is a ground plan of the crane and platform, showing the upper flange of the large ring with the holding down bolts at *c*, *c*, *c*, &c.

Fig. 3 is a section of the body of the crane taken above the Quay Wall at the point A. The cells are carried along the concave side of the jib when they terminate in two cells near the top, and also in two cells near to the bottom, where the stem enters the cast-iron shoe already mentioned.

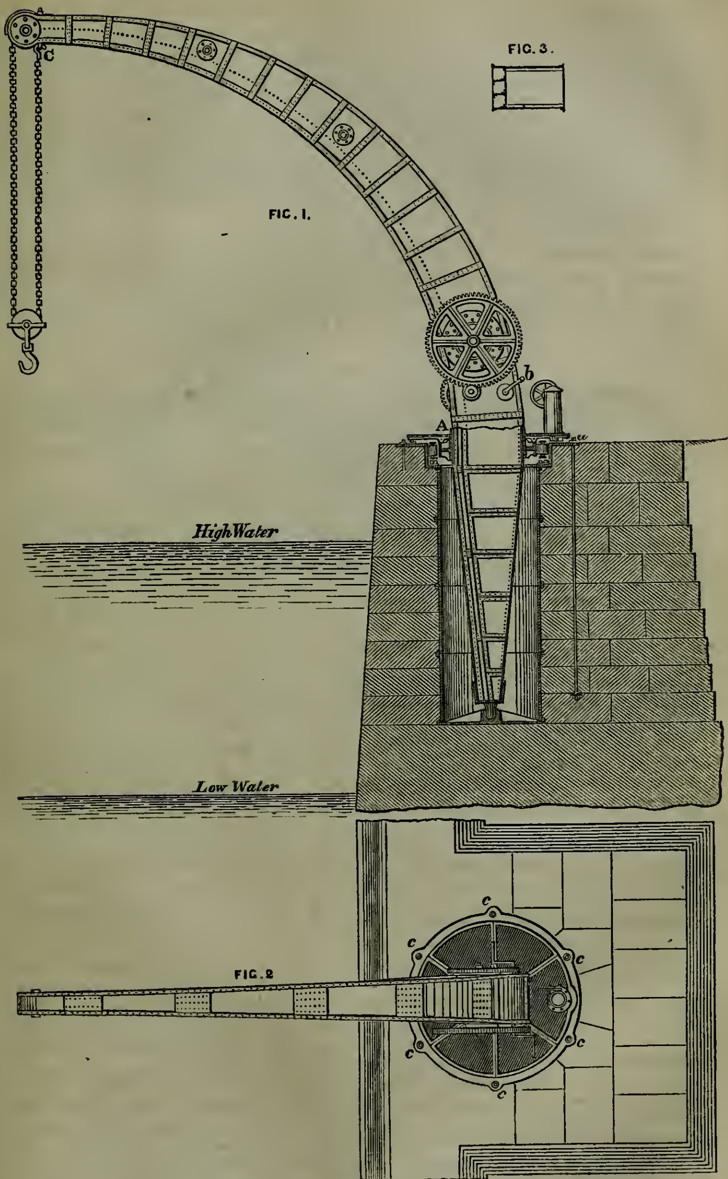


FIG. 3.
c
FIG. 1.
b
A
High Water
Low Water
c
c
c
FIG. 2
c
c
c
c

On a Folding Dome for Observatories. By W. S. JACOB, *C.E., H.E.I.C. Astronomer at Madras. Communicated by* Prof. PIAZZI SMYTH.

Revolving domes for equatorial instruments have been greatly improved and simplified of late, but are still expensive; they require skilled mechanics to execute them, and are not easily made portable: the folding dome, however, possesses these properties. It consists merely of eight triangular shutters, hinging on an octagonal wall plate, and closing against each other so as to form an octagonal pyramid.

No fixed frame-work is required in this dome, as the shutters support each other; two even will stand together, so that it is possible to open any number of sides of this octagonal pyramid from one to six: they open outwards, and are supported then in some simple way, as by a bamboo prop.

One of these domes, 8 feet in diameter, was made by Mr. Jacob seven years ago; it was all constructed by an ordinary village carpenter in India: the shutters were triangular frames covered with canvas; and the sides being bevelled, no inconvenience was found from leakage during rain. The dome has twice been taken down and carried across the country above 300 miles in a bullock cart, over bad roads or no roads at all, and is now again re-erected and in use at Bombay. Its first cost was only £25.

On a Method of Supporting a large Speculum, free from sensible Flexure, in all Positions. By WILLIAM LASSELL, *F.R.S.L. & E., F.R.A.S., &c.*

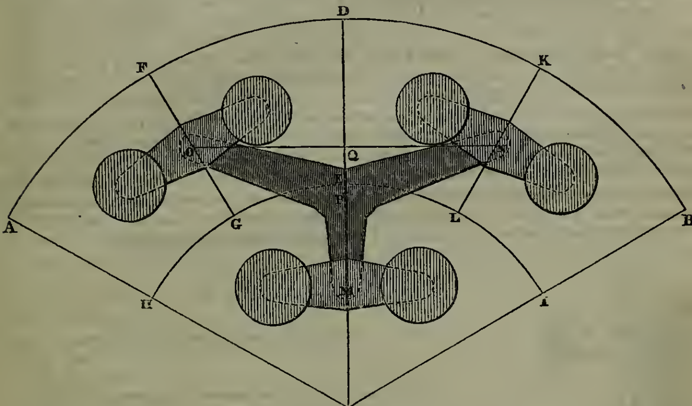
Before describing the method I propose of overcoming the tendency to flexure in large specula, I will briefly describe the evil which I desire to remove.

Your President has aptly described the nature of the metal with which we have to deal, as "harder than steel and more brittle than glass." Yet with these qualities one would scarcely expect that the *bending* of a large speculum would be one of the greatest difficulties in its use. No one unacquainted with the subject would be prepared to believe that a plate of this metal, two feet in diameter, and two and a half inches thick, would bend by its own weight, if supported only by its circumference. It is however the fact, that if such a speculum be ground and polished with the utmost accuracy to the requisite curve, it will receive such an amount of distortion by being supported only at its circumference, or on three points placed at its back, as to be greatly impaired in its performance, if not rendered totally useless as a telescope. A very much smaller speculum will be materially injured in its figure by unequal support; but I shall chiefly refer to a *two-foot speculum* in what I have to say, as to a mirror of that size my remedy is intended to be applied.

The speculum of my twenty-foot telescope is at present supported by eighteen points, or rather small discs of about $1\frac{3}{4}$ inch diameter, which are placed at the ends of a system of levers so distributed and compensated as to bear, severally, one-eighteenth part of the weight of the speculum. I will endeavour briefly to explain how this is done.

Suppose the speculum divided into three equal sectors of 120°, one of which is represented in fig. 1. Let a concentric arc H I be drawn of such radius that the area of its sector shall be equal to one-third the area of the larger sector. An additional line D E, bisecting the arc A B, and drawn in the direction of a radius, will divide the larger sector into three portions of equal area. These three portions may be again bisected by the supplemental lines F G, E C and K L. The sector is now divided into *six* portions of equal area; and therefore, similarly, the entire speculum would be divided into *eighteen* equal portions. Let the centres of gravity of these six portions be indicated by the centres of the six small circles. These circles represent discs of brass in immediate contact with the back of the speculum. They are divided into three pairs, the individuals of each pair being connected by a bar or lever, at each end of which there is a hole, loosely fitted by a pin projecting downwards from the centre of the brass disc above it. The under surfaces of the discs are *small* segments of spheres, allowing a slight rocking motion of the disc for perfect adjustment to the back of the speculum; the centres of these levers are again supported by the ends of a triangular plate or lever M N O, in the same manner as the discs are supported by the first three levers. Finally, this triangular lever is supported at its central point P by an ultimate screw or stud fixed in the end-plate of the tube. The triangular lever is of such proportions, in respect to the length of its arms, that if the points O and N be conceived to be joined by the line O Q N, the distance P M is exactly double of P Q, because the aggregate pressure upon the two points O N requiring to be counterpoised by the pressure upon the single point M, the lever P M must necessarily be twice the length of P Q. A simple inspection of this arrangement will suffice to show that the six portions of equal area are rigidly counterbalanced and in equilibrio,—and, extending it to the whole speculum, that it is equally supported in eighteen points. Theoretically, the speculum is supposed to be so supported, that if it were imagined to be really cut up into the eighteen portions marked out by the divisions while resting upon the discs and levers, it would still retain its normal shape and figure.

Fig. 1.



Practically, I find that this mode of support prevents all sensible bending when the telescope is directed to the zenith or to very high altitudes, and when there is no change of temperature. But when the temperature has altered considerably since the speculum was placed on its supporting levers, there is often indisputable evidence, on turning the telescope on a star, that some distortion of the mirror has taken place; which is I believe thus to be explained. The levers being of iron, expand and contract by variations of temperature, differently from the speculum, and therefore the equal expansions and contractions of the speculum are controlled and disturbed by the incommensurate ones of the iron bars; which, from the amount of cohesion or *stickage* between the points of support and the back of the speculum, sensibly distort the figure. This defect I have in some measure removed by making the discs of support as smooth as possible, so that the speculum may *slide* upon them with the utmost practicable ease. With a view to remove entirely this cause of distortion, I now propose to make the supporting levers of the *metallic alloy* described by Lord Rosse in Phil. Trans. 1840, Part II., which has (sensibly) the same expansion as speculum metal.

Another cause of distortion, however, perhaps more difficult to remove, exists in the *change of bearing* which the speculum necessarily takes when directed to various altitudes—the more so when the altitudes are low. In the latter case, it is evident that the method of equal support at high altitudes almost totally fails: the speculum then only depends for its uniformity of figure upon the greater stiffness that it necessarily possesses when resting upon its edge. Such, however, is the perfection of figure required, that in this position of the mirror there is generally some indication of a change of form in a greater or less degree, and I have hitherto endeavoured to remedy it by supporting the speculum in a thin semicircular iron hoop, secured at the ends of a horizontal diameter, which, supporting its edge in the greatest possible number of points, has materially diminished the evil. Still, when high powers are used, and in favourable states of the air, there is some evidence that it is not altogether removed. And the principal object of this communication is to describe a method which I intend as soon as practicable to carry into effect; and which will, I hope, remove all sensible distortion arising from this cause.

I would propose to cast on the back of the speculum a series of bars, in number about seven, whose section shall be similar to the tooth of a saw, and which shall serve as points of attachment for a number of levers, having their fulcra in the plate which supports the speculum at its back. The disposition and mode of action of these levers will be immediately understood by inspection of the annexed diagrams. In fig. 2, *a* represents the speculum in section with its bars *b*, *b*, &c., *d* the back-plate affording support to the several levers c, c, &c. The ends of the levers e are mounted with friction-wheels to prevent any tension from contact. The shorter arm of the lever should be as short as possible, in order to diminish to a minimum the weight and length of the other arm. The number of these levers may be about thirty-five, equally distributed over its back; and, in a two-foot speculum of the estimated weight of 400lbs., may each be loaded so as to exert an upward pressure of about 11lbs. each, in order that the speculum may not be altogether on a balance, but sufficiently in contact with the supporting hoop to prevent dancing, and yet supported in so many points as to prevent all distortion of the lower half by the weight of the upper, or of the upper half for want of adequate support. It is evident that these levers have no action whatever when the telescope is directed to the zenith, in which position they are not required, and are only called into action *in proportion as the telescope is depressed from the zenith*, exerting their full force when the telescope is horizontal. Fig. 3 represents a view of the back of the speculum with its several bars, and the points where the friction-wheels of the levers come in contact with them.

Fig. 2.

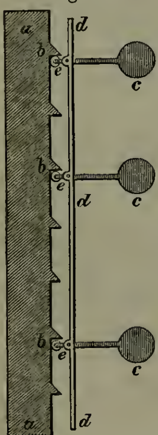
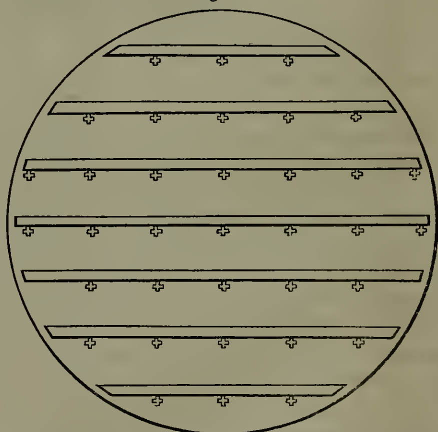


Fig. 3.



It may be objected that the casting of a speculum with these bars will be more difficult than without them, which I admit, though perhaps not in a very great degree. The bars however are not essential, for the requisite points of attachment of the levers may be obtained by cementing to the back of the speculum, with good fresh plaster of Paris, the requisite number of small pieces of speculum metal or alloy; and I have ascertained by experiment that the adhesive power of this material is quite sufficient for the purpose. It will be necessary also practically to deviate a little from the symmetry of fig. 3 in the arrangement of the supporting points, the system of levers for the vertical support in some cases interfering; but this will not be to an injurious extent.

Another exception may be taken to the weight which all these levers will add to the mounting. As however it will not be difficult to make the proportions of the arms as ten to one, the additional weight will scarcely exceed a tenth of the weight of the speculum.

The apparatus will evidently only act *perfectly*, when the bars (*i. e.* lines running along the axes of the bars) at the back of the speculum are in a horizontal position; but I presume that such a variation from that position as might be produced in a couple of hours' observation by carrying on the tube, could not produce any sensible effect.

On the Powers of Minute Vision. Results from Experiments for determining the best sort of Station-marks, and the errors liable in observing with Optical Instruments that measure on the principle of bringing two reflexions together. By William Petrie.

The experiments were performed in bright daylight (but not sunshine), being light of the maximum of advantage for perceiving black against a white ground. The general circumstances of the experiments were arranged rather to determine the facts of common practice, than the theoretic powers of vision.

The author then detailed the various distances at which circular spots, lines, &c., white on black, as well as black on white, could be seen, the distances being given in terms of the breadth of the object seen. An arrangement of lines was described, by which an alteration of their position to the extent of only *one-millionth* part of the distance of the observer was made visible.

One result of the experiments would be to show what should be the proper proportions of parts to be observed in forming *letters* to be read with the greatest distinctness at a distance, a subject of much practical use in the present day, and admitting of a strictly scientific system, although generally left to the fancy of incompetent persons. *White* letters on a *black* ground should have their component lines of only half the breadth that *black* letters should have on a white ground.

The direction of the eye, while appearing to gaze *steadily* at any object, does in reality keep *wandering* to an imperceptible distance on every side of the object looked at, but very rapidly. This *wandering* is not accidental, or an imperfection of sight, but an essential feature of vision; because it is not the *continuance* of an impression that is perceived (by any of the animal nerves), but its commencement and termination, or, more strictly speaking, its increase and decrease. This principle is probably analogous to that by which a magnet creates an electric current in a neighbouring wire, not by its *constant presence*, but by the increase or diminution of its influence, either by a variation of its *power* or of its *position*. This wandering propensity of the eye was shown to account for the relative facility with which different sorts of marks were seen at great distances: it takes place, apparently, in a minimum case, to the extent of an angle of *one in* 2500.

A dislocated line (as in a *vernier*), its *falt* being half its breadth, can be perceived to be so at a distance of 10,000 times its *falt* (if black on a white ground), and at 12,000 times if white on a black ground. It shows itself, however, by giving the line a *less steady* appearance (than a perfectly even line would have) when narrowly watched by running the eye along the line, at about half as far again.

Experiments were then described on the visibility of the positions of the *ends* of lines, and of *hiatuses* in lines, and of *square* dots as compared with *round*.

But the last conclusion of practical importance was, in respect of observing the angular position of station-marks, or of stars, by reflexion as in a sextant. From these experiments it appeared that the position of two closely adjacent dots or images, in sensible parallelism to a given direction, while it affords one of the *simplest* kinds of observation, is more accurately observable than their actual coincidence, or even than the junction of two lines as if in a vernier.

On the Application of Electricity and Heat as Moving Powers. By William Petrie.

From the dynamic equivalent of electricity already given we can infer an important fact, that *one horse power is the theoretic or absolute dynamic force possessed by a current of electricity derived from the consumption of* 1·56 (*one and fifty-six hundredths*) *pounds of zinc per hour*, in a Daniell's battery. But the *best* electro-magnetic engine that we can hope to see constructed, *cannot be expected* to give more than half or a fourth of this power: in any case, we see here the limit of power which no perfection of apparatus can make it exceed.

The peculiar mode in which the electric current produces dynamical effects has led to much miscalculation respecting the power obtainable from it. In any sort of electric engine the material to which the neighbouring current gives motion, whether it be another moveable current, or what is more usual, a magnetic body, is impelled in one direction with a constant force; and this force, whether it be attraction, repulsion, or deflection, is, like the power of gravity, *sensibly constant at all velocities*, however fast the body recedes before the action of the force; provided only the same quantity (per minute) of electric current be maintained. This is quite different from the action of steam power, in which, the faster the piston moves the greater is the volume of steam per minute that must be supplied to move it, or else the less will be the power with which it moves.

This fact, then, that the force with which an electric current, of a given 'quantity,' moves the machine, is the same at any velocity of motion, bears no analogy to the case of *steam*, but would indicate that the dynamic result obtainable from a given electric current might be indefinitely great; and so it would be, were it not that the part moved always tends to induce a current in the wire in the *reversed direction*: and this inducing influence, which increases with the velocity of motion, conflicts with the original current, and reduces its *quantity*, and consequently reduces the *power of the motion*, as well as the consumption of materials in the battery. Some have imagined that possible alterations in the position of the parts of the machine, or in its mode of action, would avoid the evil, or even might make the induced current to flow *with* the primary current instead of *against* it. The impossibility of this, though not readily proved in detail, can be at once proved by a reference to general principles; it would, if true, be a *creation* of dynamic force, the evolving an *unlimited force from a limited source*. The tendency to an opposing induced current in the primary wire must therefore be involved *in the very principle* of the system; so that no ingenuity can ever get rid of the retarding influence of the induced action. And the only way to overcome its power, so as to maintain the primary current from falling below a given rate or quantity, when the machine is allowed to attain rapid motion, is to increase the *electromotive power* of the battery, the intensity (not the quantity) of the current, so that it shall be less affected by the opposing induction.

The practical importance of these not altogether unknown truths, may justify the above somewhat particular notice of them. For want of a clearer apprehension of them, inventors have misapprehended the direction in which improvements were to be made, and much ingenuity and means have been wasted.

Some of the best electro-magnetic engines of other inventors, that have been properly tested by the author and others on a practically useful scale, have only given a power at the rate of fifty to sixty pounds of zinc per horse power per hour. The smallness of this power in comparison with the *absolute* value of the current (1·56 pound zinc per horse power per hour) should not occasion surprise if we consider the *present* case of *steam* after many years of improvement. According to the determinations of Joule and of Rankine on heat, 1 lb. water raised 1° temperature is equivalent to 700 lbs. weight raised 1 foot. The author then proceeded to show that the best Cornish engines only yield $\frac{1}{14}$th of the power that the combustion of the carbon actually represents, and many locomotives only $\frac{1}{100}$th part; showing what great rewards may yet await the exercise of inventive genius in this department, and that we need not wonder that we have as yet only obtained $\frac{1}{32}$nd part of the power possessed by electricity.

But it is to be remembered that there is a far greater likelihood of obtaining a larger proportion of the real power from electricity than from heat, owing to the character of the two agents. The author then proceeded to explain the reason why so little of the power of heat could be obtained in a useful form even in the best steam-engines, and what were the difficulties for invention first to overcome in order to a better result.

In the case of electricity, however, there is no analogous difficulty, but we have instead the difficulty and expense of developing current electricity by the chemical actions now requisite. If carbon could be burnt or oxidized by the air, directly or indirectly, so as to produce *electricity* instead of *heat*, 1 pound of it would go as far as 9⅓ pounds of zinc (in a Daniell's battery), chiefly because there are as many atoms in 1 pound of carbon as there are in 5¼ pounds of zinc, and partly because the affinity (for oxygen) of each atom of (incandescent) carbon is greater than that of an atom of (cold) zinc, *minus* the affinity of the hydrogen for the oxygen in the water of the battery. Apart, however, from such prospects of improved means of obtaining electricity, its favourable feature, on the other hand, in comparison with *heat*, is the reasonable expectation that we may obtain from electricity a considerable portion of the power which the author has determined as being the dynamic equivalent of the electric current.

Table of the Relative and Absolute Powers of Galvanic Arrangements, showing the electric current circulated, after the surfaces of the elements have been in continued action for several hours, with continuous supplies of liquids, the temperature being 70°. *By* William Petrie.

Column headed *Surface for Quantity* shows the square inches of acting negative surface requisite to circulate *one unit* of quantity.

Column headed *Intensity* shows the *permanent* electromotive force of the elements *while in action*.

Description of the Electromotor.		Surface for Quantity.	Intensity.
	Double fluid batteries.		
———	Hard cast iron with nitric acid, and zinc with dilute sulphuric acid; *warm, say* 80°......	4⅓	100°
Grove's	Platinum with nitric acid; and ditto.	4⅓	102
The author's	Carbon with nitric acid (80° *temp.*); and unamalgamated zinc, with a saline solution (*vide* patent)	4¾	112
Daniell's....	Copper with sulphate of copper, and amalgamated zinc, with dilute sulphuric acid	16	60
	Single fluid batteries.		
Smee's	Platinized silver and dilute sulphuric acid, and amalgamated zinc......................	5¼	36
———	Plain copper, with amalgamated zinc..........	52	18
———	Plain lead, with amalgamated zinc............	104	23½
Melloni's ..	Thermo-electric pairs, bars of bismuth and antimony, 1 inch long, difference of temperature of their ends 90°	section of each metal $\frac{2}{9}$ sq. in.	¼

The intensity of all the single fluid batteries is variable, except that of *lead*, which is *remarkably constant* though low (18°). That of *Smee's* is very variable, from 55° to 25° or lower, the cause of which the author explained to the Association.

These data have been found very useful in determining the best proportions and qualities of batteries for practical purposes.

On the Dynamic Equivalent of Current Electricity, and on a fixed Scale for Electromotive Force in Galvanometry. By William Petrie.

The dynamic value of a current of voltaic electricity is represented by the product of the rate at which electro-chemical action is taking place at any cross section of the current (in other words, the *quantity of the current*), and the *electromotive force* with which the current is sustained, which may be briefly termed its *energy* or *intensity* (provided the idea of *quantity* be kept distinct from this).

The first object was to secure such *units of comparison* for both these elements as should be at all times recoverable. This is given in respect of *quantity* by the *rate of chemical action* and the atomic weights. In respect of *intensity* of the current, we have no such fixed data, and the intensity of most voltaic arrangements cannot be relied upon as *constants* for comparison. But the elements of *Daniell's battery*, and those of nitric acid batteries with negative surface of platinum, carbon, or cast iron, give an electromotive force or intensity that can be recovered with considerable exactitude, if uniformity of circumstances, materials, &c. be tolerably attended to. These, therefore, may be used to give a fixed and recoverable point in a galvanometric scale of intensity.

Now it so happens that if we assume the degrees of the scale to be of such a size that the intensity of *Daniell's* (standard) *elements* shall be 60 of the degrees (temperature being 70° Fahr.) (60 being the most convenient number, by the way, for submultiples), that that of nitric acid batteries will be from 100° to 112° of the same degrees. The author therefore has always used this scale, to which all other voltaic arrangements can be referred (as shown in a table hereafter), which scale, he would suggest, would be most conveniently used in assigning the electromotive power of electric currents from any source.

The mean results of careful experiments, tried directly and conversely, is that a voltaic current of *one unit in quantity* (or that from one grain of zinc electro-oxidized per minute) and of 100° *intensity*, represents a dynamic force of $302\frac{1}{2}$ *lbs. raised one foot high per minute*. This datum is of great interest as a scientific truth in connection with the other correlative agents of nature (heat, electricity, light, and chemical affinities, neuralgic power, &c.), most of which we may hope soon to see reduced to a mutually comparable relation to each other, in terms of the great centre and medium of comparison, *mechanical force*.

On Improvements in propelling and navigating Steam Vessels. *By* M. W. Ruthven.

The principle of propulsion adopted is the pressure or force obtained in the opposite direction to the discharge of a fluid.

Water is admitted through apertures in the bottom of the vessel, into a covered canal or pipe; at the termination of the canal or pipe is placed a water-tight case enclosing a horizontal wheel with floats, or blades forming compartments. The wheel and case are under the water-line of the vessel; the wheel is thus always immersed in the water supplied by the canal. From the water-tight case a pipe is taken to each side of the vessel, and on the outside end of each is attached a bent pipe, or nozle, moveable in a socket joint at, near, or above the usual water-line. On the power being applied to make the wheel in the case revolve, the water supplied by the canal is pressed out and discharged by the nozles, with a force corresponding to the velocity of the wheel; the pressure to move the vessel depending on the area of the apertures where the water leaves the nozles.

Each nozle is turned by a wheel on the deck, and without making any change of the power applied by the engine. When the vessel is going ahead with all the power, the nozles are placed in a horizontal line, discharging the water towards the stern. To make the vessel go slow, the nozles are pointed at an angle downwards, according as the speed is wished to be reduced; and if required to remain stationary, they are pointed to discharge the water in a vertical direction. By pointing the nozles to the bows, the vessel goes astern; with a rate according to the angle of direction of the nozle. To turn the vessel round to either side, one nozle is pointed to the bows, and the other to the stern. All these movements are made on the deck, without any change on the engine, or any communication with those in attendance on the engine; the vessel is also independent of the rudder, as it can be navigated without it, by moving the nozles as required, and turned by them when the rudder could not effect it.

The author concludes his paper by enumerating many advantages which he conceives his invention to possess over the ordinary paddle-wheel motion.

On the Rubble Bridge of Ashiesteel.

By John Smith. (*Extract from a Letter to Sir David Brewster.*)

"In this bridge the object of my brother and myself was to dispense with everything costly that was not of essential service to the work, and with this view we used no materials but what could easily be managed without machinery; there was not one stone in a hundred beyond what one man could easily lift.

"Whinstone has many properties to recommend it, particularly in bridge building. No stone takes a firmer hold of lime or cement of any kind; it is a complete non-absorbent, is harder and more durable than granite, and plentiful and easily procured in many localities.

"This bridge, with the exception of the cornice and the coping-stones of the parapet walls, is entirely constructed of whinstone rubble, which was found in the immediate neighbourhood.

"My brother and I contracted with Gen. Sir James Russell of Ashiesteel to erect it opposite his house, as a private bridge. It was afterwards taken up by the road trustees, and the site fixed a little further down the river.

"Our estimate was £1200 for the whole, Sir James furnishing the rough timber for the centre; and had it not been for the centre giving way before the arch was balanced, the sum would have been sufficient.

"The timber being mostly of spruce fir quite green, rather deceived us as to its strength.

"To have done a bridge of the same dimensions in the same place, would have cost between three and four times the money.

"The arch is not a regular semi-ellipse, but is formed of three curves, the two side ones being drawn to a radius of 24, and the centre one to 110 feet.

"The breadth of the arch at the abutments is 19 feet, and it converges by curved lines towards the crown to 16 feet.

"The thickness of the solid part of the arch is $2\frac{1}{2}$ feet, and is backed by ribs $2\frac{1}{2} \times 2\frac{1}{2}$ feet; these ribs terminate at the distance of about 22 feet from the crown of the arch, and that part of it is built solid at the depth of about 4 feet.

"The spandril walls rest upon the back of the ribs above-mentioned, and are so managed as to thickness and form as to be an exact counterpoise to the crown of the arch.

"I am not aware that any arch of this extent was ever executed of Whinstone rubble, or that any stone arch of any description of the same span and radius, was ever built in Scotland."

On a new form of Equatorial Mounting now making for the Edinburgh Observatory. *By* Prof. Piazzi Smyth.

After briefly describing the two prevailing forms of equatorials, viz. the English with its long polar axis and two piers, and the German with its short polar axis and single pier, and pointing out their several defects and excellencies, the author then exhibited a model of a new construction, which appeared to combine the advantages of both the others, without their principal defects. The observatory having been already built, there was a necessity for the instrument being adapted to one central pier, as with the German; but the violent winds of the Calton hill rendered a much firmer stand necessary, especially in the power of the declination axis and frame to resist torsion.

These requirements were obtained by making the polar axis in the form of a short cylindrical shell of cast iron; the axis of motion passing transversely through the middle of it, and being defined by small pivots at either end.

The declination axis, which is a cone of great breadth, passes through the cylinder in the direction of its axis, and one of its faces becomes the declination circle, and gives most powerful means for the firmest clamping in that direction. The telescope fixed at one end of the declination axis is certainly outside the cylinder, but is midway *between* the bearings of the polar axis diameter.

The motion in right ascension is given by a screw working in a portion of a circle, or rather large flange, stretching round the cylinder, except on the telescope and declination face, in a plane at right angles to the polar axis.

For setting the instrument in right ascension, there is a small but complete circle turning on, and concentrically with, the upper pivot, but independent of it, and constantly kept in motion by clock-work.

On a Mode of Cooling the Air of Rooms in Tropical Climates. *By* Prof. PIAZZI SMYTH.

The author proposed to himself some plan by which to effect in a warm country, the reverse of what is effected in a cold country, by the simple operation of lighting a fire.

The case is shown to be a signally important one by the sufferings and early deaths of our countrymen in India, and no methods at all touching the real question at issue have yet been invented; and certainly all such partial and incomplete plans would fail, if tried in the following circumstances,—in a country where the temperature by day and by night, and by summer and winter is never under 90°, where the water and earth are as hot as the air, and where the atmosphere is saturated with moisture.

But however untoward these conditions may appear, it was shown that by the following method the air might be cooled down to any desired degree.

Compress the air in a closed vessel, the air will rise in temperature, say from 90° to 120°; keep it in the compressed state until the heat of compression shall have been dissipated by radiation and conduction, and then allow it to escape, when it will sink as much below its original temperature as it rose above it on compression, or will issue at 60.

The above is hardly anything more than merely a statement of an old fact long known, and particularly illustrated in the ancient Schemnitz machine; the author only claimed the merit of applying this property of air to so useful a sanitary purpose, of determining the quantity of compression required to produce a given alteration of temperature, and of contriving a convenient form of machine for practical purposes. The principle is said to have been applied last year in America to making ice; and in the beginning of this year Sir J. Herschel sent a reclamation of priority to the Athenæum in favour of a suggestion of his own to the same effect, but neither have given any determination of the exact amount of the thermotic effect of compression on which the practicability of the plan for the ordinary purposes of life must rest; while the author of this paper can go back as far as 1844 for the date of an apparatus which he had constructed to test the point, and to the beginning of 1849 for the first publication on the subject.

Towards the end of last year he had an unusually good opportunity afforded him of testing the subject experimentally on a very large scale by the kindness of Mr. Wilson of the Thinniel iron-works. From these experiments, it appeared that a compression of one-quarter of an atmosphere produces an elevation of 29° to 30° F. in the temperature of air at 60°. The determination is likewise borne out theoretically by Carnot's theory of heat, and by that of Mr. Macquorn Rankine, produced last winter; and he has further computed that one horse power working one hour will cool 9000 cubic feet of air 20° F., without allowing anything for friction and mechanical imperfections.

Making all due allowances for these drawbacks, Prof. Smyth had estimated from his experiments that a pair of bullocks (the most convenient and available source of mechanical power in India) should furnish 70 cubic feet of air per minute, cooled 20° below the surrounding atmosphere; and that the expense of thus cooling a house in a warm country would not be more than that of warming a house in a cold one, and might be managed as efficiently and completely.

On the Application of Telescope Sights to Rifles. *By* Prof. PIAZZI SMYTH.

The ordinary plain sights of rifles are attended with four inconveniences:—

1st. There are *three* objects to be brought in a line, the sight at the breech, that at the muzzle, and the object aimed at; and these three being at very unequal distances from the eye, cannot be seen all equally distinct at the same time.

2nd. Unless the barrel is of inordinate length, there is not sufficient radial length between the sights to give the opportunity of pointing accurately.

3rd. As only one of the breech-vanes can be raised at a time, there are no means of making allowance for distances intermediate between those for which the vanes are calculated.

4th. In sunshine there is a phase of the muzzle-sight which is very prejudicial to correct aiming.

All these difficulties may, however, be got over, by applying to the barrel a small telescope with cross wires, for—

1st. There are only *two* objects to deal with, the cross wires and the image of the object aimed at, and these are both at precisely the same distance from the eye.

2nd. The accuracy of pointing depending on the magnifying power of the telescope, the shortest barrel may be made equal to the longest.

3rd. The whole system of wires being in view at once, afford a very convenient scale for the intermediate distances.

4th. The wires being in the tube of the telescope, can be affected by no phase from sunshine.

A convenient size of telescope is about 1 foot long, including a direct eyepiece; the aperture of the object-glass being ½ inch.

The author exhibited a small rifle to which he had applied the telescope sights six years ago; but stated that he had lately found that he had been preceded by Capt. D. Davidson, Bombay Army, at present in Scotland, who had moreover carried the subject much further, and had had several telescopes made and applied to various rifles by Mr. Adie, optician, and Mr. Dickson, gunmaker of this city.

The author likewise took this opportunity of mentioning that the introduction of the sugar-loaf ball was due to Capt. D. Davidson, as it seemed to be another instance of the propriety of taking into account the resistance of the air; a matter, the neglect of which, in the simple motion of projectiles, had so utterly confounded all the results of theory, that until Robins at last took it into account, we cannot say that anything was known of gunnery.

But Robins computed, and many others have done so since his day, that if a ball be made long and heavier at one end than the other, the heavier end will always go foremost; accordingly egg-shaped and sugar-loafed and conical balls were fired out of rifles and smooth bores with the expectation of their going much straighter than spherical ones; but they went far worse, and tumbled over and over, instead of having the thicker end always first.

At length Capt. Davidson tried one of them with the point foremost, and it went perfectly straight, with the point first at all distances; and sugar-loafed balls fired point first are now not only used extensively in this country, but are coming into use on the continent also.

The reason of theory being apparently at fault here, seems to be that the greater resistance of the air to the larger end of the ball overbalances the advantage due merely to its superior weight.

Observations on the Force of the Waves.
By THOMAS STEVENSON, *F.R.S.E., Civil Engineer.*

The author, after some introductory remarks, described the action of the *marine dynamometer*, the self-registering instrument with which the observations were made, and one of the instruments was exhibited. He stated that a theoretical objection might perhaps be started to referring the action of the sea to a statical value; but contended that in designing sea-works the attempt of the engineer is to oppose the dynamical action of the sea by the *dead weight or inertia* of the masonry, so that the indications of the marine dynamometer furnish exactly the kind of information which the engineer requires. The greatest result registered in the Atlantic Ocean was at Skerryvore during the westerly gale of the 29th of March, 1845, when the force was 6083 lbs., *or 3 tons per square foot*. The greatest result registered in the German Ocean was 3013 lbs., or about 1½ *ton per square foot*. It further appeared, from taking an average result for five of the *summer* months during the years 1843 and 1844, that the force in the Atlantic Ocean was 611 lbs. per square foot, while the corresponding average for six of the *winter* months was 2086 lbs., or three times as great as in summer. These observations he had communicated in 1845 to the Royal Society of Edinburgh, and they were printed in the twelfth volume of the Transactions of that body.

The author then stated that the greatness of those results has excited surprise in almost all to whom they have been communicated, and positive doubts have been expressed by many as to the correctness of the indications. Three classes of facts essentially different from each other may be appealed to as proving that if the indications of the dynamometer are incorrect, the error must be in defect and not in excess. The first fact to which reference was made, was the elevation of spray caused by waves meeting with an obstruction to their onward motion. Most persons are familiar with the frontispiece representations of the Eddystone and Bell Rock Lighthouses during storms, which are attached to the descriptive accounts of the erection of those works; and although some deduction may be allowed for the fancy of the artists, still there can be no doubt that they are in the main faithful representations of a natural phænomenon. On the 20th of November, 1827, in a heavy ground swell after a storm, solid water rose at the Bell Rock 106 feet above the level of the sea, irrespective of the depth of the trough of the wave. Such an elevation is due to a *head* of water of the same height. The force then which urges the lower courses of the Bell Rock must have been *nearly* 3 *tons per square foot*, while the highest indication of the marine dynamometer at the same place, since the observations were commenced, hardly *equalled* $1\frac{1}{2}$ *ton*. The second class of facts to which the author alluded was the fracture of materials of known strength. The instance adduced was a small harbour in Argyllshire, where, in order to preserve the tranquillity of the tide-basin, a contrivance called *booms*, well known in harbour architecture, had been resotred to. The booms are logs of timber, which are placed across the entrance to a harbour and fit into checks or grooves which are made in the masonry on either side. The booms, therefore, act as a temporary wall or barrier against the waves. The set of booms referred to have been in use for about five years, and in that time the waves have broken no less than four Memel logs, measuring each 1 foot square in the middle, and spanning an entrance of 20 feet. From the known strength of the material, it will be found that on these four occasions a force must have been exerted equivalent to the uniform distribution of a dead weight of 30 tons, or *at the rate of* $1\frac{1}{2}$ *ton per square foot*; while the highest result that had been recorded at the same place during the short period that observations were made was about $1\frac{1}{8}$ *ton per square foot**.

The last class of effects to which the author alluded was the movement of heavy blocks of stone. The information derived from such observations was not so certain or satisfactory as from the other instances. The only record he could adduce was the movement of a block of stone *weighing about* $1\frac{1}{4}$ *ton*, to which a marine dynamometer had been bolted. The stone was turned upside down, and the dynamometer indicated a pressure of *little more than one ton*.

The author then referred to the overturning of the Carr Rock Beacon by the sea in 1817 during a heavy gale, but stated that, as we do not know the manner in which waves act when encountering obstacles, it was impossible to calculate what force had in this instance been exerted. The part of the column which was overturned was 36 feet in height and 17 feet diameter at the base, the rock being so small as to preclude a greater diameter. The author then concluded by stating the following desiderata which he thought important:—

1st. Continued observations so as to ascertain *constants* for the Atlantic and German Oceans and the Irish Sea.

2nd. Relative forces of the same wave, both above high water and below low water levels.

3rd. Relative forces of the same wave against vertical and sloping surfaces.

* Since the above was written three other booms have been broken.—March 13, 1851.

On the Limits to the Velocity of Revolving Lighthouse Apparatus caused by the time required for the production of Luminous Impressions on the Eye. By WILLIAM SWAN, *F.R.S.E.*

The object of this communication was to ascertain the greatest velocity that can be communicated to a revolving lighthouse apparatus, without impairing the brightness of its flashes. The author referred to a proposal, by the late Captain Basil Hall, to combine the superior brightness of a revolving, with the constancy of a fixed light, by causing the flashes to succeed each other so rapidly as to produce a continuous impression on the eye. The efficiency of this plan was tested by Mr. Alan Stevenson, who has described his experiments in his Account of the Skerryvore Lighthouse, p. 313. He found that as the velocity of rotation increased, the apparent brightness of the flashes diminished; and he explained this result, by supposing that the light had not had time to produce its full effect on the eye.

The correctness of this explanation is satisfactorily shown by the author's recent researches on the gradual action of light on the eye, published in the Transactions of the Royal Society of Edinburgh for 1849; which also afford the means of calculating the greatest velocity that can be communicated to a revolving light without diminishing its apparent brightness.

His experiments prove that *lights of every degree of apparent brightness require nearly one-tenth of a second to produce their full effect on the eye*; from which it follows, that the velocity of a revolving light must be regulated so that the duration of its flashes may exceed one-tenth of a second. This velocity is easily calculated, by first ascertaining the minimum divergence of the rays from the expression $t=\frac{2\pi t'}{\alpha}$, in which α is the divergence of the rays, t' the duration of a single flash, and t the time of a complete revolution. The author stated that for the great lens of Fresnel's dioptric apparatus of the first order, the velocity of rotation could not be made to exceed one revolution in eight seconds, without necessarily impairing the brightness of the light.

On a Gas Stove. By WILLIAM SYKES WARD, *Leeds.*

The novelty of this consists in constructing the stove in a vertical position so as to expose considerable surfaces for the absorption of heat from gas burners, and for the radiation of the heat; and from that flatness of construction the apparatus occupies little space, not projecting into the room more than 2 or 3 inches, being thus productive of little inconvenience when out of use.

A plate of thin sheet-iron is fitted into an ordinary fireplace in the manner of a fireboard, about 2 inches within the projection of the mantelpiece; about 3 inches in front of the back plate a similar plate of sheet-iron is secured by bolts; a third, somewhat smaller, plate of iron is about 1 inch from the second plate, and enclosed at the top, bottom and sides, so as to form a chamber of about 2 to 3 feet square and 1 inch in thickness. Towards the bottom of the last plate a long aperture is cut, closed by a sliding plate, acting as a door for lighting the gas jets and admitting a small quantity of air. A little below the aperture a pipe is introduced, in which are fixed three or more gas jets, either the ordinary small batwing burners or tips with two or three holes, so that the flames may extend laterally, not coming into immediate contact with the air. From the top of the enclosed chamber a pipe of $1\frac{1}{2}$ inch in diameter proceeds through the second and first plates into the chimney of the apartment.

The author found that his apparatus was sufficient to raise the temperature of a moderate-sized room from 5 to 10 degrees Fahr., with a consumption of about 3 feet of gas per hour, costing about twopence for ten hours, and that it was particularly useful in warming a bedroom where only a slight elevation of temperature was required, and perfectly free from the production of dirt or the slightest smell.

None of the products of combustion entered into the room, and the ventilation was improved rather than impeded.

A Collection of the Bones and Teeth of Mammalia and Fishes, parts of Crustacea, and other Organic Remains containing Phosphate of Lime, found in the Craig of Suffolk, was presented by Mr. WHINCOPP.

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Contents:—Robert Mallet, Third Report upon the Action of Air and Water, whether fresh or salt, clear or foul, and of Various Temperatures, upon Cast Iron, Wrought Iron and Steel;—Report of the Committee appointed to conduct the co-operation of the British Association in the System of Simultaneous Magnetical and Meteorological Observations;—Sir J. F. W. Herschel, Bart., Report of the Committee appointed for the Reduction of Meteorological Observations;—Report of the Committee appointed for Experiments on Steam-Engines;—Report of the Committee appointed to continue their Experiments on the Vitality of Seeds;—J. S. Russell, Report of a Series of Observations on the Tides of the Frith of Forth and the East Coast of Scotland;—J. S. Russell, Notice of a Report of the Committee on the Form of Ships;—J. Blake, Report on the Physiological Action of Medicines;—Report of the Committee on Zoological Nomenclature;—Report of the Committee for Registering the Shocks of Earthquakes, and making such Meteorological Observations as may appear to them desirable;—Report of the Committee for conducting Experiments with Captive Balloons;—Prof. Wheatstone, Appendix to the Report;—Report of the Committee for the Translation and Publication of Foreign Scientific Memoirs;—C. W. Peach, on the Habits of the Marine Testacea;—E. Forbes, Report on the Mollusca and Radiata of the Ægean Sea, and on their distribution, considered as bearing on Geology;—L. Agassiz, Synoptical Table of British Fossil Fishes, arranged in the order of the Geological Formations;—R. Owen, Report on the British Fossil Mammalia, Part II.;—E. W. Binney, Report on the excavation made at the junction of the Lower New Red Sandstone with the Coal Measures at Collyhurst;—W. Thompson, Report on the Fauna of Ireland: Div. *Invertebrata*;—Provisional Reports, and Notices of Progress in Special Researches entrusted to Committees and Individuals.

Together with the Transactions of the Sections, Earl of Rosse's Address, and Recommendations of the Association and its Committees.

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Contents:—W. B. Carpenter, on the Microscopic Structure of Shells;—J. Alder and A. Hancock, Report on the British Nudibranchiate Mollusca;—R. Hunt, Researches on the Influence of Light on the Germination of Seeds and the Growth of Plants;—Report of a Committee appointed by the British Association in 1840, for revising the Nomenclature of the Stars;—Lt.-Col. Sabine, on the Meteorology of Toronto in Canada;—J. Blackwall, Report on some recent researches into the Structure, Functions and Œconomy of the *Araneidea* made in Great Britain;—Earl of Rosse, on the Construction of large Reflecting Telescopes;—Rev. W. V. Harcourt, Report on a Gas Furnace for Experiments on Vitrifaction and other Applications of High Heat in the Laboratory;—Report of the Committee for Registering Earthquake Shocks in Scotland;—Report of a Committee for Experiments on Steam-Engines;—Report of the Committee to investigate the Varieties of the Human Race;—Fourth Report of a Committee appointed to continue their Experiments on the Vitality of Seeds;—W. Fairbairn, on the Consumption of Fuel and the prevention of Smoke;—F. Ronalds, Report concerning the Observatory of the British Association at Kew;—Sixth Report of the Committee appointed to conduct the Co-operation of the British Association in the System of Simultaneous Magnetical and Meteorological Observations;—Prof. Forchhammer on the influence of Fucoidal Plants upon the Formations of the Earth, on Metamorphism in general, and particularly the Metamorphosis of the Scandinavian Alum Slate;—H. E. Strickland, Report on the recent Progress and present State of Ornithology;—T. Oldham, Report of Committee appointed to conduct Observations on Subterranean Temperature in Ireland;—Prof. Owen, Report on the Extinct Mammals of Australia, with descriptions of certain Fossils indicative of the former existence in that Continent of large Marsupial Representatives of the Order Pachydermata;—W. S. Harris, Report on the working of Whewell and Osler's Anemometers at Plymouth, for the years 1841, 1842, 1843;—W. R. Birt, Report on Atmospheric Waves;—L. Agassiz, Report sur les Poissons Fossiles de l'Argile de Londres, with translation;—J. S. Russell, Report on Waves;—Provisional Reports, and Notices of Progress in Special Researches entrusted to Committees and Individuals.

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CONTENTS:—Seventh Report of a Committee appointed to conduct the Co-operation of the British Association in the System of Simultaneous Magnetical and Meteorological Observations;—Lt.-Col. Sabine, on some points in the Meteorology of Bombay;—J. Blake, Report on the Physiological Action of Medicines;—Dr. Von Boguslawski, on the Comet of 1843;—R. Hunt, Report on the Actinograph;—Prof. Schönbein, on Ozone;—Prof. Erman, on the Influence of Friction upon Thermo-Electricity;—Baron Senftenberg, on the Self-Registering Meteorological Instruments employed in the Observatory at Senftenberg;—W. R. Birt, Second Report on Atmospheric Waves;—G. R. Porter, on the Progress and Present Extent of Savings' Banks in the United Kingdom;—Prof. Bunsen and Dr. Playfair, Report on the Gases evolved from Iron Furnaces, with reference to the Theory of Smelting of Iron;—Dr. Richardson, Report on the Ichthyology of the Seas of China and Japan;—Report of the Committee on the Registration of Periodical Phænomena of Animals and Vegetables;—Fifth Report of the Committee on the Vitality of Seeds;—Appendix, &c.

Together with the Transactions of the Sections, Sir J. F. W. Herschel's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE SIXTEENTH MEETING, at Southampton, 1846, *Published at* 15*s.*

CONTENTS:—G. G. Stokes, Report on Recent Researches in Hydrodynamics;—Sixth Report of the Committee on the Vitality of Seeds;—Dr. Schunck, on the Colouring Matters of Madder;—J. Blake, on the Physiological Action of Medicines;—R. Hunt, Report on the Actinograph;—R. Hunt, Notices on the Influence of Light on the Growth of Plants;—R. L. Ellis, on the Recent Progress of Analysis;—Prof. Forchhammer, on Comparative Analytical Researches on Sea Water;—A. Erman, on the Calculation of the Gaussian Constants for 1829;—G. R. Porter, on the Progress, present Amount, and probable future Condition of the Iron Manufacture in Great Britain;—W. R. Birt, Third Report on Atmospheric Waves;—Prof. Owen, Report on the Archetype and Homologies of the Vertebrate Skeleton;—J. Phillips, on Anemometry;—J. Percy, M.D., Report on the Crystalline Slags;—Addenda to Mr. Birt's Report on Atmospheric Waves.

Together with the Transactions of the Sections, Sir R. I. Murchison's Address, and Recommendations of the Association and its Committees.

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CONTENTS:—Prof. Langberg, on the Specific Gravity of Sulphuric Acid at different degrees of dilution, and on the relation which exists between the Development of Heat and the coincident contraction of Volume in Sulphuric Acid when mixed with Water;—R. Hunt, Researches on the Influence of the Solar Rays on the Growth of Plants;—R. Mallet, on the Facts of Earthquake Phænomena;—Prof. Nilsson, on the Primitive Inhabitants of Scandinavia;—W. Hopkins, Report on the Geological Theories of Elevation and Earthquakes;—Dr. W. B. Carpenter, Report on the Microscopic Structure of Shells;—Rev. W. Whewell and Sir James C. Ross, Report upon the Recommendation of an Expedition for the purpose of completing our knowledge of the Tides;—Dr. Schunck, on Colouring Matters;—Seventh Report of the Committee on the Vitality of Seeds;—J. Glynn, on the Turbine or Horizontal Water-Wheel of France and Germany;—Dr. R. G. Latham, on the present state and recent progress of Ethnographical Philology;—Dr. J. C. Prichard, on the various methods of Research which contribute to the Advancement of Ethnology, and of the relations of that Science to other branches of Knowledge;—Dr. C. C. J. Bunsen, on the results of the recent Egyptian researches in reference to Asiatic and African Ethnology, and the Classification of Languages;

—Dr. C. Meyer, on the Importance of the Study of the Celtic Language as exhibited by the Modern Celtic Dialects still extant;—Dr. Max Müller, on the Relation of the Bengali to the Arian and Aboriginal Languages of India;—W. R. Birt, Fourth Report on Atmospheric Waves;—Prof. W. H. Dove, Temperature Tables; with Introductory Remarks by Lieut.-Col. E. Sabine;—A. Erman and H. Petersen, Third Report on the Calculation of the Gaussian Constants for 1829.

Together with the Transactions of the Sections, Sir Robert Harry Inglis's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE EIGHTEENTH MEETING, at Swansea, 1848, *Published at* 9*s*.

CONTENTS:—Rev. B. Powell, A Catalogue of Observations of Luminous Meteors;—J. Glynn, on Water-pressure Engines;—R. A. Smith, on the Air and Water of Towns;—Eighth Report of a Committee on the Growth and Vitality of Seeds;—W. R. Birt, Fifth Report on Atmospheric Waves;—E. Schunck, on Colouring Matters;—J. P. Budd, on the advantageous use made of the gaseous escape from the Blast Furnaces at the Ystalyfera Iron Works;—R. Hunt, Report of progress in the investigation of the Action of Carbonic Acid on the Growth of Plants allied to those of the Coal Formations;—Prof. H. W. Dove, Supplement to the Temperature Tables printed in the Report of the British Association for 1847;—Remarks by Prof. Dove on his recently constructed Maps of the Monthly Isothermal Lines of the Globe, and on some of the principal Conclusions in regard to Climatology deducible from them; with an introductory Notice by Lt.-Col. E. Sabine;—Dr. Daubeny, on the Progress of the investigation on the Influence of Carbonic Acid on the Growth of Ferns;—J. Phillips, Notice of further progress in Anemometrical Researches;—Mr. Mallet's Letter to the Assistant-General Secretary;—A. Erman, Second Report on the Gaussian Constants;—Report of a Committee relative to the expediency of recommending the continuance of the Toronto Magnetical and Meteorological Observatory until December 1850.

Together with the Transactions of the Sections, the Marquis of Northampton's Address, and Recommendations of the Association and its Committees.

PROCEEDINGS OF THE NINETEENTH MEETING, at Birmingham, 1849, *Published at* 10*s*.

CONTENTS:—Rev. B. Powell, A Catalogue of Observations of Luminous Meteors;—Earl of Rosse, Notice of Nebulæ lately observed in the Six-feet Reflector;—Prof. Daubeny, on the Influence of Carbonic Acid Gas on the health of Plants, especially of those allied to the Fossil Remains fonnd in the Coal Formation;—Thomas Andrews, M.D., Report on the Heat of Combination;—Report of the Committee on the Registration of the Periodic Phænomena of Plants and Animals;—Ninth Report of a Committee appointed to continue their Experiments on the Growth and Vitality of Seeds;—Francis Ronalds, Report concerning the Observatory of the British Association at Kew, from Aug. 9, 1848 to Sept. 12, 1849;—Robert Mallet, Report on the Experimental Inquiry conducted at the request of the British Association, on Railway Bar Corrosion;—William Radcliff Birt, Report on the Discussion of the Electrical Observations at Kew.

Together with the Transactions of the Sections, the Rev. T. R. Robinson's Address, and Recommendations of the Association and its Committees.

DOVE'S MONTHLY ISOTHERMAL MAPS OF THE GLOBE, with the accompanying Memoir, Price 5*s*.

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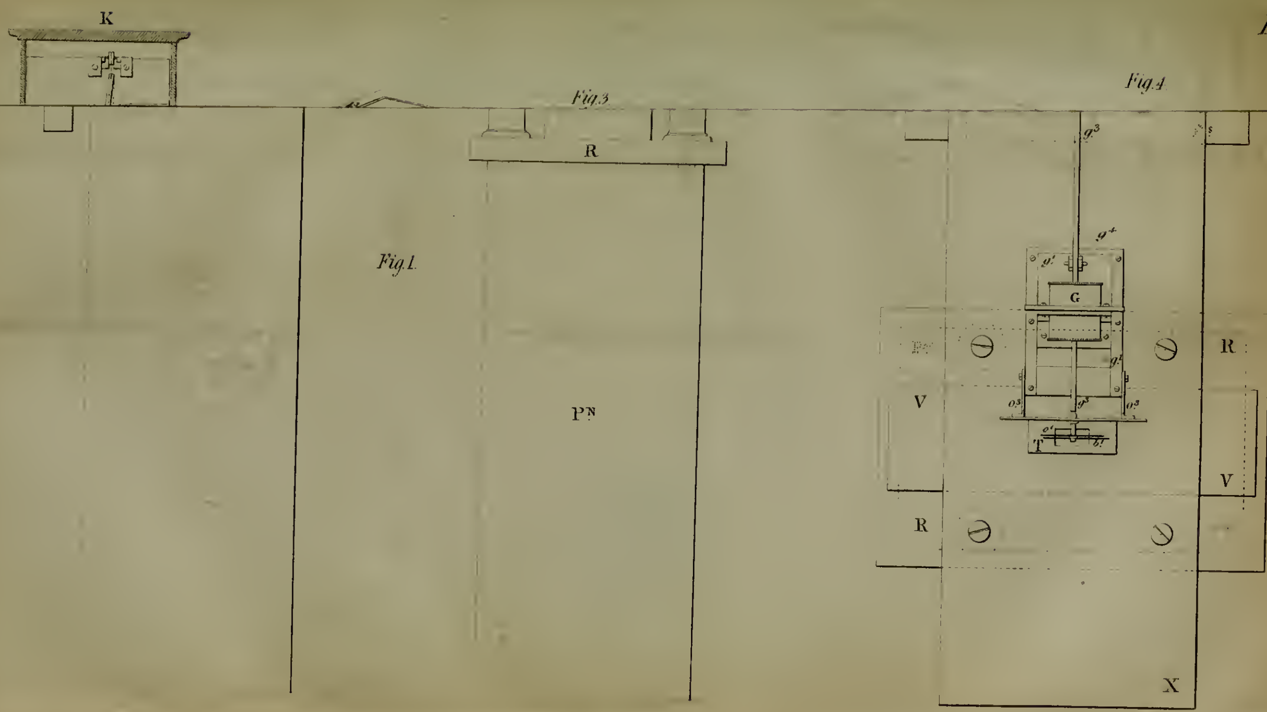
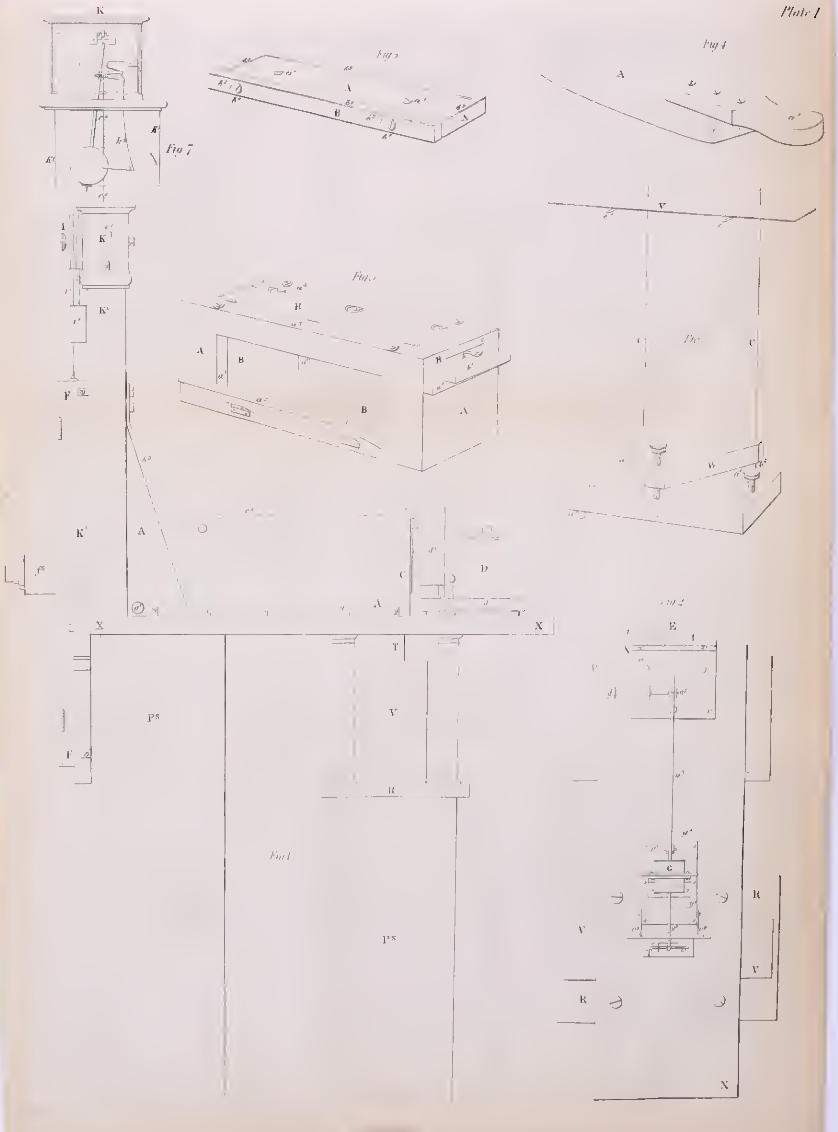


Plate I



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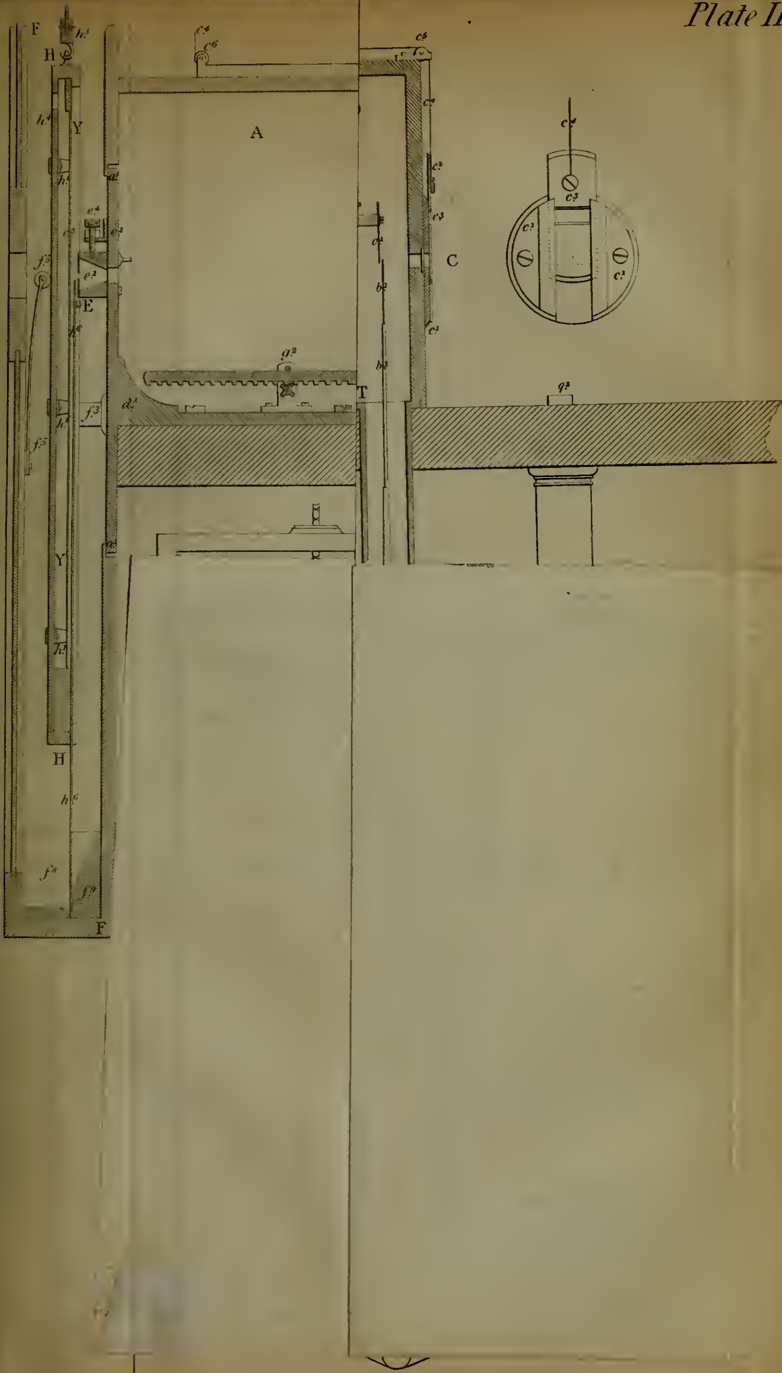

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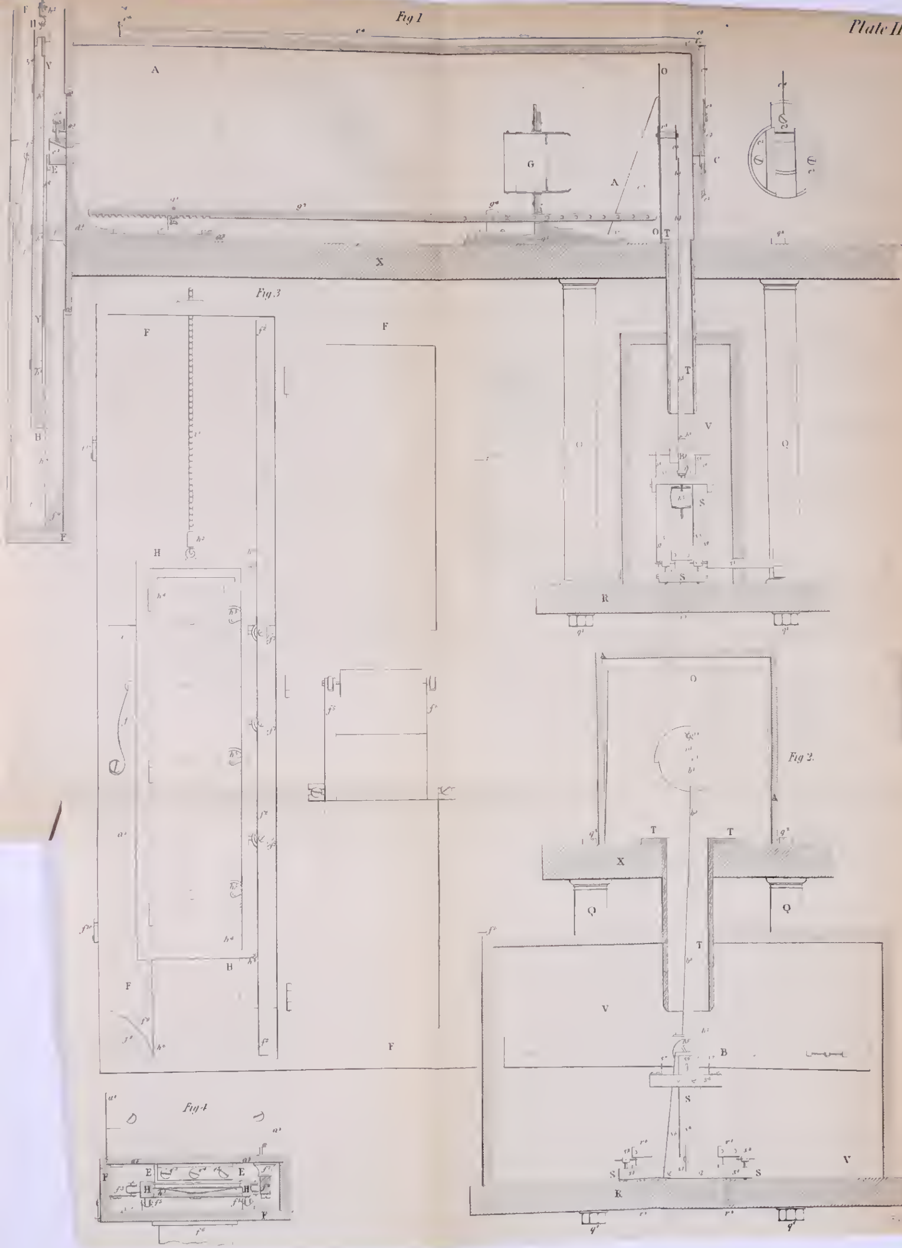


Plate III.

Fig.2.

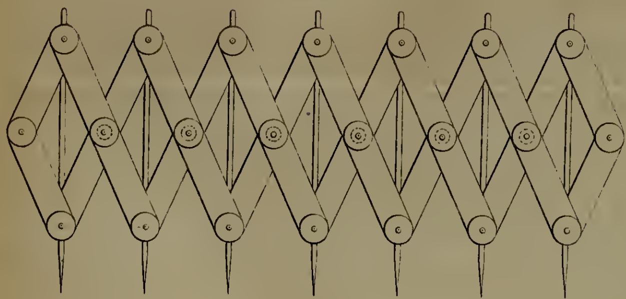
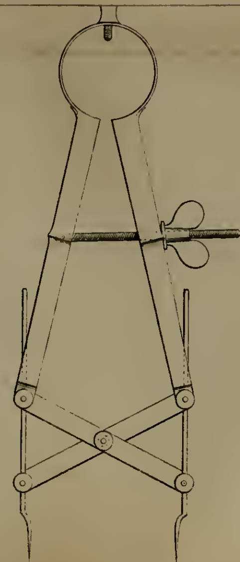


Fig.3.



J.E. Wood. Sc.

Fig. 1

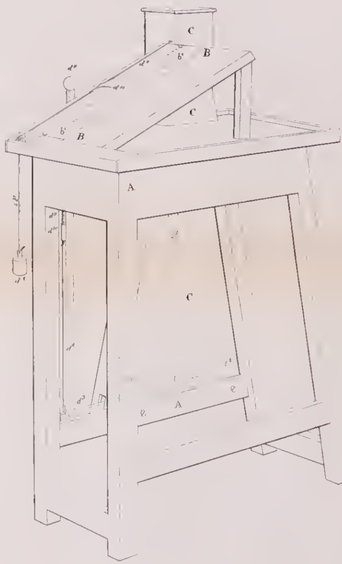


Fig. 2

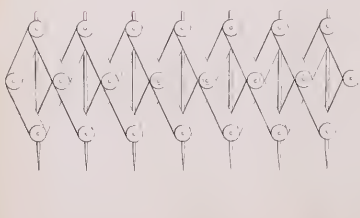


Fig. 3

Fig. 4

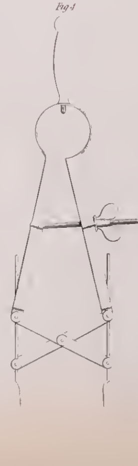
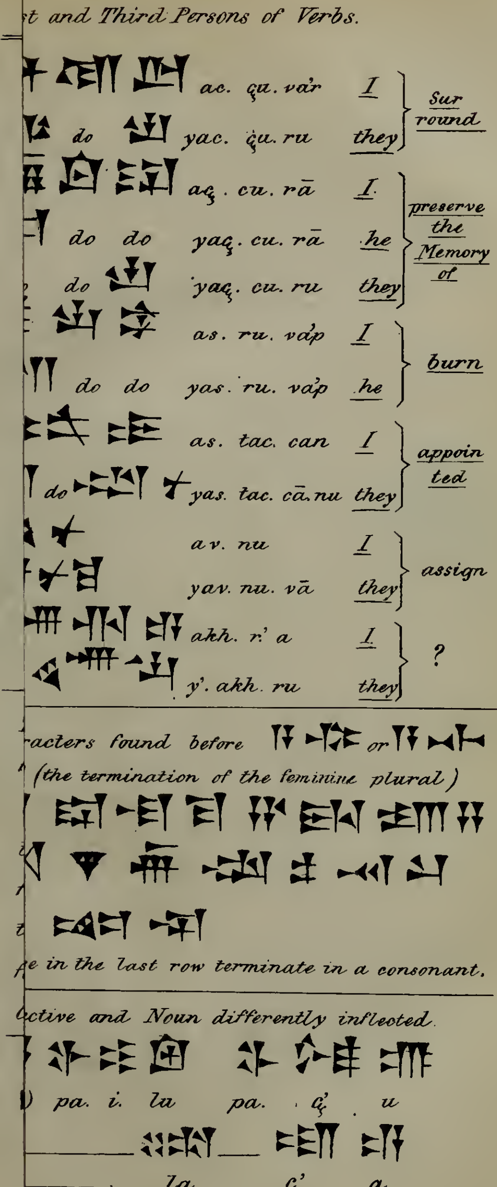
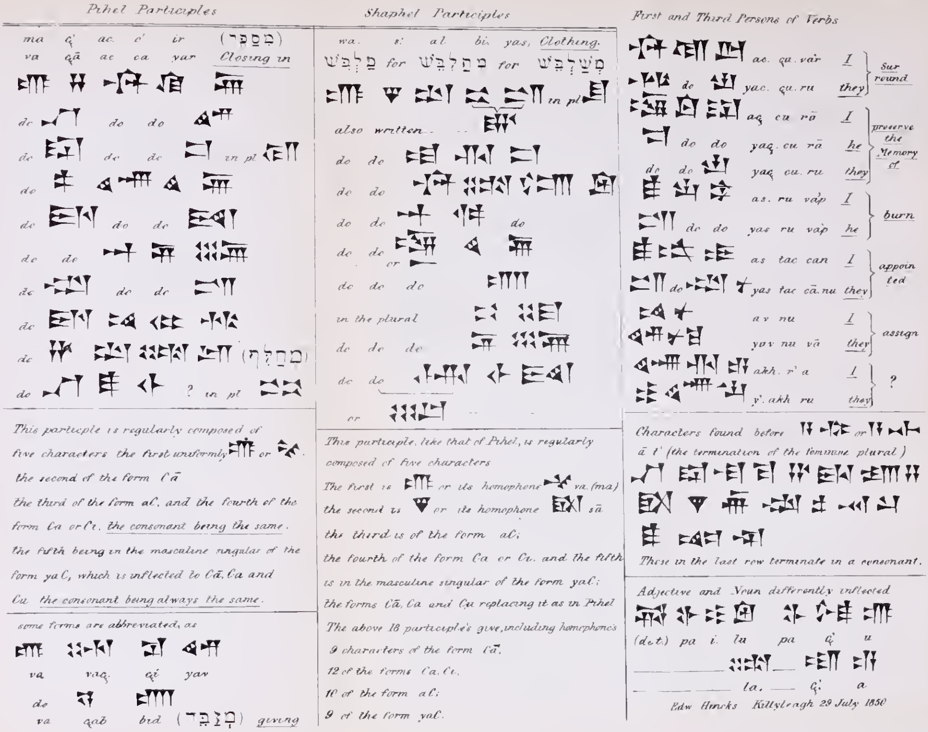


Fig. 5



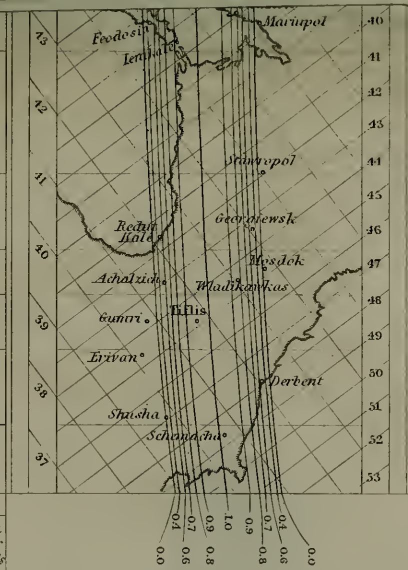
Edw. Hincks. Killyleagh. 29. July 1850.

J. Basire, Lith.



J Basire, Lith

Local Time of beginning of Eclipse (h m)	Angle from Sun's upper point towards the West (°)	Local Time of total obscuration of the Sun (h m)	Angle from Sun's upper point towards the East for disappearance on the central line of shadow (°)	Duration of total Darknefs on the central line of shadow (m s)	Angle from Sun's upper point towards the West for reappearance on the central line of shadow (°)	Local Time of end of Eclipse (h m)	Angle from Sun's upper point towards the East (°)
5 . 9	123	6 . 3	59	2 . 45	—		
5 . 25	124	6 . 18	58	2 . 40	122	7 . 12	60
5 . 36	126	6 . 29	57	2 . 36	123	Sun sets before end of Eclipse	Sun sets before end of Eclipse
5 . 42	127	6 . 35	56	2 . 34	124		
5 . 51	127	6 . 43	56	2 . 31	124		
6 . 0	127	6 . 52	56	2 . 26	124		



Factor for multiplying the duration of darknefs on the central line of shadow to give the duration of darknefs in other parts of the shadow.

The times are in mean solar time of those points of the central line of shadow to which they are opposite. They correspond strictly to the phænomena seen at those points of the central line, and approximately to neighbouring points within the shadow.

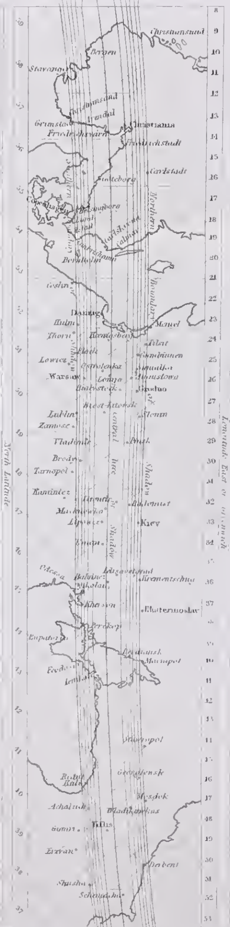
J. W. Lowry fc

Total Eclipse of the Sun 1851, July 28.

1 Local Time of beginning of Eclipse (h m)	2 Angle from Suns upper point towards the West (°)	3 Local time of total obscuration of the Sun (h m)	4 Angle from Suns upper point towards the East for disappearance on the central line of shadow (°)	5 Duration of total Darkness on the central line of shadow (m s)	6 Angle from Suns upper point towards the West for reappearance on the central line of shadow (°)	7 Local Time of end of Eclipse (h m)	8 Angle from Suns upper point towards the East (°)
2 17	98	3 21	78	3 37	102	4 25	74
2 30	100	3 33	76	3 35	104	4 37	73
2 42	102	3 45	75	3 33	105	4 49	72
2 55	104	3 57	73	3 30	107	5 0	70
3 8	107	4 4	71	3 27	109	5 12	68
3 21	109	4 22	69	3 23	111	5 24	67
3 34	111	4 35	67	3 19	113	5 36	66
3 48	113	4 48	65	3 15	115	5 48	65
4 3	115	5 2	64	3 10	116	6 1	64
4 18	117	5 16	63	3 5	117	6 15	63
4 34	119	5 31	62	2 59	118	6 29	62
4 52	122	5 46	60	2 52	120	6 44	61
5 9	123	6 3	59	2 45	121	[illegible]	60
5 25	124	6 18	58	2 40	122	7 12	60
5 36	126	6 29	57	2 36	123	Sun sets before end of Eclipse	Sun sets before end of Eclipse
5 42	127	6 35	56	2 34	124		
5 51	127	6 43	56	2 31	124		
6 0	127	6 52	56	2 26	124		

Correction to be applied to the Angles from Suns upper point at disappearance and reappearance on the central line of shadow to give the angles from Suns upper point in other parts of the shadow

Correction towards S — Correction towards N



Factor for multiplying the duration of darkness on the central line of shadow to give the duration of darkness in other parts of the shadow

The times are in mean solar time at those points of the central line of shadow to which they are opposite. They correspond strictly to the phenomena seen at those points of the central line, and approximately to neighbouring points within the shadow.