A

MANUAL OF THE INFUSORIA.

VOLUME I.

"Our little systems have their day,
They have their day and cease to be;
They are but broken lights of Thee,
And Thou, O Lord, art more than they."

TENNYSON, *In Memoriam.*

A

MANUAL OF THE INFUSORIA:

INCLUDING A DESCRIPTION OF ALL KNOWN

FLAGELLATE, CILIATE, AND TENTACULIFEROUS PROTOZOA,

BRITISH AND FOREIGN,

AND AN ACCOUNT OF THE

ORGANIZATION AND AFFINITIES OF THE SPONGES.

BY

W. SAVILLE KENT, F.L.S., F.Z.S., F.R.M.S.,

FORMERLY ASSISTANT IN THE NATURAL HISTORY DEPARTMENTS OF THE BRITISH MUSEUM.

VOLUME I.

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TO

THOMAS HENRY HUXLEY, LL.D., F.R.S.,

TO WHOM THE AUTHOR IS INDEBTED FOR MANY MARKS OF PERSONAL KINDNESS

AND WORDS OF ENCOURAGEMENT

DURING THE PREPARATION OF THIS TREATISE;

AND TO WHOSE TEACHING IN THE LECTURE-ROOM AND LABORATORY HE IS CHIEFLY

BEHOLDEN FOR HIS QUALIFICATION

TO ENTER AS A HUMBLE LABOURER UPON THE ARENA OF SCIENTIFIC INVESTIGATION,

THIS 'MANUAL OF THE INFUSORIA' IS GRATEFULLY

Dedicated.

PREFACE.

It is now some ten years since the author, then but a recruit in the ranks of practical microscopists, elected to concentrate his attention upon the group of organisms that form the subject of this treatise. At a very early period of his investigations, formidable obstructions to substantial progress in the course mapped out, presented themselves in connection not only with the very backward condition of the literature of this country relating to this topic, but by reason also of the exceedingly wide and scattered area of Continental bibliography that had to be explored and sifted before it was possible to arrive at any adequate idea of the state of contemporary knowledge concerning almost any given type that might be the subject of examination. It was the recognition of, and continual contact with these difficulties that suggested to the author the advantages that would accrue both to himself and all English-speaking microscopists, from the compilation of a treatise, brought up to date, that should contain a concise description of the innumerable species known to science whose descriptions were distributed throughout many scattered sources, and that led to the efforts, now carried into execution, to supply this desideratum.

It was in the first instance suggested that this Manual should be based upon the same lines as the, at the time, only other English treatise devoted to the subject, 'A History of the Infusoria,' by Andrew Pritchard, the fourth and last edition of which was published so long since as the year 1861; that it should include in a similar manner an account of the several distinct groups of microscopical organisms known as the Rotifera, Desmidiaceæ, Diatomaceæ, and other Protophytes which form, as being a reproduction of Ehrenberg's 'Infusionsthiere,' so conspicuous a feature of Mr. Pritchard's book. It soon became apparent, however, that to compass so comprehensive a task with any degree of efficiency would extend the size of this treatise far beyond convenient limits, and that indeed more than sufficient material for a work on the same scale as the one above-named had accumulated in connection with the Infusoria in the most limited and restricted sense as represented by the Flagellate, Ciliate, and Tentaculiferous Protozoa.

Those readers and subscribers, therefore, who at first sight may experience some disappointment at the relatively narrow scope of this work, will, the author trusts, find on a closer acquaintance with it, sufficient compensation in the vastly extended assemblage of forms here included within the ranks of the true Infusoria as compared with that dealt with in any pre-existing treatise. The most notable accessions in this connection are undoubtedly associated with the class Flagellata, hitherto occupying in our text-books a very uncertain status upon the border-land of the animal and vegetable kingdoms, but which is now shown to include an infinitely varied series of unquestionable animal forms. All these Flagellata, to which the author has devoted special attention, are of exceedingly minute size, requiring the highest magnifying powers of modern construction for their correct interpretation. The majority of the Flagellate types figured and described in this treatise, indeed, not only represent the outcome of the most recent research, but may be regarded also as a first instalment of the almost inexhaustible harvest that awaits the garnering of the industrious investigator. It is hoped that this work may in this manner constitute a fresh basis of departure, and supply an incentive towards the acquisition of a yet truer and more comprehensive knowledge of the diversified and exquisitely beautiful representatives of this, excepting to the initiated, practically invisible world.

For the general Biologist, to whom for the most part the Infusorial series represents but a single scarcely noteworthy link in the grand scheme of organic nature, it has been the endeavour of the author to demonstrate that there yet remain in connection with this group certain side issues of the highest interest and importance. Should he combine with his general knowledge of the morphology and embryology of the more highly organized Metazoic animals, a practical acquaintance with that remarkable order here figured and described at length under the title of the Choano-Flagellata, he will scarcely fail to recognize the close bond of affinity that subsists between these Infusoria and the Sponges, however much the last named organisms may be apparently modified in the direction of a Metazoic formula. In connection, again, with the innumerable varieties of ciliated embryos of the Annelida, Echinodermata, Mollusca, and other Invertebrate series, there is, as indicated in the opening pages of Vol. II., ample scope for speculation with respect to the by no means improbable derivation of these higher organisms from Infusoria Ciliata, of which, in their embryonic condition, they are indeed, in so many cases, the most remarkable possible homotypes.

Some apology is perhaps due from the author on account of the very considerable interval that has elapsed since the first announcement of this work and its ultimate publication, as also for the delay that has intervened between the issue of the first part in October 1880, and the concluding number in June 1882. With respect to that first named, it may be stated that the publication, dated November 1878,* of Stein's 'Infusionsthiere' Abth. III. Heft 1, devoted to the Flagellata, occasioned an almost complete recasting of the manuscript referring to this group, then ready for the press, the work involved being greatly increased through the fact that the diagnoses and descriptions of the species figured being reserved by Stein for an as yet unpublished volume, the onus of forming diagnoses from these figures for the many new forms illustrated, devolved upon the author. Since, again, the publication of Part I. of this Manual in October 1880, the energy of Continental investigators in this department of Biology has been so marked that it became requisite, at the risk of some slight delay, to make suitable provision both in the text and plates of the later numbers of the treatise for the record of their discoveries. No more substantial illustration of this circumstance could perhaps be afforded than by a reference to Part VI., devoted chiefly to the class Tentaculifera, in which it will be found that no small space is occupied by the description and illustration of many new and interesting species described by Maupas so recently as November 1881, the same number including the results of the author's yet later personal investigation of the remarkable type *Dendrosoma radians.* Such inconvenience therefore as subscribers may have sustained in consequence of its tardier issue, they will, the author hopes, consider to some extent counterbalanced by the considerable augmentation and continuation literally up to date of the subject-matter of this treatise.

Having during the progress of this work received from numerous English and American sources an intimation that a few suggestions respecting the apparatus and means employed by the author for the effectual investigation of the more minute Flagellate Infusoria would be greatly appreciated, he has much pleasure in submitting, in connection with Pl. LI., an illustration, with accompanying explanation, of a simple method whereby, with the least expenditure of manipulative energy, the best results may be readily obtained. For his first acquaintance with this method, as also for the kind permission to make the present use of the same, the author's thanks are due to Mr. E. M. Nelson, F.R.M.S., one of our leading and most experienced experts in the use of the higher powers of the compound microscope.

The pleasing task yet devolves upon the author of tendering his grateful acknowledgments to the officers of the libraries of the various scientific societies, including more especially those of the Royal, Linnean, and Zoological Societies, as also of the Royal College of Surgeons, for their

* Not received in England till January 1879.

ready and valuable assistance in working out the voluminous and, in many cases, exceedingly intricate bibliography of the present subject. He has also to record his high appreciation of the accurate and highly artistic manner in which Mr. W. Rhein has reproduced on stone the drawings for the plates committed to his care.

For an abundant supply of living material for investigation, much of which has been utilized in the record of new data, and for the illustration of this Manual, the best thanks are due from the author to Mr. Thomas Bolton of Birmingham, and to Mr. John Hood of Dundee.

Lastly, but not leastly, the author has to acknowledge his great indebtedness to the Council of the Royal Society, through whose recommendation a grant from the Government Fund for the Promotion of Scientific Research has been on several occasions allotted him, thus assisting him with the means of obtaining the necessary costly microscopical apparatus, and of devoting that time to original research, without which the prolonged investigations recorded in this treatise, more especially in connection with the Flagelliferous Infusoria, could scarcely have been accomplished.

LONDON, *May* 1882.

A

MANUAL OF THE INFUSORIA.

CHAPTER I.

INTRODUCTORY—GENERAL HISTORY OF THE INFUSORIA FROM THE TIME OF THEIR DISCOVERY BY LEEUWENHOEK IN 1675 TO THE YEAR 1880.

INAPPRECIABLE individually to the unaided vision, the countless hosts of the Infusorial world, more familiar perhaps to the popular mind under the designation of animalcules, or animalcula, surround us literally on every side. They abound in the full plenitude of life alike in the running stream, the still and weed-grown pond, or the trackless ocean. Nay, more, as demonstrated in a future page,* every dew-laden blade of grass supports its multitudes, while in their semi-torpid encysted or sporular state they permeate as dust the atmosphere we breathe, and beyond question form a more or less considerable increment of the very food we swallow. Yet again, and apparently as the inevitable corollary of the last-named circumstance, they occur abundantly as parasites within the viscera or vital fluids of the representatives of almost every higher organic group. Essentially dependent on a liquid medium for the exhibition of their vital functions, there is practically, the simple conditions of air and moisture being granted, no limit to the area of their distribution, no field so barren but will yield its quota of strange and varied forms to the industrious explorer. For the professional biologist and the dilettante investigator alike, the members of this intangible and yet omnipresent group of organisms present a fascination unshared by any other section of the organic world. Their very intangibility and practically inexhaustible variety—each improvement and augmentation of the penetrating power of the optical appliances yet employed enabling us to discover, as in the sister science of astronomy, "fresh fields and pastures new" for exploration—no doubt represent important factors in this power of fascination, though by no means the most influential ones. With the Infusoria we encounter not only the as yet known most minute, but also the most elementary and simply formed productions of the Creator's handiwork, though, for all that, none the less complete and excellently finished. Among the Infusoria,

* See p. 140.

making a free adaptation of the admirable thesis propounded by the illustrious Oken, we find in their primeval shape the very bricks and mortar out of which the entire superstructure of the organic world has been erected. So early as the year 1805, long before the conception of the unicellular nature of the Infusoria by Theodor von Siebold, this astute philosopher, the co-originator with Goethe of the vertebrate theory of the skull, had enunciated the opinion that the infusorial animalcules consisted of simple cells or vesicles, and formed the protoplasmic basis from whence all higher organisms were fashioned or evolved, and into which condition of simple cells or vesicles these same higher organisms were again resolved by the process of dissolution. The divine fiat, "Dust thou art, and unto dust thou shalt return," thus received unconsciously at the hands of Oken a practical and truly remarkable illustration. Finally, among the world of Infusoria we arrive at that dim boundary line, too subtle and obscure for arbitrary definition, that separates, or more correctly blends into one harmonious whole, the two departments of the animal and vegetable worlds; and here, moreover, with all reverence be it said, we approach, if anywhere, the confines of the organic and inorganic, and are brought face to face with that already half-lifted veil behind which lies, waiting to reward our patient search, the very clue to the deep mystery of Life itself.

Postponing to a succeeding chapter a detailed account of the structural, developmental, and other vital phenomena pertaining to the Infusoria, as made manifest by the light of modern investigation, it has been decided that some space in the first instance might be advantageously devoted to a brief epitomization of the more important epochs in the history of these minute organisms, as accumulated step by step from the time of their earliest discovery. As a matter of necessity, man's acquaintanceship with the puny members of this organic group has been comparatively short, and is co-extensive only with the invention and practical application of the microscope. None of the myriad forms—though in some few instances conspicuous in their concrete state or discernible individually by the unassisted vision, as mere moving points—yield up the secret of their separate organization and life-history without the aid of that most invaluable and indispensable auxiliary to biological discovery. In like manner, our present advanced, though still far from perfect knowledge, of the Infusoria has been acquired by slow degrees, and contemporaneously with the improvements made upon that instrument, each successive stage of progress achieved in this direction representing, indeed, but a reflex of the higher perfection of the appliances placed from time to time at the disposal of the histologist through the augmented skill of the optician. It is much to be regretted that authentic evidence is wanting that can identify with absolute certainty the first inventor of the microscope, or rather of those simple spheres of glass or doubly convex lenses, mostly home made, employed over two centuries ago, with which in the hands of the earliest investigators, as presently related, such truly astonishing results were obtained, and out of which the highly perfected optical instruments of the present day have, by slow and tedious steps, been finally elaborated. Fontana, of Naples, Cornelius Drebell, the Dutchman, and Zacharius Jansen and son, fellow-countrymen of Drebell, have thus alike been respectively credited by different authorities with this distinction. However this may be, it is at all events generally conceded that the microscope, in its simplest form, was first brought into public notice in or about the year 1619. Regarded at this early date in the mere light of an ingenious and interesting toy, little or no promise was then given of the important rôle in the onward march of science it was afterwards destined to fulfil. Nearly half a century, indeed, elapsed before its aid was invoked for the systematic exploration of the hidden mysteries of nature. With the exception, perhaps, of the Italian philosopher Petrus Borellus, our own countryman Dr. Robert Hooke, author in the year 1665 of the famous 'Micrographia Illustrata,' claims the first place in the ranks of scientific microscopic investigators. The discovery of the minute organic beings that form the special subject of this treatise, fell, however, a few years later to the lot of the illustrious Dutchman Antony van Leeuwenhoek. The accounts of the animalcules first observed, as given by Leeuwenhoek and a few other investigators who, animated by his example, towards the close of the seventeenth century devoted their attention to the further exploration of this fascinating and then newly opened field for discovery, possess intrinsically such high classic interest, and display, notwithstanding the simple and imperfect character of the optical appliances employed, so keen an insight into, and appreciation of, the structural features and phenomena of the various forms encountered, that quotations from the same, with a faithful reproduction of their original quaint style of diction, are herewith appended *in extenso*. Leeuwenhoek's earliest contribution to the literature of this subject necessarily takes the first place upon the list, and is found embodied in the 'Philosophical Transactions,' vol. xii. No. 133, for the year 1677. The title of his first record and associated account of the various species therein described runs as follows:—

"Observations communicated to the Publisher by Mr. Antony van Leeuwenhoek, in a Dutch letter of the 9th of October, 1676, here Englished, concerning little animals observed in Rain, Well, Sea, and Snow Water, as also in Water wherein Pepper had lain infused."

OBSERVATION I.

"In the year 1675 I discovered living creatures in rain-water which had stood but four days in a new earthen pot, glased blew within. This invited me to view this water with great attention, especially those little animals appearing to me ten thousand times less than those represented by Mons. Swammerdam, and by him called water-fleas or water-lice, which may be perceived in the water with the naked eye. The first sort by me discovered in the said water, I divers times observed to consist of 5, 6, 7, or 8 clear globules, without being able to discover any film that held them together, or contained them. When these *animalcula* or living atoms did move, they put forth two little horns, continually moving themselves; the place between these two horns was flat, though the rest of the body was roundish, sharpening a little towards the end, where they had a tayle, near four times the length of the whole body, of the thickness (by my microscope) of a spider's web; at the end of which appear'd a globul, of the bigness of one of those which made up the body; which tayl I could not perceive, even in very clear water, to be mov'd by them. These little creatures, if they chanced to light upon the least filament or string, or other such particle, of which there are many in the water, especially after it hath stood some days, they stook entangled therein, extending their body in a long round, and striving to dis-entangle their tayle; whereby it came to pass, that their whole body lept back towards the globul of the tayle, which then rolled together serpent-like, and after the manner of copper or iron-wire that having been wound about a stick, and unwound again, retains those windings and turnings. This motion of extension and contraction continued a while; and I have seen several hundreds of these poor little creatures, within the space of a grain of gross sand, lie cluster'd together in a few filaments.

"I also discovered a *second* sort, the figure of which was oval, and I imagine their head to stand on the sharp end, these were a little bigger than the former. The inferior part of their body is flat, furnished with divers incredibly thin feet, which moved very nimbly and which I was not able to discern till after several Observations. The upper part of the body was round, and had within 8, 10, or 12 globuls, where they were very clear. These little animals did sometimes change their figure into a perfect round, especially when they came to lie on any dry place. Their body was also very flexible; for as soon as they hit against any the smallest fibre or string, their body was bent in, which bending presently also jerked out again. When I put any of them in a dry place, I observ'd, that changing themselves into a round, their body was raised pyramidal-wise with an extant point in the middle, and having lain thus a little while with a motion of their feet, they burst asunder, and globuls were presently diffus'd and dissipated, so that I could not discern the least thing of any film, in which the globuls had doubtless been inclosed: And at this time of their bursting asunder I was able to discover more globuls than when they were alive.

"But then I observ'd a *third* sort of little animals, that were twice as long as broad, and to my eye yet eight times smaller than the first. Yet for all this, I thought I discerned little feet, whereby they moved very briskly, both in a round and streight line.

"There was further a *fourth* sort, which were so small that I was not able to give them any figure at all. These were a thousand times smaller than the eye of a big louse; For I judge, the axis of the eye of such a louse to be more than ten times as long as the axis of any of the said little creatures. These exceeded all the former in celerity. I have often observ'd them to stand still as 'twere upon a point, and then turn themselves about with that swiftness, as we see a top turn round, the circumference they made being no bigger than that of a small grain of sand, and then extending themselves streight forward, and by and by lying in a bending posture.

Observ. II.

"The 26. May it rained hard; the rain growing less I caused some of the rain-water, running down from the house top, to be gathered in a clean glass, after it had been washed two or three times with the water. And in this I observed some few very little living creatures, and seeing them, I thought they might have been produced in the leaden gutters in some water that had there remained before.

Observ. III.

"On the same day, the rain continuing, I took a great porcelain-dish, and exposed it to the free air upon a wooden vessel, about a foot and a half high, that so no earthy parts, from the falling of the rain-water upon that place, might be spattered or dashed into the said dish. With the first water that fell into the dish, I washed it very clean, and then flung the water away, and receiv'd fresh into it, but could discern no living creatures therein; only I saw many irregular terrestrial parts in the same. The 30th of May, after I had, ever since the 26th, observ'd every day twice or thrice the same rain-water, I now discovered some but very few, exceeding little animals, which were very clear. The 31st of May, I perceived in the same water more of those animals, as also some that were somewhat bigger. And, I imagine, that many thousands of these little creatures do not equal an ordinary grain of sand in bigness: And comparing them with a cheese-mite, to be like that of a bee to a horse: For, the circumference of one of these little animals in water, is not so big as the thickness of a hair in a cheese-mite.

Observ. IV.

"June 9th, having received, early in the morning, some rain-water in a dish, as before, and poured it into a very clean wine-glass, and exposed it about 8 of the clock in the morning to the air, about the height of the third story of my house, to find, whether the little animals would appear the sooner in the water, thus standing in the air: Observing the same accordingly the 10th of June, I imagin'd I saw some living creatures therein; but because they seem'd to be but very few in number, nor were plainly discernible, I had no mind to trust to this observation. The 11th of the same month, seeing this water move in the glass from a stiff gale of wind (which had blown for thirty-six hours without intermission, accompanied with a cold, that I could very well endure my winter-cloaths,) I did not think I should then perceive any living creatures therein; yet viewing it attentively, I did, with admiration, observe a thousand of them in one drop of water, which were of the smallest sort, that I had seen hitherto.

Observ. V.

"The 9th of June I put of the same rain-water in a very clean wine-glass on my counter of study, and viewing the same, I perceived no living creatures in it.

"The 10th of June, observing the mentioned rain-water, which now had stood twenty-four hours in my study, I noted some few very small living creatures in which by reason of their extreme minuteness I could see no figure, and among the rest I discovered one that was somewhat greater, of an oval figure. *Note*, that when I say I have viewed the water, I mean, that I have viewed only three, four, or five drops of the water, which I also flung away.

"The 11th of June, looking upon the water afresh, I saw the said little creatures again, but there were then but very few of them.

"The 12th, I saw them as the day before; besides I took notice of one figured like a mussel-shell, with its hollow side downwards, and it was of a length equal to the eye of a louse.

Observ. VI.

"The 17th of this month of June it rained very hard; and I catched some of that rain-water in a new porcelain-dish, which had never been used before, but found no living creatures at all in it, but many terrestrial particles, and, among others, such as I thought came from the smoak of smith's-coals and some thin thrids, ten times thinner than the thrid of a silk-worm, which seemed to be made up of globuls; and where they lay thick upon one another, they had a green colour. The 26th, having been eight days out of town, and kept my study shut up close, when I was come home and did view the said water, I perceived several *animalcula*, that were very small, and herewith I desisted from making at this time any further observations of rain-water.

"Mean time, this town of Delft being very rich in water and we receiving from the river Maase fresh water, which maketh our water very good; I viewed this water divers times, and saw extream small creatures in it, of different kinds and colours; and even so small, that I could very hardly discern their figures: But some were much bigger, the describing of whose motion and shape would be too tedious: this only I must mention here, that the number of them in this water was far less than that of those found in rain-water; for I saw a matter of twenty-five of them in one drop of this town-water, that was much. In the open court of my house I have a well which is about 15 foot deep, before one comes to the water. It is encompassed with high walls, so that the sun, though in *Cancer*, yet can hardly shine much upon it. This water comes out of the ground, which is sandy, with such a power, that when I have laboured to empty this well, I could not so do it but there remained ever a foot's depth of water in it. This water is in summer time so cold, that you cannot possibly endure your hand in it for any reasonable time. Not thinking at all to meet with any living creatures in it (it being of a good taste and clear), looking upon it in September of the last year, I discovered in it a great number of living animals, very small, that were exceeding clear, and a little bigger than the smallest of all that I ever saw; and I think, that in a grain weight of this water there were above 500 of these creatures, which were very quiet and without motion. In the winter I perceived none of these little animals, nor have I seen any of them this year before the month of July, and then they appeared not very numerous, but in the month of August I saw them in great plenty.

"July 27, 1676, I went to the sea-side at Schevelingen, the wind coming from the sea with a very warm sun-shine; and viewing some of the water very attentively, I discovered divers living animals therein. I gave to a man, that went into the sea to wash himself, a new glass bottle, bought on purpose for that end, intreating him, that being on the sea, he would first wash it well twice or thrice, and then fill it full of the sea water; which desire of mine having been complied with, I tyed the bottle close with a clean bladder, and coming home and viewing it, I saw in it a little animal that was blackish, looking as if it had been made up of two globuls. This creature had a peculiar motion, after the manner as when we see a very little flea leaping upon a white paper; so that it might very well be called a water-flea; but it was by far not so great as the eye of that little animal which Dr. Swammerdam calls the water-flea. I also discovered little creatures therein, that were clear, of the same size with the former animal which I first observed in this water, but of an oval figure, whose motion was serpent-like. I took notice of a third sort, which were very slow in their motion: Their body was of a mouse-colour, clear towards the oval point; and before the head, and behind the body there stood out a sharp little point angle-wise. This sort was a little bigger. But there was yet a fourth sort somewhat longer than oval. Yet of all these sorts there were but a few of each, so that in a drop of water I could see sometimes but three or four, sometimes but one.

"*Observations of water, wherein whole Pepper had layn infused several dayes.*

"1. I having several times endeavoured to discover the cause of the pungency of pepper upon our tongue, and that the rather because it hath been found, that though pepper had layn a whole year in vinegar, yet it retained its full pungency; I did put about $\frac{1}{3}$ of an ounce of whole pepper in water, placing it in my study, with this design, that the pepper being thereby rendered soft, I might be enabled the better to observe what I proposed to myself. The pepper having layn about 3 weeks in the water, to which I had twice added some snow-water, the other water being in great part exhaled; I looked upon it the 24. of April 1676, and discovered in it, to my great wonder, an incredible number of little animals of divers kinds; and among the rest some that were 3 or 4 times as long as broad; but their whole thickness did, in my estimation, not much exceed that of the hair of a louse. They had a very pretty motion, often tumbling about and sideways; and when I let the water run off from them, they turned as round as a top, and at first their body changed into an oval, and afterwards, when the circular motion ceased, they returned to their former length.

"The 26th of April I took $2\frac{1}{2}$ ounces of snow-water, which was almost three years old, and which had stood either in my cellar or study in a glass bottle well stopped. In it I could discover no living creatures: And having poured some of it into a porcelain thea-cup, I put therein half an ounce of whole pepper, and so I placed it in my study. Observing it daily until the 3rd of May, I could never discover any living thing in it; and by this time the water was so far evaporated, and imbibed by the pepper, that some of the pepper-corns began to lye dry. This water was now very thick of odd particles; and then I poured more snow-water to the pepper, until the pepper-corns were cover'd with water half an inch high. Whereupon viewing it again the 4th and 5th of May, I found no living creatures in it; but the 6th I did very many, and these exceeding small ones, whose body seemed to me twice as long as broad; but they moved very slowly and often roundways.

"The 7th I saw them yet in far greater numbers.

"The 10th I put more snow-water to the pepper, because the former was again so exhaled, that the pepper-corns began to dry again.

"The 13th and 14th I saw the little creatures as before; but the 18th the water was again so dryed away, that it made me pour in more of it. And the 23rd I discovered, besides the aforesaid little animals, another sort, that were perfectly oval, and in figure like cuckow-eggs. Me thought the head of them stood on the sharp end: their body did consist, within, of 10, 12 or 14 globuls, which lay separate from one another. When I put these *animalcula* in a dry place, they then changed their body into a perfect round and often burst asunder, and the globuls, together with some aqueous particles, spread themselves everywhere about, without my being able to discern any other remains. These globuls, which in the bursting of these creatures did flow asunder here and there, were about the bigness of the first very small creatures. And though as yet I could not discern any feet in them, yet me thought, they must needs be furnished with very many, seeing that the smallest creatures, which I said before to be very plentiful in the water, and lay sometimes more than 100 of them on one of the oval creatures, were by the motion made in the water by the great ones (though to my eye they seem'd to lye still) driven away by them as we blow a feather from our mouth. Of the same oval creatures I never could discover any very little ones, how attentive soever I was to observe them.

"The 24th of May observing this water again, I found in it the oval little animals in a much greater abundance. And in the evening of the same day, I perceived so great a plenty of the same oval ones, that 'tis not one only thousand which I saw in one drop; and of the very small ones, several thousands in one drop.*

"The 25th I saw yet more oval creatures: and the 26th I found so vast a plenty of these oval creatures, that I believe there were more than 6 or 8000 in one drop, besides the abundance of those very little animals whose number was yet far greater. This water I took from the very surface; but when I took up any from beneath, I found that not so full of them by far. Observing that these creatures did augment into vast numbers, but not being able to observe them increase in bigness, I began to think whether they might not in a moment, as 'twere, be composed or put together: But this speculation I leave to others. The 26th of May at night, I discovered almost none of the little creatures, but saw some with tayls, of which I have spoken heretofore, to have seen them in rain-water: But there drove in the water throughout an infinity of little particles, like very thin hairs, only with this difference, that some of them were bent.

"May the 26th, I took about $\frac{1}{3}$ of an ounce of whole pepper, and having pounded it small, I put it into a thea-cup with $2\frac{1}{2}$ ounces of rain-water upon it, stirring it about, the better to mingle the pepper with it, and then suffering the pepper to fall to the bottom. After it had so stood an hour or two, I took some of the water, before spoken of, wherein the whole pepper lay, and wherein were so many several sorts of little animals; and mingled it with this water, wherein the pounded pepper had lain an hour or two, and observed that when there was much of the water of the pounded pepper, with that other, the said animals soon died, but when little they remained alive."

* "This phænomenon and some of the following ones seeming to be very extraordinary, the author hath been desired to acquaint us with his method of observing, that others may confirm such observations as these."

Although it is scarcely possible to fix with certainty the specific identity of the numerous animalcules enumerated by Leeuwenhoek in the foregoing "Observations" in various instances, the characters recorded are so well defined as to clearly indicate the generic group to which the organism described should be relegated. Taking, for example, the first form encountered by him in rain-water, having a globular body with two little anterior horns and a long thread-like tail, which under certain conditions contracted into a spiral form, there can be no question that this type represents some species of *Vorticella*, or bell-animalcule, and is apparently identical with the form now known by the distinctive title of *Vorticella microstomum*. While the recorded presence of the two anterior "horn-like processes" appears at first sight to represent a somewhat anomalous structural characteristic, this seeming incongruity vanishes on applying to it the standard of a slightly later acquired knowledge of the members of this infusorial group, and through which medium it is at once made evident that the appendages above referred to as seen by Leeuwenhoek represented merely the imperfectly defined optical aspect of the lateral edges of the characteristic peristomal fringe of cilia. As a remarkable illustration of the manner in which "history repeats itself" even in the annals of scientific discovery, it may be here noted that a precisely similar error of interpretation is associated by Mr. H. J. Carter, close upon two centuries later, in his figure and description of the flagellate organism described in this volume under the name of *Salpingœca Carteri* (see Pl. VI. Fig. 39). The characteristic membranous collar distinctive of this type and its allies, which occupies a position corresponding with that of the ciliary wreath of a *Vorticella*, is so exceedingly transparent as to be distinctly visible only with the aid of the highest magnifying powers of the modern compound microscope. The structure as observed by Mr. Carter with inadequate magnification, displayed simply its two lateral peripheries, assuming under such conditions the aspect of two projecting ear-like processes, and under which latter designation they are chronicled in the description quoted. The second oval form described by Leeuwenhoek as furnished on the under side with divers incredibly thin feet, and having a soft flexible body capable of assuming a variety of figures, would appear to be a species of *Oxytricha*, while in the little animal like a mussel-shell, having also on its under side little feet, recorded in the course of his fifth Observation, is at once recognized a form closely allied to, if not specifically identical with the cosmopolitan type *Stylonychia mytilus*. It is well worthy of note, that while Leeuwenhoek in this first recorded account of the members of the infusorial world more usually associates with them the vague terms of little animals or creatures, he employs for them at the commencement of his discourse that of "animalcula," or, in English, animalcules, generally adopted in conjunction with that of the Infusoria by the majority of later writers. In his observations of various species discovered by him in an infusion of pepper we finally find the origin of the burning question of the possible "spontaneous generation" of these minute beings, and which, while not entirely accepted by Leeuwenhoek, is conceived and tossed by him as a very apple of discord to posterity.*

The period intervening between this first discovery of the Infusoria by Leeuwenhoek, and his further contribution to the literature of the same subject in the year 1703, is signalized by the corroboration of that authority's observations, and an extension of our knowledge of the group, at the hands of several of our own countrymen, among whom have to be more especially mentioned the names of Sir E. King, John Harris, and Stephen Gray. In each case the results obtained by these early investigators are recorded in the pages of the 'Philosophical Transactions,' and in connection with one contribution, that of Sir E. King, is to be found the first published illustration of infusorial life. The form thus represented was obtained in an infusion of pepper, and appears to be identical with the *Enchelys arcuata* of Ehrenberg. This authority also places on record the results of the experimental application of certain chemical and other substances to living animalcules, a subject which will be found referred to at greater length in the section devoted to this special topic. The account of John Harris's investigations contained in the 'Philosophical Transactions' for the year 1696, embodies the earliest description given of *Euglena viridis*, and some remarkably shrewd and philosophic speculations as to the manner in which Infusoria were so rapidly and unaccountably developed. These latter were altogether opposed to the then newly-conceived theory of spontaneous generation, and, as hereafter shown, add their weight to the evidence which has been since adduced in a similar direction. Mr. Harris's description of *Euglena* and certain other associated forms, that first mentioned being evidently a species of *Anguillula*, and the second a Rotifer, probably *R. vulgaris*, is as follows:—

"On July 7th, 1694, I examined a small drop of rain-water that had stood in a gally-pot in my window for about two months. In the thick part of the drop—for the water from whence I took it had contracted a thickish skum—I found two sorts of animals as a kind of eels like those in vinegar. I saw here also an animal like a large maggot, which would contract itself up into a spherical figure, and then stretch itself out again; the end of the last appeared with a forceps like that of an earwig; and I could plainly see it open and shut its mouth, from whence air-bubbles would frequently be discharged. Of these I could number about four or five, and they seemed to be busie with their mouths as if in feeding. April 27th, 1696. With a much better microscope I examined some rain-water that had stood uncovered a pretty while, but had not contracted any such thick and discoloured a skum as that before mentioned had. A little thin white skum, that like grease began to appear on

* In association with the discoveries of Leeuwenhoek here recorded, it is worthy of remark that a cabinet of the microscopes, to the number of twenty-six, as self-constructed and employed by that investigator, and consisting of simple doubly convex lenses, were originally presented by him to the Royal Society of England, but have long since been lost sight of. The latest tidings of them would appear to be furnished by Mr. Henry Baker, who in his work, 'The Microscope Made Easy,' published in the year 1785, attests to having had these glasses under examination away from the Society's premises and at his own private residence. The recovery of such precious heirlooms, and the reconsignment of the same to their former custody, or among the series of optical instruments belonging to the Royal Microscopical Society, where perhaps they would be even more highly prized, is a consummation most devoutly to be wished, and may possibly be helped forward by this notice.

the surface, I found to be a congeres of exceeding small animalcula of different shapes and sizes. At the same time I look't on a small drop of the green surface of some puddle-water, which stood in my yard; this I found to be altogether composed of animals of several shapes and magnitudes. But the most remarkable were those which I found gave the water that green colour, and were oval creatures, whose middle was of a grass green, but each end clear and transparent. They would contract and dilate themselves, tumble over and over many times together, and then shoot away like fishes. Their head was at the broadest end, for they still moved that way. They were very numerous, but yet so large, that I could distinguish them very plainly, with a glass that did not magnify very much.

"April 29th, 1696. I found another sort of creatures in the water (some of which I had kept in a window, in an open glass). They were as large as three of the other, with the green border about their middles, but these were perfectly clear and colourless. Then also examining more accurately the belts or girdles of green that were about the animals, mentioned above, I found them to be composed of globules, so like the rowes or spawn of fishes, that I could not but fancy that they served for the same use in the little creatures: For I found now since April 27. many of them without anything at all of that green belt or girdle; others with it very much and that unequally diminished, and the water filled with a vast number of small animals, which before I saw not there, and which I now looked on as the young animated frye, which the old ones had shed. I continued looking on them at times for two days, during which time the old ones with the green girdles decreased more and more; and at last I could not see one of them so encompassed, but they were all clear and colourless from end to end.

"May 18th, 1696. I look't in some of the surface of puddle-water which was blewish, or rather of a changeable colour, between blew and red. In a large quantity of it I found a prodigious number of animals, and of such various bignesses, that I could not but admire their great number and variety; but among these were none with those girdles before-mentioned, either of green, or any other colour. I then also examined the surface of some other puddle-water, that look't a little greenish; and this I found stockt with such an infinite number of animals, that I yet never saw the like anywhere but in the *Genitura masculina* of some creatures. Among these there were many of a greenish colour; but they all moved about so strangely swift, and were so near to each other, that tho' I tried my eyes, I could not distinguish whether the green colour were all over their bodies, or whether it were only round their middle in girdles, as before, but from the roundness of their figure and their smallness, I judge that they chiefly consisted of the young animated spawn of the kind of animals mentioned already. I found that the point of a pin dipt in spittle would presently kill them all; as I suppose it will other animalcula of this kind."

The interest attached to the writings upon this same subject of Stephen Gray, published also in the same volume of the 'Philosophical Transactions' for the year 1696, is connected most prominently with the discovery made by this early investigator, that particles contained within a simple sphere of glass, or animalcules contained in a corresponding globule of water, become when viewed under favourable conditions more powerfully magnified than with the assistance of any ordinary bi-convex lens. Several varieties of animalcules were described by Stephen Gray, as examined by him with this most simple optical apparatus, among them being a form, apparently the *Halteria grandinella* of Dujardin, in association with which he places on record the earliest account of what, while interpreted by him as a possible act of generation, was more probably an instance of the more ordinary phenomenon of transverse fission. A brief abstract, in his own words, of Stephen Gray's account of his discoveries in these several directions is herewith subjoined:—

"I know not well how at this time to account for this strange phenomenon, that an object should be placed so far within the focus of a spherule, as to be within the glass, and yet seen distinctly to the eye so near it; but since by matter of fact, I found it was so, I made this inference, and concluded, that if I conveyed a small globule of water to my eye, and that there were any opacous or less transparent particles than the water therein, I might see them distinctly.

"Exp. 4. Having by me a small bottle of water, which I knew to have in it some of those minute insects, which the deservedly famous observator Mr. Leeuwenhoek discovered, by the help of excellent microscopes. Having seen them with the common glass microscopes, and with the first aqueous, as above mentioned, I poured a few drops of this water on the table, and taking a small portion thereof on a pin, I laid it on the end of a small piece of brass wire, of about one-tenth of an inch diameter. I continued to lay on two or three portions of water, till there was formed somewhat more than an hemispherule of water; then keeping the wire erect, I applied it to my eye, and standing at a proper distance from the light, I saw them and some other irregular particles, as I had predicted, but most enormously magnified; for whereas they are scarce discernible by the glass microscopes, or the first aqueous one, within the globule, they appeared not much different both in their form, nor less in magnitude than ordinary peas. They cannot well be seen by daylight except the room be darkened, after the manner of the famous dioptrical experiment, but most distinctly by candle-light; they may be very well seen by the full moon light, and the pin sometimes takes up the water round enough to shew its objects distinct.

"The insects I have yet this way observed, are of two sorts, globular and elliptical: I shall first describe the former. They are of a globular form, they are but a little less transparent than the water they swim in; they have sometimes two dark spots diametrically opposite, but these are rarely seen; there are sometimes two of these globular insects sticking together; where they are joined 'tis opacous, possibly they may be in the act of generation; they have a twofold motion, a swift progressive irregular one, and at the same time a rotation on their axes at right angles to the diameter that has the dark spots, but this is seen only when they move slowly. They are almost of an incredible minuteness. Mr. Leeuwenhoek is moderate enough in his computation, when he tells us * he saw insects in water, so small, that 30,000 could not more than equal a coarse sand; but I believe it will seem a paradox to him, when one that tells him so shall at the same time say, that he can see them by only applying the bare eye, to a portion of water wherein they are contained."

In the year 1703 Leeuwenhoek contributed to the 'Philosophical Transactions' an account of several species of animalcules observed by him on the roots of duckweed obtained from the River Maes at Delf-haven in Holland, which was accompanied by woodcut illustrations of the various forms encountered. Among them are especially conspicuous a species of *Vorticella*, apparently *V. nebulifera*, and a tube-dwelling variety allied to, if not identical with *Vaginicola crystallina*. In addition to the true Infusoria above named, Leeuwenhoek figured and described for the first time the Freshwater Polyp (*Hydra*) and a large sedentary Rotifer most nearly resembling *Limnias ceratophylli*. The majority of these types are represented as adherent to a single rootlet of duckweed, having interspersed among them several acicular diatoms (*Fragillaria*), and a few other exceedingly minute stalked particles referred to by him as "little flower-like figures," and which

* 'Phil. Trans.,' No. 213, p. 198.

are undoubtedly minute sedentary Flagellata, such as *Spumella* or *Oikomonas.*

The issue of the 'Philosophical Transactions' following upon the one containing the foregoing figures and descriptions, is conspicuous for the insertion, at the hands of an anonymous writer, of an account of a considerable number of infusorial forms obtained from an infusion of pepper. The type first described by Leeuwenhoek, *Vorticella microstomum* or *putrinum*, is here figured for the first time, as also *Paramecium aurelia* showing its characteristic ciliation, a species of *Euplotes*, *Enchelys*, *Oxytricha*, and a variety of other animalcules whose identity cannot so easily be determined. Among the delineations given of the *Euplotes*, one example represents an animalcule dividing by transverse fission, and is referred to in the accompanying text as a probable example of copulation. The highest interest attached to this early contribution to microscopic literature is, however, associated with the fact that it embodies a remarkably clear and graphic account of several species of the exceedingly minute and low-organized Phytozoa, *Vibrio* and *Spirillum*—briefly referred to by Leeuwenhoek in the preceding quotations as "an infinity of little particles like very thin hairs which drove through the water"—which is accompanied by illustrations of the types observed, equal both in execution and the scale of magnification employed to those produced by workers in this same field of research for more than a century later. The apparatus, nevertheless, at the disposal of this early investigator was the single-lensed instrument only manufactured by Mr. Wilson, but out of which he testifies to having succeeded in obtaining a magnification of no less than 640 diameters. In recognition of their attenuate serpentine form and movements, this discoverer proposed to confer upon the hair-like bodies just referred to the distinctive title of "Capillary Eels." A brief abstract of this anonymous author's original and earliest recognizable description of these exceptionally minute and highly interesting organisms is here appended. After submitting an account of the instrument employed and various forms observed by him in his infusion of pepper, he continues :—

"One sort I never discovered till but three or four days ago. These are very long slender worms, of which my pepper-water is prodigiously full. They are all of the same thickness, but their lengths are very different, some twice and some thrice as long as others, and at a medium I judge the proportions of their length to their breadth at least as 50 to 1. To the largest magnifiers they look like threads of horse-hair, (to a naked eye), from a quarter to three-quarters of an inch long, and their motion is equable and slow and generally they wave their bodies but little in their progression, though sometimes they make greater undulations. But what is more remarkable, they swim with the same facility both backward and forward, so that I cannot distinguish at which end the head is, and I have seen the same worm go forward with one end, and back again with the other end foremost about twenty times together. And sometimes they will (like leeches) fix one end on the glass plate (on which I lay the water), and move the loose part of their body round about very oddly. These I take leave to call Capillary Eels, and I have given you as well as I could a representation of their appearance to a great magnifier, in the several postures I have seen them swim.

"Oct. 6th, 1702. I thought those which I called capillary eels had been peculiar to pepper-water, but have since observed the same (tho' but few) in some standing water which drained from an horse dunghill. Among these the prettiest object was a great number of a kind of eels which appear most distinctly when the water is almost dry, which make brisk shoots, and have a pretty wriggling motion; they are of different lengths, and are about the thickness of what I call capillary eels."

Among the contributors to our knowledge of infusorial life during the earlier half of the eighteenth century the names of Louis Joblot, Henry Baker, and Abraham Trembley hold a prominent position. Joblot, author in the year 1718 of a large treatise upon microscopes and the forms of microscopic animals to be found in various artificial infusions, was unfortunately led, through his possession of a more than ordinarily romantic imagination, to embellish very considerably his descriptions and drawings of the various types observed, these latter being in many instances moulded by his facile pen into the similitude of satyrs' heads, and other monstrosities having no existence in the plain and solid ground of fact. Henry Baker's work, 'The Microscope Made Easy,' published in the year 1742, while embracing a general account of all the various forms of microscopes in use up to that date, and of subjects suitable for examination with the aid of that instrument, includes in addition, a description with figures of many forms of animalcules discovered by himself in organic infusions. This special subject is, however, treated still more extensively in his subsequent volume, 'Employment for the Microscope,' published in the year 1753. In this last-named treatise is to be found the first printed account, accompanied by an easily recognizable figure, of the species now well known by the title of the Swan Animalcule, *Lacrymaria olor*, and upon which Mr. Baker conferred the name of the "Proteus." Of this he writes:—

"Having one evening been examining of the slime-like matter taken from the side of a glass jar, in which small fishes, water-snails, and other creatures had been kept alive two or three months, by giving them fresh water frequently, I was diverted with the sudden appearance of a little creature whose figure was entirely new to me, moving about with great agility, and having so much seeming intention in all its motions, that my eyes were immediately fixed upon it with admiration. Its body in substance and colour resembled a snail's; the shape thereof was somewhat elliptical, but pointed at one end, whilst from the other a long, slender and finely proportioned neck stretched itself out, and was terminated with what I judged to be an head, of a size perfectly suitable to the other parts of the animal. In short, without the least fancy, which is ever carefully to be guarded against in the use of the microscope, the head and neck, and indeed the whole appearance of the animal, had no little resemblance to that of a swan: With this difference, however, that its neck was never raised above the water, as the neck of a swan is, but extended forwards, or moved from side to side, either upon the surface of the water, or in a plane nearly parallel to the surface thereof. It swam to and fro with great vivacity, but stopped now and then for a minute or two, during which time its long neck was usually employed, as far as it could reach, forwards, and on every side, with a somewhat slow but equable motion, like that of a snake, frequently extending thrice the length of its body, and seemingly in search of food. I could discern no eyes, nor any opening like a mouth in what appears to be the head; but its actions plainly prove it an animal that can see; for notwithstanding multitudes of different animalcules were swimming about in the same water, and its own progressive motion was very swift, it never struck against any of them, but directed its course between them, with a dexterity wholly unaccountable, should we suppose it destitute of sight."

Henry Baker's speculations concerning the probable origin of animalcules in hay and other infusions will be referred to in a future chapter.

Abraham Trembley's name, while most famous in association with his remarkable discoveries concerning the extraordinary recuperative properties after mutilation possessed by the fresh-water polypes, *Hydra vulgaris* and *viridis*, has also to be included in the list of contributors to our early knowledge of the Infusoria. In the course of his investigations and experiments upon the more highly organized forms just mentioned, he was the first to encounter many of the larger Stentors or trumpet-animalcules, and regarding them as structurally allied to the latter, described them in the 'Philosophical Transactions' for 1744 under the respective titles of the white, blue, and green funnel- or tunnel-like polypes. Through a prolonged study of these forms Trembley made himself familiar with, and recounted at length, the peculiar oblique manner in which they subdivide, the mode in which the new head and oral aperture is formed upon the posterior segment, and a new caudal prolongation upon the anterior one, being related with such true and exhaustive detail as to leave but little to be added in this connection by later investigators. Under the title of "Clustering Polypes" this authority also figured and described several varieties of *Epistylis*, notably *E. flavicans*, relating precisely the manner in which by constant and even longitudinal subdivision and prolongation of the supporting pedicle the branched compound colony is built up. This premised affinity of the trumpet-animalcules with the polypes suggested by Trembley received the full approbation of the father of systematic natural history, the immortal and illustrious Linnæus, by whom they were included in the tenth edition of his famous 'Systema Naturæ,' published in the year 1758, under the title of *Hydra stentorea*.

Five years later, 1763, we find for the first time the term "Infusoria" introduced for the distinction of the minute beings that form the subject of this treatise. M. F. Ledermuller, of Nuremberg, to whom must be awarded the credit of creating this highly suggestive title, which has since been almost universally adopted, employed it in the first instance for the distinction of all those microscopically minute animals discovered by himself and earlier investigators in water in which hay had been for some few days previously steeped. This new title he further proposed to extend to all the microscopical forms of animal life inhabiting infusions and putrid liquids, including also those discovered in stagnant rain-water nearly a century previously by Leeuwenhoek; the Stentors were, nevertheless, left by him in the position among the polypes assigned to them by Linnæus and Trembley. The names of Rösel, 1755, Wrisberg, 1765, and Pallas, 1766, may be mentioned among the more prominent contributors to our earliest knowledge of the larger forms of animalcules, chiefly Vorticellidæ and Stentoridæ, preceding the appearance of what to the present day holds rank as the earliest standard work that embodies a complete and systematic account of the members of the infusorial world. Reference is here made to the 'Animalcula Infusoria' of Otho Friedrich Müller, a posthumous quarto volume published in the year 1786, containing no less than fifty plates and 367 pages of letterpress devoted to the description and illustration of close upon three hundred species, fluviatile and marine, investigated and drawn from the life by this indefatigable worker during a period extending over no less than twenty years.

This early pioneer in the then *terra incognita* of the Protozoic sub-kingdom had already in his 'Vermium terrestrium et fluviatilium succincta Historia,' 'Zoologica Danicæ Prodromus,' and 'Zool. Dan. Icones,' published respectively in the years 1773, 1776, and 1779, given descriptions and illustrations of a large number of these numerous types, to all of which he attached distinctive generic and specific titles in conformity with Linnæus' then newly-introduced binomial system of nomenclature; each of these compilations, however, possess but minor value compared with the work first quoted. To this latter, one is justified, indeed, in conceding as important a status, as compared with all preceding literature upon the subject, as is subsequently commanded by C. G. Ehrenberg's classic volume, 'Die Infusionsthierchen,' published a little over half a century later. As might be anticipated, O. F. Müller embraces in his 'Animalcula Infusoria' numerous minute organisms that find no place in the infusorial group as at present constituted, although in this respect he trespasses but slightly from the path subsequently pursued by Ehrenberg. In all, Müller institutes seventeen generic denominations, the whole of which are still in use, and only one, his genus *Cercaria*, being founded upon forms not admitted into Ehrenberg's system of classification, while another, his genus *Vibrio*, embraces in addition to many common forms of *Bacteria*, *Vibrio*, and *Spirillum*, as now recognized, various examples of the microscopic hair-worms or *Anguillulæ*. The several species of *Stentor* were now recognized as members of the same infusorial series, and transferred to his somewhat comprehensive genus, *Vorticella*. As a necessary consequence of the very imperfect instruments available for investigation at this early date, little more than a rough general outline of the species examined, and no details of their internal organization, are usually recorded, while in many of the types figured the cilia are but represented in part, or even altogether omitted. A reproduction of O. F. Müller's generic subdivisions and earliest proposed scheme of classification of the Infusoria will be found in the chapter hereafter devoted to this special subject.

In the long interval intervening between the publication of Müller's 'Animalcula Infusoria' and the appearance of Ehrenberg's world-famed treatise, a considerable number of investigators occupied themselves in the study of these minute organisms, but without achieving any very notable results.

Bonnet, Goeze, Gleichen, Eichorn, Spallanzani, and Schranck, towards the termination of the eighteenth, and Treviranus, Oken, Dutrochet, Nitzsch, and Bory de St. Vincent, during the commencement of the present century, are among the more conspicuous of these. Gleichen's name, perhaps, deserves special notice, he being the first to demonstrate, through the admixture of finely comminuted carmine with the water, the capacity of Infusoria to appropriate this and other solid substances as food. Spallanzani detected within the body-plasma of various species the bubble-like pulsating space or spaces afterwards denominated contractile vesicles, while the presence of an internal, more solid, gland-like structure, the nucleus or endoplast, and the capacity of many to increase by longitudinal or transverse subdivision were familiar to the majority of these observers. Examples of these last-named phenomena were, indeed, figured and described by Müller, and had, as already intimated, been observed long previously by Trembley in association with the Stentors or trumpet-animalcules. Dutrochet, in the year 1812, achieved a progressive step by the recognition of the essential distinction of all the species referred by O. F. Müller to the genus *Brachionus;* these were shown to exhibit a much higher organization than the ordinary Infusoria, possessing well-developed internal organs, and a much more complex type of external contour, and were now distinguished for the first time by the title of Rotiferæ or wheel-animalcules. This distinction, pointed out by Dutrochet, was recognized by Lamarck and Cuvier in their respective classifications of the animal kingdom, the Infusoria as embodied in Cuvier's scheme including all of Müller's types, subdivided into two leading orders, the one including the more complex Rotiferæ, and the other the apparently structureless and homogeneous animalcules. These latter were, indeed, accepted by Cuvier and all leading authorities up to the year 1830 as the simplest forms of animal life, exhibiting a degree of organization most appropriately compared with mere specks of animate jelly variously modified in external shape.

With the last-named date commenced an entirely new era in the history of the Infusoria. For fourteen years previously Christian Gottfried Ehrenberg had been devoting studious attention to the investigation of the lowest grades of vegetable and animal life, the matured fruits of which now took the scientific world completely by surprise. He at this time commenced the publication of his various essays, seeking to demonstrate that the Infusoria, notwithstanding their minute size, possessed a degree of organization as perfect and complex as that of the higher animals, which culminated in the year 1838 in the production of his world-famed history of the Infusoria, 'Die Infusionsthierchen als Volkommene Organismen.' This magnificent folio treatise, embodying no less than 532 pages of letterpress and an accompanying atlas of 64 coloured plates, including several hundred specific forms delineated for the most part with a life-like exactitude, will ever remain a lasting memorial of the unflagging industry and talent of this most indefatigable investigator.

Notwithstanding the comparative imperfection of the optical appliances at his disposal, it may indeed with justice be said that Ehrenberg's figures, so far as they relate to contour and broad superficial details of structure, are scarcely to be improved upon, and considerably excel, in execution, the delineation of the same forms included in many more modern treatises. Ehrenberg, like Müller, associated together under the collective title of the Infusoria a vast assemblage of minute animal and vegetable organisms, a small section only of which finds its equivalent under the same classificatory term in its more modern and restricted sense. In addition to the true Infusoria he still retained the Rotifera, or wheel-animalcules, the descriptions and illustrations of these monopolizing over one-third of the text and plates of his entire volume, while a very considerable portion of the remainder is occupied with the description and delineation of the essentially vegetable Desmidiaceæ and Diatomaceæ, to which are also added many forms of Rhizopoda and unicellular plants other than the Bacillaria.

It was to the residual portion, that alone coincides with the tribe Infusoria as at present recognized, that Ehrenberg attributed the possession of a highly complex internal structure, whose chief feature was further described as consisting of a large number of pedunculate bubble-like stomach-cavities associated with one another in a clustered form. The most weighty testimony relied on by Ehrenberg in support of this theory was derived from his repetition and extension of the experiments of Gleichen, by whom it was demonstrated that carmine, indigo, or other pigmentary matter suspended in the water was freely devoured. After passing through the oral aperture this coloured matter was found to become collected in small spherical bubble-like masses, variously distributed throughout the body-substance or parenchyma, and without apparently taking the pains to assure himself that these vacuoles occupied a permanently fixed position, Ehrenberg assumed that such was the case, and assigned to each vacuole the significance of a distinct food-receptacle or stomach; it was with special reference to these supposed numerous stomach-cavities that the title of the Polygastrica was adopted by him for the distinction of this particular group. Ehrenberg's conception of the high and complex organization of his so-called Polygastrica, however, by no means ended here. The transparent vacuole possessing the property of contracting rhythmically, first observed by Spallanzani, conjointly with the still more universally recognized gland-like nucleus or endoplast, were pronounced to be integral parts of the male generative organs, the former representing a seminal vesicle, and the latter a seminal gland or testis. The minute granular corpuscles distributed more or less abundantly throughout the substance of the body were declared to be eggs, which after fecundation from the seminal vesicle were discharged through the anal aperture or vent. The possession by these Polygastrica of a complex muscular, nervous, and blood-circulating system was likewise insisted on, though no proof in these latter instances was brought forward; the coloured eye-like pigment specks conspicuous in *Euglena*, *Ophryoglena*, and various other types, were finally regarded by him as highly differentiated visual organs.

Ehrenberg's evidence in support of his many-stomached or polygastric theory was built on too insecure a foundation to stand the test of contemporary investigation, and before which, indeed, the entire superstructure of his most ingeniously conceived digestive, neural, hæmal, and reproductive systems was speedily demolished.

The first and most prominent authority to call in question the accuracy of Ehrenberg's interpretations was M. Felix Dujardin, who, firstly in various contributions to the 'Annales des Sciences Naturelles,' extending through the years 1835–38, and later in a special treatise devoted to this subject, 'Histoire Naturelle des Infusoires,' 1841, brought forward evidence that threw an entirely new light on the organization of the members of this group. Through an investigation, in their living state, of various representatives of the minute marine shell-forming organisms upon which D'Orbigny, in the year 1826, conferred the distinctive title of Foraminifera, Dujardin discovered that their internal structure was far more simple than had been previously conjectured. Guided only by an acquaintance with the empty shells or tests of these minute beings, and taking into account their predominating nautiloid form and chambered character, D'Orbigny and his contemporaries concluded that their fabricators exhibited a correspondingly high degree of organization, and described them as diminutive representatives of the Cephalopodous order of the Mollusca. Dujardin, examining various Mediterranean forms belonging chiefly to the genera *Cristellaria*, *Miliola*, and *Vorticialis*, speedily determined that their living occupants could lay claim to no such exalted position, being found by him to possess no distinct organs or differentiated tissues, but in their place a simple transparent gelatinous body, capable of extending fine thread-like prolongations of its substance in every direction, by means of which they adhered to and crept over submerged objects. Dujardin likewise discovered in both salt and fresh water minute organisms possessing similarly extensile gelatinous bodies and still more simple, unchambered, and mostly corneous tests, upon which he conferred the generic names of *Gromia* and *Euglyphia*. Between these several types and Ehrenberg's test-inhabiting polygastric genera *Arcella* and *Difflugia*, and the still more simple shell-less *Amœbæ*, Dujardin soon recognized that there subsisted the closest affinity, and separating them from all other forms, instituted for their reception, in reference to their peculiar mode of locomotion by root-like extensions of their body-substance, the class title of the Rhizopoda. Dujardin further conferred upon the plastic, gelatinous, and apparently homogeneous body-substance of these Rhizopoda the distinctive name of "sarcode," and finally sought to demonstrate that in all those infusorial forms described by Ehrenberg as exhibiting a polygastric type of structure, their body-substance possessed a similar simple gelatinous or sarcode consistence, although, through the superaddition of a denser external membrane, they were incapable of emitting thread- or root-like pseudopodic processes. No trace of a muscular or nervous system could be detected by this authority, while the non-existence of the complex digestive apparatus described by Ehrenberg was effectually demonstrated. On feeding Vorticellæ and other animalcules with carmine, in accordance with the plan adopted by Gleichen and Ehrenberg, Dujardin found that the food-particles, after their reception at the oral aperture, were not retained in definite and permanently fixed stomach-sacculi, but after aggregation into small spheroidal masses were passed backwards into the body-sarcode or parenchyma, and there freely circulated until digestion or rejection at the anal aperture. The somewhat similar and characteristic independent circulation of the inner sarcode or parenchyma of *Paramecium bursaria* and *Vaginicola crystallina* was also recorded for the first time by Dujardin. The contractile organ, first discovered by Spallanzani, and interpreted by Ehrenberg as belonging to the reproductive system, was pronounced by this investigator to be a mere vacuolar space situated close to the surface, apparently fulfilling a respiratory function by the continual absorption and expulsion of water.

This simple interpretation of the organization of the Infusoria arrived at by Dujardin, in opposition to that of Ehrenberg, soon gained powerful adherents. Among the more noteworthy authorities who also by their independent and almost contemporaneous researches, arrived at conclusions coinciding with those of Dujardin and antagonistic to the polygastric theory, may be mentioned the names of Meyen and Focke. Thuret and Unger, again, from a botanical point of view, indicated the close correspondence of the zoospores of *Chara*, *Vaucheria*, and various confervoid algæ with the monadiform animalcules referred by Ehrenberg to the genera *Chlamydomonas*, *Phacelomonas*, and *Microglena*. The most decisive advance made towards the elucidation of the true structure and affinities of the Infusoria, following upon Dujardin's investigations, was, however, accomplished by Carl Theodor von Siebold. It was this biologist who, in his 'Text-book of Comparative Anatomy,' published in the year 1845, first enunciated the theory, anticipated to some extent by Oken, Schleiden and Schwann, that the representatives of the Infusoria were unicellular organisms. Each separate animalcule possessed, in his opinion, the value only of a simple cell, of which the central gland-like organ observed by so many previous authorities, was now for the first time declared to be homologous with an ordinary cell-nucleus, and described under a like distinctive title. The contractile spaces or vesicles were further interpreted by Siebold as possessing a circulatory or cardiac function. The simple sarcodic nature of the body-substance of the Infusoria, first pointed out by Dujardin, was fully recognized by this authority, and all the organisms possessing such a simple unicellular structure were assembled together as the representatives of an independent sub-kingdom of the Invertebrata, upon which he conferred the suggestive title of the Protozoa. These Protozoa Siebold further divided into the two subordinate classes of the Rhizopoda and Infusoria, the former corresponding with the same section as similarly named by Dujardin, and including all those forms whose locomotion was accomplished by the extension of lobate or filiform processes or pseudopodia, while the latter embraced those in which cilia or flagelliform appendages fulfilled a similar function. The distinction between the Ciliate and Flagellate sections of the Infusoria was also fully recognized by this investigator, who, however, conferred upon them titles differing from those now recognized. The Ciliata only being regarded by him as possessing a distinct oral aperture, were denominated the "Stomatoda," and the supposed entirely mouthless flagellate animalcules, the "Astomata." Siebold, by his creation of the sub-kingdom Protozoa, acceptation of the Infusoria as simple sarcode organisms possessing individually the morphological value of a simple cell, and restriction of the Infusoria to the Ciliate and Flagellate members of the Protozoa, practically initiated that definition of the boundaries and organization of the class that receives the most powerful support at the present day, and is closely adhered to by the present author.

As might be anticipated, a universal concession to Siebold's unicellular interpretation of infusorial organization was by no means granted at the period of its announcement to the scientific world. Although the polygastric hypothesis, in the sense rendered by Ehrenberg, was speedily rejected, there have not been wanting those who from that earlier date up to the present time have sought to associate with these microscopic beings a complex type of structure, and to demonstrate their affinities with many of the more highly organized invertebrate sub-kingdoms. Among the first opponents of Siebold in this direction the names of Eckard and Oscar Schmidt are the most prominent. Both founded their arguments against the unicellular theory partly from their independent observation of the development of embryos from within the interior of the body-substance of *Stentor cæruleus* and *polymorphus*, while the latter more especially sought to demonstrate the close affinity of the higher ciliate animalcules with the Turbellarian group of the sub-kingdom Annuloida. O. Schmidt's indication of this supposed affinity was brought about by his discovery in *Paramecium aurelia* and *Bursaria* (*Panophrys*) *flavicans* of a subcuticular layer of minute rod-like bodies—now familiarly known (as trichocysts) to be developed in many infusorial forms—similar to those met with in various Turbellaria and lower Annelides. He further discovered that the contractile vesicle in various animalcules communicated with the outer water, a fact which at once suggested to his mind the probable correspondence of this structure with the water-vascular system of the last-named higher zoological groups.

These results of O. Schmidt's researches bring us to the year 1849, a date memorable for the appearance on the field of that accomplished investigator to whom we are most indebted for our present knowledge of the morphology and development of the infusorial animalcules, and from whom also we have received that scheme of classification of the Ciliate section of the class that obtains the widest recognition at the present day, and is mainly adopted in this volume. It is almost superfluous to add that the authority here referred to is none other than Friedrich Ritter von Stein, who, after his first contribution to the literature of this subject in the year first named, may be said thenceforward, and up to the present day, to have made a life-study of the history, habits, and organization of the representatives of this highly interesting group. The earliest published results of this eminent observer are specially remarkable for their association with a theory relating to the development of the Vorticellidæ, which commanded at the time almost as large a share of attention and adverse criticism as followed upon Ehrenberg's polygastric interpretations. Instead of accepting *Acineta* and its numerous allies, collected together in this treatise under the title of the Tentaculifera, as animalcules possessing an independent history and organization, Stein was led, through their frequent occurrence in company with certain species of Vorticellidæ, and by his observation of the production by some *Acinetæ* of Vorticella-like ciliated embryos, to regard these organisms as developmental conditions only of the latter. In accordance with this interpretation, the *Podophrya fixa* of Ehrenberg was pronounced by Stein * to be a transitional or acinete phase of *Vorticella microstoma; Acineta mystacina*, that of *Vaginicola crystallina;* and the form here included under the name of *Podophrya lemnarum* as a similar condition of *Opercularia nutans*. Additional instances in support of this Acineta theory were brought forward by Stein in the 'Zeitschrift für Wissenschaftliche Zoologie' for February 1852, its most extensive application and amplification being, however, embodied in his separate treatise 'Die Infusionsthiere auf ihre Entwickelunggeschichte,' published at Leipzig in the year 1854. This volume, notwithstanding the fact that its associated Acineta theory was shortly after disputed, and ultimately abandoned by Stein himself, still constitutes what may be almost regarded as a monograph of the Vorticellidæ and Tentaculiferous section of the Infusoria. In addition to embodying the most accurate account and delineations of the form, structure, and developmental phenomena of numerous representatives of these groups that had yet appeared, similar details concerning various Holotrichous types were likewise included; the multiplication of *Colpoda cucullulus*, through encystment and the subdivision of its substance into two, four, or eight spore-like bodies, as amply described later on, being among the most important of these supplementary data thus recorded. The supposed relationship of the twelve or more acinete types described by Stein to an equivalent number of Peritricha, including representatives of the genera *Vorticella*, *Epistylis*, *Opercularia*, *Zoothamnium*, *Cothurnia*, *Vaginicola*, *Spirochona*, and *Ophrydium*, is referred to at length in the descriptions hereafter given of the Acinetæ as independent organisms.

* Wiegmann's 'Archiv für Naturgeschichte,' 1849.

Contemporaneously with the earlier publications of Stein as above recorded, mention must be made of the work of Maximilian Perty, 'Zur Kentniss kleinster Lebensformen,' published at Bern in the year 1852. This treatise, like the earlier ones of Müller and Ehrenberg, embraces an account, with illustrations, of a heterogeneous assemblage of microscopic aquatic beings, including Rotifera, Rhizopods, and Bacillaria in addition to the ordinary Infusoria. These latter are, however, together with the Rhizopoda, separated by Perty from the associated animal and vegetable organisms, and collated together as distinct classes of a subkingdom, essentially identical with the Protozoa of Von Siebold, but upon which he conferred the new title of the Archezoa. The class of the Infusoria is further divided by Perty into the two orders of the Ciliata and Phytozoida, the former comprising all the ordinary ciliate animalcules, and the latter flagellate organisms generally, whether of an animal or vegetable nature. The innumerable infusorial forms figured and described by Perty were collected by himself entirely in the vicinity of the Bernese Alps, and embrace many new species, some of which have not been since met with, while a few, such as his *Eutreptia viridis* and *Mallomonas Plosslii,* are delineated in this present volume after examination, for the first time, with the higher magnifying powers of the compound microscope in its present comparatively perfected state. Taken as a whole, Perty's illustrations of the Infusoria, and of his Ciliata in particular, are exceedingly rough and unsatisfactory, being inferior in many respects to those previously given by Ehrenberg, and not to be compared with the contemporaneous ones of Stein. The view taken by this author with reference to the organization and internal structure of the Infusoria, is distinguished by its opposition to both the unicellular one of Siebold and the polygastric one of Ehrenberg. In place of these, Perty substituted the interpretation that these microscopic beings are composed of an aggregation of separate cells, none of which have attained their complete development, but remain indistinguishably united with each other. He thus, as presently related, anticipated to some extent the views adopted by Max Schultze in the same direction. The presence of any nervous, muscular, or other complex organization he entirely denied, as also that of a distinct internal parenchyma, the body being described by him as composed wholly of simple contractile substance. The thickly ciliated cuticular surface of *Stentor* and other forms he nevertheless compared to the ciliated epithelium of more highly differentiated organic types.

The first onslaught upon the Acineta theory enunciated about this date by Stein, was delivered by Johannes Lachmann, who, in Müller's 'Archives' for the year 1856, adduced testimony strongly in favour of the independent organization of *Acineta* and its allies, showing the characteristic manner in which they preyed upon other Infusoria, and their mode of reproduction through the separating of a portion of the central nucleus or endoplast. Corroborative evidence of a still more conclusive character, and which indeed finally established the claim of these remarkable animalcules to hold rank as the members of a distinct order of the Infusoria, was brought forward by the last-named investigator in conjunction with Edouard Claparède, in three extensive essays, published in volumes v. to vii. of the 'Mémoires de l'Institut Genevois,' extending over the years 1858 to 1860. These three memoirs, derived from the joint work of the above authorities, both co-workers in the laboratories, and disciples of the eminent Johannes Müller, form, as issued more recently in a single volume, the well-known 'Études sur les Infusoires et les Rhizopodes,' containing collectively over seven hundred pages of text, and thirty-seven quarto plates, constantly referred to in these pages, and which holds rank as one of the most complete and important contributions to the literature of the present subject as yet extant. That portion of the volume above quoted which relates more especially to the organization of the Acinetæ, proving the same to be entirely independent of the Vorticellidæ, and thus reversing the verdict of Stein, is embodied chiefly in the so-called third part of the 'Études.' Actually, however, this section of the work was published the first of all, its substance being included in the conjoint prize essay communicated to the Paris Academy of Sciences in February of the year 1855. The scheme of classification adopted by Claparède and Lachmann is submitted in its fully extended state later on, but may be briefly referred to here as comprising the ordinary infusorial orders of the Ciliata and Flagellata, two smaller groups of similar value being, however, instituted, the one entitled the Suctoria for the reception of *Acineta*, *Podophrya*, and all corresponding forms in which prey was seized and incepted through the medium of tubular and suctorial tentacle-like appendages, while that of the Cilio-flagellata was proposed by the same authorities for the distinction of *Peridinium* and various associated types which have as locomotive organs a girdle or other supplementary series of fine vibratile cilia, in addition to one or more flagellate appendages.

Claparède and Lachmann's interpretation of the organization and affinities of the Infusoria, for which, however, the first-named writer would appear to be chiefly responsible, is altogether opposed to the unicellular one of Von Siebold. While conceding to these organisms a separate and even the lowest position in the animal scale, they proposed to regard them as approximated most nearly, on the one hand, to the Cœlenterata, and on the other, more remotely, to the lower Annelids. In accordance with the views of these Geneva anatomists, the Infusoria were, in short, represented as possessing a well-defined body-wall, the softer internal area enclosed and bounded by which constituted an equally distinct chyme-filled somatic or gastric cavity. A very considerable accession to the number of known forms of animalcules, and more especially as relates to the previously little studied marine types, e. g. genera *Freia* (*Follicularia*), *Tintinnus*, and *Peridinium*, was effected through the indefatigable labours of Claparède and Lachmann, while the evidence accumulated by them respecting the developmental phenomena of the class in general is of the utmost value.

The same decade, conspicuous for the substantial progress effected towards a more accurate and extensive knowledge of the Infusoria at the hands of Stein, Claparède, and Lachmann, includes divers other names which, although not similarly associated with the authorship of separate treatises, hold a deservedly high place in the annals of infusorial literature. That of Balbiani is especially noteworthy in this direction, he having been the first, in the year 1858, to announce that the hitherto supposed longitudinal fission of *Paramecium aurelia* and various other animalcules, was not an act of division at all, but one of genetic or sexual union, attended with complex internal changes, as detailed at length in the chapter devoted to an account of the reproductive phenomena of this class.

Max Schultze's name, though more intimately connected with the history of the Rhizopodous section of the Protozoa, demands notice here, he having in the years 1860 and 1861 developed and modified to a marked extent the unicellular theory of the Infusoria first originated by Von Siebold. By this author the frequent absence from, and non-essentiality of, a bounding membrane or distinct cell-wall to many lower unicellular protozoic structures, was especially insisted on, the probability also being suggested that many, such as *Actinosphærium Eichornii*, and others possessing a multiplicity of nucleus-like structures, were composed of a greater or less number of wall-less cells indistinguishably amalgamated with each other. Further, Max Schultze in his demonstration that the soft plastic contents only, independently of an outer bounding wall, constitute the very essence or essential factor of cell organization, proposed to distinguish this soft and contractile substance by the characteristic title of "protoplasm" in contradistinction to that of "sarcode," introduced in a somewhat similar but narrower sense some years previously by Dujardin. With this author there also originated the brilliant and fortunate conception that the cell-contents of all animal and vegetable organisms were composed of a similar simple protoplasmic basis, such forms again, in their simplest expression, as in an *Amœba*, consisting of a mere animated speck or lump of undifferentiated protoplasm. Max Schultze's interpretation concerning the probable composite structure of certain Rhizopoda and Radiolaria received substantial confirmation at the hands of Ernst Haeckel, in his magnificent monograph of the Radiolaria, published in the year 1862.

Stein, already mentioned as having in the year 1854 published an important work devoted more especially to the organization of the Vorticellidæ and their supposed associated *Acinetæ*, gave abundant evidence of continued activity in the same field by the production, in the year 1859, of the first volume of the folio series still in course of progress, having as its aim the description and illustration of all known infusorial forms. In this volume Stein carried into practical application the new system of classification of the higher or Ciliate section of the Infusoria first introduced by him a few years previously,* and which has since been generally adopted as the most natural and convenient scheme yet proposed. In accordance with this, the ciliate animalcules were divided, with reference to the character and distribution of their cilia, into the four subordinate orders of the Holotricha, Heterotricha, Hypotricha, and Peritricha ; this special volume, in addition to including a complete summary of the biography and organization of the Infusoria as known up to that date, constituting an exhaustive account or monograph of the Hypotrichous section. The position conceded to the Infusoria by Stein in this treatise is that of the highest group of the Protozoa, though, taken individually, a more complex type of organization is assigned to them than is involved with the unicellular interpretation of Von Siebold. The characteristic contractile vesicle, with its frequently associated radiating canals, more particularly, is here accepted as formerly by O. Schmidt and Claparède and Lachmann as indicative of a more or less remote relationship with the Turbellaria and lower Annelids.

The interval intervening before the issue, in the year 1867, of Stein's second volume of his 'General History of the Infusoria,' bore substantial fruit through the researches of Balbiani and T. W. Engelmann in the direction of that more extended knowledge of the developmental phenomena of the class referred to at length in a succeeding chapter. The number of known infusorial forms was also considerably enriched, and their structure accurately described and delineated by the authority last quoted and many other able investigators, among whom the names of A. Quennerstedt, H. J. Carter, Frederick Cohn, J. D'Udekem, and A. Wrzesniowski, are especially conspicuous.

In association with the period now under consideration the novel interpretation of the affinities of the Infusoria and proposed subdivision of the group introduced by R. M. Diesing, may be suitably referred to. In accordance with the views of this author, the sub-kingdom of the Protozoa, as instituted by Von Siebold, possessed no real existence, the entire assemblage of forms included in it representing simply lower or imperfectly developed conditions of various more highly organized animal groups. The Rhizopoda and Foraminifera were thus held by Diesing, following the views of D'Orbigny, to be degraded headless Mollusca, the majority of the Ciliata and mouth-bearing Flagellata to be lower worms, while the Vorticellidæ and Stentors, with reference to the closely approximated location of their oral and anal apertures, were referred to the Polyzoa, and collected into a group upon which he conferred the title of the Bryozoa Anopisthia. This breaking up of the class of the Infusoria and distribution of its members among various other Invertebrate sub-kingdoms, while first proposed by Diesing in the year 1848, received its full development in his 'Systema Helminthum, Order Prothelmintha,' and 'Revision der

* 'Sitzung. der königl. Böhmischen Gesellschaft der Wissenschaften,' Oct. 1857.

Prothelminthen,' published respectively in the years 1850, 1865, and 1866. These last-named contributions constitute practically a synopsis, with accompanying diagnoses, of all the infusorial forms then known, exclusive of the Vorticellidæ and Stentoridæ, the chief value of which undoubtedly depends upon their very complete bibliographic references. In no case does Diesing appear to have personally acquainted himself with even a single example of the numerous types epitomized, his diagnoses being framed entirely upon the descriptions given by their original discoverers, and whose errata are also necessarily reproduced. Thus, accepting the dictum of Ehrenberg, all the Flagellata are erroneously represented as possessing a distinct oral aperture, *Volvox*, *Pandorina*, and other undoubted mouthless Phytozoa even being included in the category. Viewed as a whole, Diesing divides his so-called order of the Prothelmintha into the two sub-orders of the Mastigophora and Amastiga, the same corresponding respectively, exclusive of exceptions above named, with the Flagellate and Ciliate divisions of the Infusoria first instituted by Von Siebold. The Flagellata, or Mastigophora, are further separated by him into the two sections of the Atrichosomata and Trichosomata, the latter group including only the Peridinidæ and other allied forms possessing cilia in addition to the characteristic flagella, and therefore corresponding with the order of the Cilio-Flagellata as comprehended in this volume. The two sectional titles of the Holotricha and Hypotricha introduced by Stein are made by this author to include all his recognized representatives of the Amastiga or Ciliata. A considerable number of new generic names, established some with, and some without, substantial grounds, were, as hereafter frequently attested to, founded by Diesing on various of the older specific forms.

Here mention may be most appropriately made of the one complete book devoted to the organization of the Infusoria that had so far, or has since up to the publication of this present volume, issued from the British press. This work, 'A History of the Infusoria,' by Andrew Pritchard, which in the year 1861 arrived at its fourth enlarged and revised edition, the first appearing in the year 1834, can, however, in no way be cited as an independent treatise, it constituting merely an excellent and abbreviated transcript of the technical descriptions of all so-called infusorial forms published up to the year 1858, and included chiefly in the works of Ehrenberg, Perty, and Dujardin. The views of these and other contemporaneous authorities are fully enunciated, and the whole series of forms described made to amalgamate with the system of classification adopted by Ehrenberg in his 'Die Infusionsthierchen.' No original views, no trace of original research, nor any record of newly discovered species, are contained in this volume, which must therefore be considered rather as a compilation than as an independent work. As such, and in connection with the state of our knowledge at that time, its utility was unquestionable, and more especially to the general working microscopist, since its scope, corresponding with that of Ehrenberg's *opus magnum*, includes not only the Infusoria proper, but also the several entirely unrelated groups of the Diatomaceæ, Desmidiaceæ, Confervaceæ, and many Rhizopods, Radiolaria, and even Acari. It is scarcely to be wondered at that, placed in front of so vast and heterogeneous an assemblage of organic forms, the author should have called in extraneous assistance, and hence it is we find the names of J. T. Arlidge, W. Archer, J. Ralfs, and W. E. Williamson—all high authorities on one or other of the several groups separate from the true Infusoria—associated as coadjutors in the fourth edition of Mr. Pritchard's work.

Stein's second volume, issued, as already mentioned, in the year 1867, constitutes a monograph of the Heterotrichous order of the Ciliata, and forms a worthy companion to the one previously published, the series of types included in this section being delineated and described with an accuracy and exhaustiveness of detail hitherto unapproached. This monograph embodies, in addition to the above-mentioned more special subject-matter, data of the highest importance concerning the general organization and reproductive phenomena of the Infusoria, and is also notable for containing a formal abandonment, with some slight reservation, of his original theory associated with the *Acinetæ*, and acknowledgment of the claim of these animalcules to the independent position assigned to them by Claparède and Lachmann. This reservation, as above intimated, was manifested by Stein's continued adhesion to the opinion that certain infusorial types, e. g. *Stentor*, *Stylonychia*, and *Urostyla*, commenced their existence within the parent body as minute ovate or subspheroidal embryos, with or without cilia, and possessing in addition a greater or less number of retractile tentaculiform appendages corresponding with those of the ordinary Acinetæ. These supposed embryos of the associated Ciliata are, however, now shown to be minute parasites, referable chiefly to Claparède and Lachmann's genus *Sphærophrya*.

The following year (1868) commands a conspicuous position in the bibliography of the present subject, through its association with the discovery by Professor H. James-Clark, of the Agricultural College of Pennsylvania, U.S.A., of certain Flagellate Infusoria exhibiting an entirely new type of structure, accompanied by his simultaneous announcement that all sponges consist essentially of colonial aggregations of similar Flagellate animalcules. Three years later, 1871, the present author had the good fortune to encounter the greater portion of H. James-Clark's types, and several new but closely allied forms, upon this side of the Atlantic, and having since selected this group as the subject of special attention, has so augmented its original numbers and demonstrated their distinctive features as compared with the more ordinary Flagellata, as to have felt justified in establishing for them a new order, upon which it is here proposed to bestow the title of the Choano-Flagellata. Pursuing the path indicated by Professor Clark with reference to the structure and zoological position of the sponges, the result of the author's investigations has, as recorded in the chapter hereafter devoted to this special subject, been the accumulation of additional data of the most substantial character in support of the previously suggested affinities.

Among the numerous contributors towards a more extended knowledge of the Infusoria as yet unreferred to, may be mentioned, more especially in association with the Ciliata, the names of Wrzesniowski, Richard Greeff, and Edouard Everts, and with the Flagellata, that of L. Cienkowski. Among the former Greeff is exceptionally prominent, he being led, through his discovery in the Vorticellidæ of a more complex pharyngeal apparatus and muscular system—hereafter described—than had hitherto been attributed to them, to adopt a Cœlenterate interpretation of infusorial structure closely identical with that first enunciated by Claparède and Lachmann. Cienkowski's investigations are especially interesting, as being productive of a masterly account of the structure and developmental history of *Noctiluca*, which is definitely shown by him to be intimately related to the more ordinary Flagellata.

Associated with those that take a prominent position within the present decade as expositors of the structure and affinities of the Infusoria, Professor Ernst Haeckel's name is eminently noteworthy. In his admirable essay, "Zur Morphologie der Infusorien," published in the 'Jenaische Zeitschrift,' Bd. vii. Heft 4, for the year 1873, this gifted biologist brings forward, beyond question, the most powerful evidence in support of the unicellular composition of these protozoic organisms adduced since the first conception of the theory by Carl von Siebold, in the year 1845. The lucid exposition given by him of the general morphology, reproduction, and developmental aspects of the higher Infusoria, may be further said to constitute one of the most complete accounts of this interesting group yet produced. It must be noted here, however, that Professor Haeckel in his essay admits to the rank of true Infusoria those representatives of the class only that are here collated under the title of the Ciliata, the equally or even more abundant and important class of the Flagellata being dismissed as containing an association of doubtful forms, chiefly referable to the vegetable kingdom. The great progress that has been made since the date of this essay in our knowledge of the last-named group will no doubt, however, exert its influence, and reconcile Professor Haeckel to its occupation of a position in the animal scale contiguous to that conceded in his earlier classificatory systems to the Ciliata.

Comparatively insignificant as has hitherto been the sum of contributions to our knowledge of infusorial life and structure by English investigators, and as is conspicuously evidenced on reference to the Bibliographical list appended to this volume, a brilliant exception is furnished in connection with the names of Messrs. W. H. Dallinger and J. Drysdale, whose joint investigations are recorded in various numbers of the 'Microscopical Journal' extending through the years 1873 to 1875. The chief interest and value attached to the results achieved by these joint workers is accomplished through their having struck upon and most successfully followed up an entirely new channel of discovery. Employing the highest and most perfectly constructed modern powers of the compound microscope, and concentrating upon their task an amount of energy and patience scarcely before equalled, Messrs. Dallinger and Drysdale directed their attention to unravelling the mystery so long associated with the inconceivably rapid production of low flagellate organisms or monads in organic infusions, and more especially such as are so abundantly produced in fish macerations. Taking turn by turn at the microscope, and patiently watching the same forms from hour to hour and day to day, the entire life-history of numerous species of these most minute organisms was now revealed for the first time. Not only was it found that these animalcules increased to an indefinite extent by the familiar phenomena of longitudinal and transverse fission, but also that under certain conditions two or even more individuals of the same species would become intimately united, the result of this fusion or coalescence being the formation of encystments, whose contents broke up into a greater or less number of spore-like bodies, which speedily developed into the parent type. In some cases these reproductive spores were so excessively minute as to defy individual detection under a magnifying power of no less than 15,000 linear, their presence being indicated only by their presenting as they escaped *en masse* from the investing envelope the aspect of a fluid possessing a slightly higher refractive index than the surrounding water. The power to withstand great vicissitudes of temperature—in some cases even up to and beyond boiling point, and *pari passu* the practical indestructibility of these monad spores—was also proved by these investigators; the facts elicited as a whole, affording some of the most important evidence yet educed towards the solution of the much-vexed question of spontaneous generation, and in demonstration of the dominance of the inexorable law of "like begetting like" among even these most minute and humble members of the organic world. The special bearing of Messrs. Dallinger and Drysdale's evidence upon these highly interesting points receives extensive notice in a future chapter.

Among the more recent literary productions bearing upon the subject of the Infusoria, brief allusion must be here made to the 'Études sur les Microzoaires ou Infusoires proprement dits,' published by E. de Fromentel in the year 1876. The expectations raised by a first glance at this portly volume and its thirty quarto plates receive a somewhat severe shock on proceeding to a more intimate acquaintance. This writer is apparently entirely ignorant of the work achieved in the same field by Stein, Engelmann, and other modern German investigators, their names not being so much as mentioned throughout the whole course of his treatise. With scarcely an exception, his entire series of diagnoses of the innumerable forms, new and old, are so vague and indefinite as to be scarcely in advance of the necessarily incomplete ones given last century by O. F. Müller, while the numerous figures accompanying these descriptions will in most instances scarcely compare favourably with those handed down to us by Perty and Dujardin. Taken as a whole, it is but too evident that De Fromentel's volume is published prematurely, the author possessing but the most superficial acquaintance with his subject. As a consequence, and notwithstanding the fact that many new forms of high interest are embodied in his volume, the reader closes De Fromentel's book regretting the fine opportunity lost and that so much valuable space and expenditure of time should have been bestowed upon a work so inadequately representing our present comparatively advanced knowledge of infusorial morphology.

A few names only are now wanting to conclude this list. With the exception of Stein's most recently issued volume, 'Der Organismus der Infusionsthiere,' Abth. iii. Heft 1, 1878, containing a general account of the Flagellata, with twenty-four magnificently executed plates—referred to at length in the introductory portion of Chapter VII., no works of primary importance remain to be enumerated. At the same time various authorities, through the exhaustive investigation of special representatives of the infusorial world, have considerably extended our knowledge and appreciation of the structure and affinities of the group as a whole, contributing largely towards the establishment of that solid basis of practical evidence from whence future exploration must depart. Hertwig, Bütschli, Sterki, Ernst Zeller, Wrzesniowski, Mereschkowsky, and C. Robin are more especially deserving of mention in this last-named category, their respective publications receiving due notice in both the subsequent Bibliographic list and in association with the systematic descriptions of those specific types that formed the more immediate subject of their investigation.

This chapter may be concluded with the citation of one other prominent and most worthy name. John Tyndall, the talented physicist and contributor to the 'Philosophical Transactions' for the years 1876 and 1877 of two most important papers treating upon the optical deportment of the atmosphere in relation to the phenomena of putrefaction, and upon the vital persistence of putrefactive and infective organisms, has beyond question, through his most carefully conducted experiments and philosophic deductions, as hereafter reported *in extenso*, furnished some of the most crucial evidence yet adduced towards the subversion of the now well-nigh abandoned doctrine of Heterogeny, or, in other words, the production of Infusoria and other lowly organized animal and vegetable types out of inorganic elements.

CHAPTER II.

THE SUB-KINGDOM PROTOZOA.

THE contents of the preceding chapter constitute a brief chronological summary of the more important advances gained in our knowledge of the Infusoria from the date of their first discovery by Leeuwenhoek up to the present time. A comprehensive survey of the organization and affinities of the members of this zoological group, as illumined by the light of recent research, has now to be proceeded with.

As an *initial step* in this direction, a short space must, however, be first devoted to a consideration of that larger subdivision of the animal kingdom, of which as a whole the Infusoria are most generally and here definitively accepted as a constituent group or groups. This subdivision, the Protozoa of Von Siebold, or Archezoa of Max Perty, has undergone much modification at the hands of biologists since its first institution in the year 1845. Great diversity of opinion exists, even at the present day, with respect to the delimitations both of its own borders and those of the minor sections and orders into which it may be most conveniently and naturally subdivided. As here accepted, the sub-kingdom Protozoa may be defined as embracing all those forms of life referable to the lowest grade of the animal kingdom, whose members are for the most part represented by organisms possessing the histologic value only of a single cell, or of a congeries or colonial aggregation of similar independent unicellular beings. In such cases as *Opalina* and other multinucleate forms, in which from the compound character of the nuclear or endoplastic element the organism would appear to be composed of several cells, these cells are indistinguishably fused with each other, and have not allocated to them separate functions or properties as in all more highly organized multicellular animals or Metazoa.

The essential body-substance of all Protozoa consists of apparently homogeneous, or more or less conspicuously granular, slime-like sarcode or protoplasm, all organs of locomotion or prehension consisting of simple or variously modified prolongations of this element. The food-substances ingested by the Protozoa may be incepted by a single well-defined oral orifice or cytostome, or there may be a plurality of such apertures. Among the Rhizopoda and many Flagellata, on the other hand, such material may be indefinitely received at any point of the periphery, while in yet a fourth series, chiefly endoparasitic—such as the Opalinidæ—there is no oral aperture, definite or distributed, the zooid absorbing through the surface of its integument the nutritious liquid pabulum in which it is constantly immersed. In their development the Protozoa exhibit a tendency to increase chiefly by the process of binary subdivision or gemmation, or through the breaking up of the entire body into a number of sporular elements, which may or may not be preceded by the conjugation or zygosis of two or more individual zooids or units. No sexual elements developed separately, and corresponding with the ova or spermatozoa of higher animals, occur among the Protozoa, and in no case is there associated with the developmental phenomena of this sub-kingdom the formation of a multicellular germinal layer or blastoderm, the fundamental origin and groundwork of all tissue structures in the more highly organized animal groups or Metazoa.

The earliest subdivision of the Protozoa into secondary sections or orders as initiated by Von Siebold partook, as related in the preceding chapter, of the simplest possible character. All the types then known were separated by this author into the two subordinate groups of the Rhizopoda and Infusoria, the former characterized by the pseudopodous, and the latter by the ciliate or flagelliform character of the locomotive appendages. Correlated with the systems of the present day, this proposed primary subdivision of the Protozoa still finds many advocates, an identical plan, though in different wording, being indeed adopted by Professor Huxley in his 'Anatomy of Invertebrated Animals,' 1878, p. 76, and in which it is suggested that all Protozoa may be conveniently distinguished as Myxopods and Mastigopods. These two correspond so precisely and respectively, with reference to their locomotive appendages, with the Rhizopoda and Infusoria as instituted by Von Siebold, that but little advantage is to be gained apparently by the proposed exchange. With reference to the latter of these two terms, it is further worthy of remark that it coincides to a considerable extent, in both sound and the sense implied, with the Mastigophora of R. M. Diesing.

Following out the further subdivision of the two foregoing primary sections of the Protozoa into secondary groups or orders which has up to the present time found most extensive support, the first—that of the Rhizopoda, or Myxopoda—is found to include the Amœbina, Foraminifera, and Radiolaria, while the second—that of the Infusoria, or Mastigopoda—embraces in a similar manner, and in accordance more especially with the classification-scheme introduced byMessrs. Claparède and Lachmann, the four orders of the Ciliata, Cilio-Flagellata, Flagellata, and Suctoria. For this last group—that of the Suctoria—Professor Huxley has proposed to substitute the very appropriate title of the Tentaculifera, recent investigation having shown that the more customary suctorial organs may be replaced by simply prehensile and non-suctorial tentacles. By some, the small endoparasitic group of the Gregarinidæ is reckoned to constitute a third and distinct class of the Protozoa, but it is evident that we have here a degraded group of the ordinary Rhizopoda most nearly allied to the Amœbina, which exhibit a like modification of structure with relation to the latter as is presented by the Opalinidæ with respect to the ordinary Ciliata. The much-vexed question of the zoological position and affinities of the Spongida or Porifera has necessarily to be considered in association with the delimitation of the sub-kingdom Protozoa. Formerly the members of this important section were regarded mostly as forming either a subordinate group of the Rhizopoda, or an independent class of the Protozoa. More recently, however, there has been a tendency to exclude the sponges entirely from the Protozoic sub-kingdom, and to assign to them a position more nearly approximating that of the Cœlenterata, or zoophytes and corals, among the more highly organized tissue-constructed animals or Metazoa. Professor Ernst Haeckel, the most powerful supporter and also the originator of this proposed innovation, has based his arguments in favour of such transfer chiefly upon his own peculiar interpretation of the structure and developmental phenomena of those bodies, the swarm-gemmules or so-called ciliated larvæ, hereafter described, by which the local distribution of special sponge species is periodically effected. Taking on trust this developmental interpretation of Ernst Haeckel, many leading biologists have committed themselves to a similar exclusion of the Spongida from the Protozoa, and it is thus that in Professor Huxley's recently quoted work—which must be accepted as the latest and most important exposition of Invertebrate anatomy in this country—a like allocation of this much-debated group to the Metazoic section of the animal kingdom is upheld. Postponing for a future chapter a complete summary of the grounds upon which an interpretation entirely opposed to that advocated by Professor Haeckel is adopted in this volume, it will suffice for present purposes to state that a considerable interval devoted to a careful investigation of the structural and developmental phenomena of the sponges and Protozoa generally has resulted in the arrival by the present author at the opinion that—(1) these phenomena accord essentially and entirely with those presented by the typical Protozoa ; (2) that there is no formation of a germinal layer or true tissue structure in any period of their development ; and (3) that the position of the Spongida among the Protozoa is most nearly allied to that Infusorial group here distinguished by the title of the Choano-Flagellata, and out of which, by the process of evolution, there is substantial reason to presume they were primarily derived.

Proceeding with the consideration of the subdivision of the Protozoa into subordinate classes and orders, it has been further found, in association with the investigations above referred to, that the older and primary groups of the Rhizopoda and Infusoria, or of the Myxopoda and Mastigopoda, as more recently proposed, by no means allow of as clear and natural a grouping of their various orders as it is possible to submit, while it is still less efficacious for the indication of the many complex affinities that undoubtedly subsist between one and another, or, as it is often found, between one and many of these orders. The inadequacy of the several systems hitherto proposed for the fulfilment of these last-named requirements, as also an outline of one closely corresponding with that here introduced, were respectively recognized and provided for by the author in association with the paper entitled 'A Monograph of the Gymnozoidal Discostomatous Flagellata, with a Proposed New Scheme of Classification of the Protozoa,' communicated to the Linnæan Society on the 21st of June, 1877, and referred to at some length in the 'Annals and Magazine of Natural History' for January 1878.* In accordance with the scheme then proposed, and as now submitted in its more extended form with certain amendments, the fundamental basis upon which the subdivision of the Protozoa into primary groups or sections is founded, bears relation not so much to the varied character of the locomotive or prehensile appendages possessed by the representatives of this sub-kingdom as to the nature of the oral apparatus or systems subordinated to the function of food-ingestion. Comparing small things with great, this morphological element yields indeed as convenient and sound a basis for taxinomical diagnosis as is afforded by the oral systems of the higher Invertebrata or the dental formulæ of the mammalian class.

Following out this newly proposed plan of subdivision, it will be found that the entire series of the sub-kingdom Protozoa range themselves into four natural and readily distinguished groups or sections. In the first, most lowly organized, and with reference to its subordinate subdivisions or orders most numerically abundant of these several groups, an oral orifice in the literal sense of the term has no existence, food being incepted indifferently at any point of the periphery or general surface of the body. This most simple or elementary type of structure of the Protozoa is best illustrated by such familiar examples as *Amœba* and *Actinophrys*, the various representatives of the Foraminifera, and certain Flagellata such as *Spumella* and *Anthophysa*. For the distinction of these most simply organized forms, characterized by the indefinite or generally diffused character of their oral or introceptive area, the divisional title of the PANTOSTOMATA is here adopted in place of that of the Holostomata originally proposed in the earlier communications by the present author as above mentioned. This latter term, while scarcely conveying the sense intended, possesses the disadvantage of having been previously employed for the distinction of a group of the Mollusca. Next in the ascending scale a group of the Protozoa is met with, in which though differentiation has not proceeded so far as to arrive at the constitution of a distinct oral aperture, the inception of food-substances is limited to a discoidal area occupying the anterior extremity of the body, and is associated with the special food-arresting apparatus described in detail later on. To this section of the Protozoa are naturally relegated all the minute collar-bearing flagellate animalcules first discovered by Professor H. James-Clark, of which so

* Mr. Saville Kent, "Observations upon Professor Ernst Haeckel's Group of the Physemaria and on the Affinities of the Sponges."

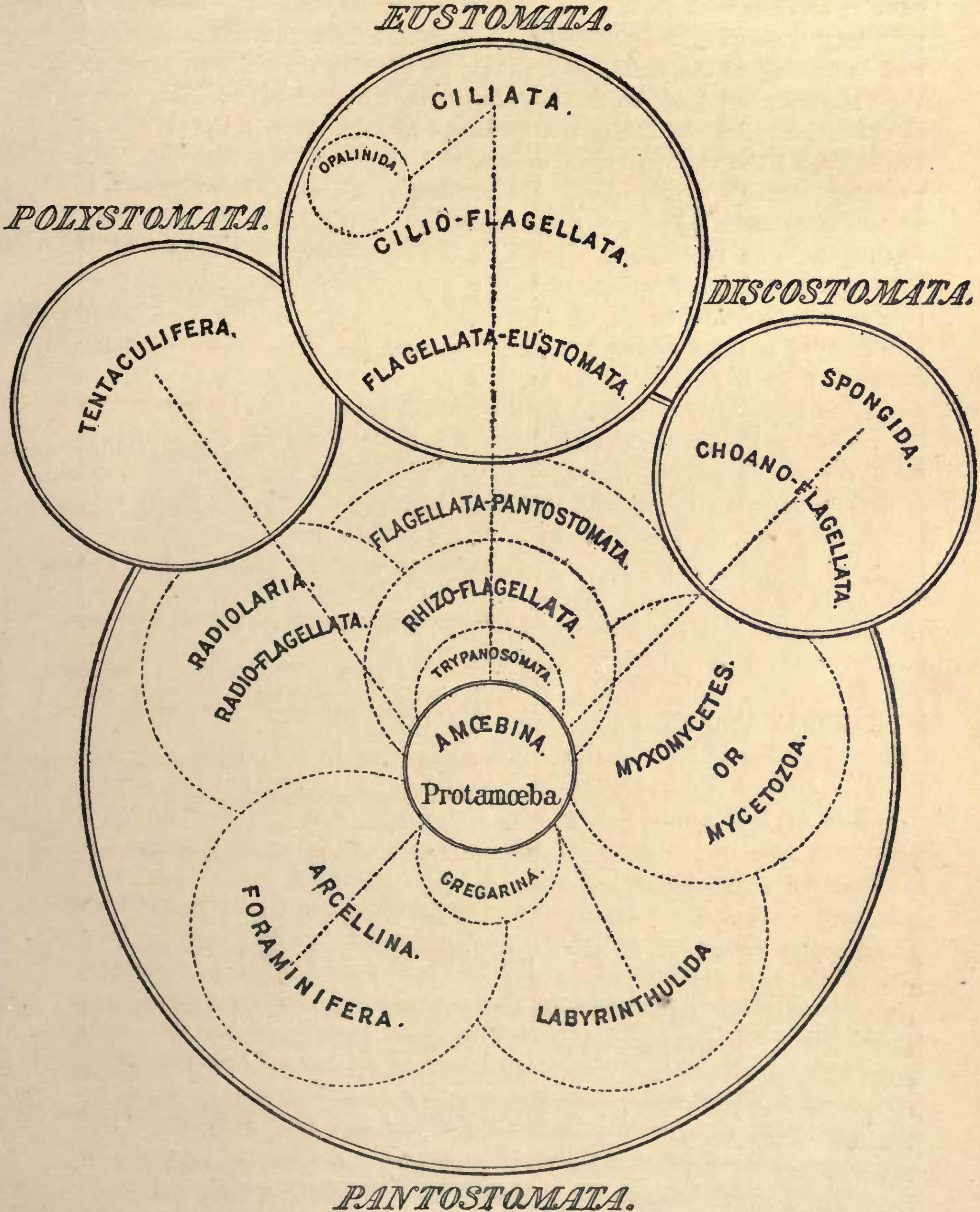
many new species are figured and described in this volume, and also the entire assemblage of the sponges or Porifera. For this group, and with reference to the characteristic discoidal configuration of the introceptive area, the title of the DISCOSTOMATA, as previously proposed, is still retained. In the third section of the Protozoa, as here defined, the highest degree of organization is arrived at. Here alone, and for the first time, a single simple or often highly differentiated oral aperture or *true mouth* is met with, for which reason the group appropriately commands the title of the EUSTOMATA. Associated with this section are found the majority of those organisms that collectively constitute the class Infusoria in the more modern acceptation of the term, it embracing the majority of the Ciliata, the Cilio-Flagellata, and such Flagellata as *Euglena* and *Chilomonas*, in which the presence of a distinct and circumscribed oral aperture has been clearly demonstrated. With the fourth and remaining natural Protozoic section, the oral or inceptive apparatus exhibits a remarkable and highly characteristic structural modification. This is not, as in the preceding groups, restricted to a definite area, nor is it associated indefinitely with the entire general surface of the creature's body. In place of this, a variable and usually considerable number of flexible retractile tentacle-like organs radiate from diverse irregularly disposed or definite regions of the periphery, each of which subserves as a tubular sucking-mouth, or for the purposes of grasping food. The representatives of this section, including the so-called suctorial animalcules of Claparède and Lachmann, or Tentaculifera of Professor Huxley, may be literally described as many-mouthed, and appropriately designated the POLYSTOMATA.

A tabular view of these four sections of the Protozoa as above defined, with their included classes, orders, and characteristic genera, is herewith annexed. Upon examining this table it will be apparent that the *secondary* subdivisions or classes of the Protozoa, as therein defined, by no means coincide precisely with those more comprehensive and fundamental sections or groups into which the sub-kingdom may, as just proposed, be *primarily* divided. Thus, within the section of the Pantostomata are found comprised the whole of the class Rhizopoda, and a portion only of the Flagellata. The remainder of this last-named class falls partly within the section of the Discostomata, which so far as known includes Flagelliferous Protozoa only, and partly within the more highly differentiated group of the Eustomata; while within the boundaries of the latter section are included, in addition to the Stomatode Flagellata, the entire class of the Ciliata. It is in point of fact altogether impossible in any such arbitrary and necessarily artificial, lineally arranged table to adequately and intelligibly illustrate the innumerable cross-relationships or lines of evolution that undoubtedly connect these various orders and classes with one another. The special diagrammatic scheme given on the page succeeding that of the tabular view, has therefore been constructed by the writer with the purpose of as far as possible indicating, with the following explanation, the more obvious of these affinities :—

Tabular View of the Sections, Classes, Orders, and Typical Genera of the Sub-Kingdom PROTOZOA.

Sections.	Classes.	Orders.	Genera.
A. PANTOSTOMATA. Ingestive area diffuse.	I. Rhizopoda. Appendages pseudopodic, lobate or radiate.	1. Amœbina	*Amœba.*
		2. Gregarinida	*Gregarina.*
		3. Arcellinida..	*Gromia, Arcella.*
		4. Foraminifera	*Rotalia, Nummulina.*
		5. Labyrinthulida	*Labyrinthula.*
		6. Radiolaria	*Actinophrys, Collosphæra.*
	II. Flagellata. Appendages flagelliform.	7. Mycetozoa	*Æthalium, Didymium.*
		8. Trypanosomata	*Trypanosoma.*
		9. Rhizo-Flagellata	*Mastigamœba, Podostoma.*
		10. Radio-Flagellata	*Actinomonas, Euchitonia.*
		11. Flagellata-Pantostomata ..	*Spumella, Anthophysa.*
B. DISCOSTOMATA. Ingestive area discoidal, not constituting a distinct mouth.		12. Choano-Flagellata .. .. (vel Discostomata-Gymnozoida)	*Codosiga, Salpingœca, Protospongia.*
		13. Spongida .. .. (vel Discostomata-Cryptozoida)	*Halisarca, Grantia, Spongilla.*
C. EUSTOMATA. Ingestive area taking the form of a single distinct mouth.		14. Flagellata-Eustomata ..	*Euglena, Noctiluca.*
		15. Cilio-Flagellata	*Peridinium, Heteromastix.*
	III. Ciliata. Appendages ciliate.	16. Holotricha	*Paramecium.*
		17. Heterotricha	*Stentor, Spirostomum.*
		18. Hypotricha	*Euplotes, Oxytricha.*
		19. Peritricha	*Vorticella, Ophrydium.*
D. POLYSTOMATA. Ingestive areas distinct and multiple.	IV. Tentaculifera. Appendages tentaculate.	20. Actinaria	*Ephelota.*
		21. Suctoria	*Acineta, Dendrosoma.*

DIAGRAMMATIC SCHEME :—Showing Relationships, and presumed Phylogeny, or Lines of Evolution, of Sections, Classes, and Orders of the Sub-kingdom Protozoa.



Referring to the foregoing diagrammatic scheme, it will be observed that the four primary sections of the PANTOSTOMATA, DISCOSTOMATA, POLYSTOMATA, and EUSTOMATA, including their more important classes and orders as embodied in the preceding table, are circumscribed by a broader and double circular line. Making use of a convenient metaphor, these circular sections with their varied contents may be compared to so many planetary systems or constellations, all derivable from one common centre and indicating at the points where their peripheries are made to intersect, their mutual relationship to, and interdependence on each other. The centre of the entire series and common source from whence, through the process of evolution, all the various types, orders, and classes of the Protozoa have probably through a more or less extensive epoch of time developed, is undoubtedly to be found among the most simply organized Pantostomata, finding there its typical embodiment in the amœban order, the hypothetic primeval ancestor of which may, for convenience' sake, appropriately receive the generic name of *Protamœba*. Accepting this last-named generic type as the common basis for departure, the dotted lines radiating outwards from it exhibit, so far as it is possible to predicate, the various directions apparently traversed by the several phylogenetic lines or tracks of evolution before their arrival at the more complex and outlying members of the series. Selecting that phylogenetic line connecting the central or amœban group with the most highly differentiated Eustomata typified by the class Ciliata, as a first example in illustration of this proposed scheme, the following explanation may be submitted. The first cycle of development in this direction, exhibiting a transition from the Rhizopodal or Myxopodous towards the Flagelliform or Mastigopodous structural type, is evidently embodied in the group or order of the Trypanosomata. An *Amœba* flapping through the water, or other inhabited fluid, through the medium of a flattened, crest-like and undulating extension of its lateral margin, constitutes to all intents and purposes a representative *Trypanosoma*. Although among the few known members of this series a flagellate appendage is not as yet perfectly developed, such organ may be said to exist in its most pristine and rudimentary condition in the tag-like prolongation of one extremity of the body that constitutes so important a characteristic of the species *Trypanosoma sanguinis*, as more recently figured by Professor E. Ray Lankester, and reproduced in Pl. I. Figs. 1 and 2 of this volume. The lateral crest-like extension which represents the most prominent characteristic of this order, carries with it an equally, if not still more important significance. A similar structure associated with the title of an undulating crest or membrane, is constantly recurring among the more highly organized groups of both the Flagellate and Ciliate Protozoa, and undoubtedly takes its origin from this source. As illustrations in this direction, reference may be made to the supplementary undulating membranes that form a permanent characteristic of certain species of the genera *Trichomonas*, *Hexamita*, and *Conchonema*, among the Flagellata; and of

Lembus, Condylostoma, and *Spirochona*, among the Ciliate class of the Protozoa. Furthermore, as recorded by the author in the systematic portion of this treatise, the characteristic adoral fringe of certain higher Ciliata, such as *Stentor* and *Euplotes*, is developed through the splitting up of a similar primary undulating membrane.

In the next cycle of advance, as exemplified in the order of the Rhizo-Flagellata, the several genera, *Mastigamœba, Rhizomonas*, and *Podostoma*, while retaining the general characteristics of repent or floating *Amœbæ*, have superadded a distinct flagellum, and undoubtedly constitute the root-forms of several leading sections of the Protozoa hereafter referred to. The retraction of the pseudopodic processes of the Rhizo-Flagellata, with the retention of the flagellum and capacity to incept food at any point of the periphery, is alone required to perfect the passage to the next succeeding order, that of Flagellata-Pantostomata. In this group we find a considerable diversity in the number and character of the flagellate appendages, this organ being single in such simple types as *Monas* and *Bodo*, double in *Spumella* and *Anthophysa*, while in others such as *Tetramitus, Hexamita*, and *Lophomonas*, the number is very considerably increased. It is among the Polymastigous section of this order, somewhere near *Lophomonas*, that the remarkable compound marine type *Magosphæra planula*, Pl. I. Figs. 12–17, upon which Professor Haeckel has proposed to found a new class group entitled the Catallacta, should apparently be placed. A special feature of *Magosphæra*, as described by Haeckel, is exhibited by its tendency to revert to a repent amœboid phase pending the process of encystment and reproduction. A similar disposition is, however, as hereafter shown, shared by the majority of the Pantostomata.

In proceeding to the next group or order in the direct line of evolution, the boundary line that circumscribes the class of the Pantostomata is necessarily traversed, and the associated forms, while still characterized by the possession of one or more flagellate appendages, exhibit their higher grade of organization through the development of a well-defined oral aperture. This order, upon which is here conferred the title of the Flagellata-Eustomata, embraces among its more familiar genera the types *Euglena, Astasia, Noctiluca*, and *Anisonema*. The interesting order of the Cilio-Flagellata, including chiefly the Peridiniidæ and a few aberrant forms such as *Heteromastix* and *Mallomonas*, are alone wanting to make the phylogenetic line from Amœba to the most highly specialized class of the Protozoa, that of the typical Ciliata, entirely complete. Arriving at the termination of this evolutionary line or phylum, it is requisite to make a passing reference only to the group of the Opalinidæ, which, although possessing no oral aperture, are plainly retrograde forms of Holotrichous Ciliata, exhibiting, by reason of their endoparasitic habits, a similar loss of this otherwise essential organ of nutrition as obtains in the corresponding parasitic Cestoidea among the Annelidous, or the Rhizocephala among the Crustaceous sections of the Invertebrata.

Returning once more to the Amœbina, and following out the line that terminates in the Tentaculifera, the first important divergence from the preceding track is encountered on arriving at the newly instituted order of the Radio-Flagellata. This small group, to which at present are referred the four genera, *Actinomonas*, *Spongocyclia*, *Spongasteriscus*, and *Euchitonia*, may be said to retain the same relationship with respect to the ordinary Radiolaria as subsists between the Rhizo-Flagellata and various other orders of the Pantostomata. In the form *Actinomonas*, figured and described for the first time in this volume, Pl. I. Figs. 7, 8, and 18, the permanent possession of a terminal vibratile flagellum alone distinguishes it from a stalked Heliozoidal Radiolarian such as *Actinolophus* in its naked phase, and with which type it was presumed at first sight to be identical. Inversely, it needs only the withdrawal of the radiating pseudopodia, with the retention of the flagellum, to produce the Pantostomatous Flagellate genus *Oikomonas*. The primary derivation of the entire Radiolarian order from the Flagelliferous section of the Pantostomata is clearly indicated in association with the embryonic conditions of its representatives, and all of which, so far as at present known, exhibit a Pantostomatous Flagellate structure. The direct metamorphosis of such a simple flagellate zooid into the Radiolarian type *Actinophrys*, as recently observed by the author, will be found recorded in the systematic description of the Radio-Flagellata, and is illustrated at Pl. I. Figs. 9–11.

The passage from the extensive group of the Radiolaria with its subsections of the Heliozoa, Monocyttaria, and Polycyttaria, onward to the Tentaculifera, appears at first sight to be somewhat obscure. As shown, however, in the chapter devoted specially to their description, the Tentaculifera, as now known, form among themselves two natural subordinate groups or orders: the one, that of the Suctoria, being distinguished by the sucker-like form and function of the radiating tentacles; while in the other, that of the Actinaria, these appendages closely resemble ordinary pseudopodia, being simply adhesive, and in some instances, e. g. *Ephelota*, invertile. The transition from the Radiolaria to the Tentaculifera is apparently accomplished through this last-named group, such types as *Zooteira* and *Actinolophus* on the one hand, and *Ephelota* and *Actinocyathus* on the other, representing the most conspicuous connecting forms. The Tentaculifera, in their highest phase of development, exhibit several noteworthy peculiarities. The embryos do not, as with most Radiolaria, take a flagelliferous or monadiform contour, but are, while mouthless, more or less thickly ciliate. The ciliation in the different genera and species, moreover, varies considerably, the several more important deviations in this respect exhibiting a remarkable conformity with the three types of ciliation that characterize the three leading orders of the ordinary Ciliata, as distinguished by the respective titles of the Holotricha, Hypotricha, and Peritricha. On account of this last-named circumstance, it may be reasonably inferred that some genetic relationship subsists between the two sections of the Polystomata and Eustomata, this probable affinity being indicated in the accompanying diagrammatic plan by the intersection of the circles enclosing the respective groups. A speculation as to the possible affinities of the Tentaculifera in a totally independent direction is recorded in the chapter devoted more especially to the general organization of the Infusoria.

The line of evolution or phylogeny from the Amœbina to the Discostomatous class of the Protozoa, remains to be traced. The direct relationship of the highest and most complex factor in this section, that of the Spongida, to the more simple Choano-Flagellata, as illustrated by the genera *Codosiga*, *Salpingœca*, and other recently discovered types, is, as explained in Chapter V., devoted to the organization of the sponges, too obvious to need extensive comment here. As there demonstrated, the representatives of this last-named organic group can be regarded only as specialized, colonial stocks of similar collar-bearing Flagellata living immersed within a channelled and collectively exuded common gelatinous matrix or cytoblastema, and whose substance is more usually strengthened by calcareous or siliceous spicula, or a network of horny matter. As demonstrated by the present author in the chapter cited, the separate zooids or units of both the Spongida and simpler Choano-Flagellata exhibit in their developmental phenomena the closest possible affinity. These originate chiefly in either case from mouthless monadiform flagellate germs, thus exhibiting their phylogenetic relationship with the Pantostomatous Flagellata, while the adult zooids revert at will to the condition of either Rhizo-Flagellata or simple *Amœbæ*. In certain species of *Salpingœca*, as hereafter described, e. g. *S. amphoridium*, new zooids are shown to originate as amœbiform gemmules separated by division from the parent animalcule, thus completing the retracement of the line to the central or primitive ancestral stock.

In the foregoing diagrammatic scheme the line of evolution of the Spongida is made to abut upon or traverse the group of the Myxomycetes or Mycetozoa. The reasons for adopting this course require brief explanation. Formerly, and by some even yet regarded as a low order of fungi, or as a special group of organisms intermediate between animals and plants, which exhibit at one epoch of their life all the vital characteristics of the former, and at another those of the latter kingdom, their admission into the Protozoic galaxy or system will no doubt encounter objection. The evidence most recently and independently eliminated by L. Cienkowski * and Dr. A. de Bary,† concerning the structure and life-history of this most remarkable group, establishes, however, beyond question their purely animal nature. The Mycetozoa, in common with all ordinary representatives of the Protozoa, originate from minute sporuloid bodies which escape from the spore case as monadiform animalcules having a soft, plastic body-substance, a single terminal flagellum, contractile vesicle, and endoplast

* L. Cienkowski, "Zur Entwickelungsgeschichte der Myxomyceten." Pringsheim's Jahrbücher, Bd. iii., Hft. 2 and 3, 1862.

† A. de Bary, 'Die Mycetozoen. Ein Beitrag zur Kenntniss der Niedersten Organismen.' Leipzig, 1864.

or nucleus, being thus in no way distinguishable from the typical representatives of the ordinary Flagellata-Pantostomata, as met with in the genus *Monas*. By-and-by these monadiform zooids become more sluggish, subside to the bottom of the inhabited fluid medium, and for a while retaining their flagella, creep about after the manner of a *Mastigamœba*, incepting in the same way solid food-particles at any point of the periphery. The zooids in this condition may be said to represent the adult form of the Rhizo-Flagellata. Sooner or later the flagella are withdrawn, and an entirely amœboid condition is assumed. These amœboid zooids, encountering their fellows in the course of their wanderings, at once coalesce with them, and form at length by their amalgamated numbers and increase of size through the incessant increment of food, those conspicuously large masses of gelatinous consistence, characteristic of the so-called animal phase of the Myxomycetan, technically known as the "plasmodium." This plasmodium, exhibiting diverse forms in various species, may be found creeping over wet tan, rotten wood, or decaying leaves in the similitude of a colossal Amœba, or, taking a reticulate form, spreads itself over the surface of these substances, and presents under such conditions the aspect of the mycelia of various fungi. Examined with the microscope, all trace of the multicellular or multizooidal origin of the plasmodium is found to have disappeared, the entire mass exhibiting the character of homogeneous granular sarcode. A greater or less number of rhythmically pulsating contractile vesicles are discernible at various points, and a distinct circulatory motion or cyclosis of the granular plasma, sometimes in a single and sometimes in contrary directions, is exhibited within the deeper substance of the plasmodium. This phenomenon of cyclosis is most readily observed in those forms, like *Didymium serpula*, in which the plasmodium assumes a reticulate or much ramified mycelium-like outline, the motile currents of sarcode under such conditions closely corresponding with those common to the pseudopodic reticulations and ramifications of the Foraminifera and Labyrinthulina. Following upon the plasmodium state, the highly characteristic so-called vegetable phase is now arrived at. In this condition animal vitality is apparently entirely suspended, the aspect being usually that of a minute Gasteromycetous fungus, mostly stalked, and with a spheroidal, ovate, or urn-shaped capitulum or sporangium. The outer wall of this capitulum is more or less coriaceous, and is found interiorly to be densely packed with spore-like bodies, mostly held together by a dense network of delicate anastomosing fibres of a horn-like consistence. By the dehiscence of a cup-like lid or the disintegration of the walls of the sporangium, the contained spores are eventually liberated and repeat the metamorphoses just described. It is upon the external likeness to certain fungi of the quiescent sporangia of the Myxomycetes, as developed from the plasmodium, that the arguments in favour of the vegetable nature of these singular organisms have been chiefly based.

From the foregoing brief recapitulation of the developmental history of this group it is evident, however, that we have here a quiescent or resting phase preceding sporular reproduction corresponding on a compound and enlarged scale with the simple encapsuled or sporocyst state of the more ordinary Protozoa known as encystment. In both the formation of the gigantic compound plasmodium and in the development therefrom of the characteristic sporangia, these Myxomycetes exhibit certain phenomena singularly suggestive of a more or less remote affinity with the sponges. In these latter also the initial term takes the form of spore-developed uniflagellate monads, which, uniting in social colonies, form a gelatinous mass corresponding closely with the plasmodial element of the former group. In the fine horny network usually contained with the spores within the sporangium developed by the mature plasmodium, a substance is produced singularly resembling the fine horn-like elements or keratose fibre of certain sponges, while, what is still more remarkable, in certain forms spicule-like bodies composed of carbonate of lime are also developed within the substance of the walls of the sporangium, or so-called "peridium," that accord substantially in outline with the stellate siliceous spicula of the Tetthyidæ and other familiar sponge-groups. In illustration of the apparent close approximation of the Mycetozoa to the Spongida and other flagellate Protozoa, as here presumed, the lower half of Plate XI. of this volume, with its accompanying descriptions, has been devoted to a reproduction of some of the more characteristic figures given by de Bary and Cienkowski in the works quoted, that would appear to substantially support the author's views.

Two or three orders of the Protozoa, included within the section of the Pantostomata and indicating apparently an independent derivation from the central ancestral stock, have yet to be mentioned. That of the Labyrinthulida, as typified in Cienkowski's genus *Labyrinthula*, exhibits in its normal and adult condition a more or less extensively ramified or reticulate sarcode expansion upon submerged objects, corresponding to a considerable degree with the finely branched plasmodia of certain of the Myxomycetes last described. This expansion, however, does not appear to be derived from, or to be associated at any date of its existence with flagelliferous zooids, while an additional element in the form of minute ovate or spindle-shaped bodies, travelling in the directions assumed by the characteristic currents of circulation or cyclosis, is to be observed. In this last-named feature the constituent sarcode exhibits a close correspondence with that of the test-inhabiting Foraminifera, and the natural position of the group, as indicated in the diagram, would appear to be midway between the latter order and that of the Myxomycetes. The derivation of the Foraminifera themselves from the Amœbina, through such types as *Arcella*, *Lieberkuhnia*, and *Gromia*, is too patent to require prolonged notice. Of the small supplementary group of the Gregarinidæ, it remains to be remarked that it exhibits a similar type of degradation or retrograde development in association with the Amœbina as is presented by the Opalinida with relation to the normal Ciliata. All pass an endoparasitic condition within the viscera of other animals, and derive their sustenance through the direct imbibition or endosmosis of the juices of the selected host through their cuticular surface.

While the foregoing sketch suffices to indicate the leading aspects and characteristics of the Protozoic sub-kingdom generally, and to explain the view of the derivation and affinities of the various orders adopted by the author of this volume, a few other points demand brief attention. Among these, reference has yet to be made to the undoubtedly close relationship which subsists between the lowest members of the Protozoic sub-kingdom and the unicellular members of the vegetable world, and to the opinions maintained in this direction by recent authorities of note. The difficulty of indicating a clear line of demarcation that shall arbitrarily separate certain unicellular cryptogamic plants or Protophyta from the unicellular animals or Protozoa, has long been recognized, and even at the present day cannot be said to have obtained its final solution. It is, indeed, scarcely to be anticipated that any such result should be arrived at, since here, as between many other arbitrarily defined so-called natural classes and subdivisions of the animal and vegetable worlds, modern discovery is unceasingly revealing the existence of intermediate forms that, filling up the pre-existing lacunæ, further demonstrate the harmonious continuity of the entire organic series. Taxonomy, or classification, through this consideration, is necessarily reduced to a purely empirical and constantly progressive status, to an artificial means for the demarcation of those boundaries or landmarks most clearly conspicuous to our appreciation, that system recommending itself most, and having the most lasting duration, whose foundations are established upon the most simple and natural basis.

Failing to eliminate such a natural or artificial boundary line as shall serve to decisively mark out the apparently intersecting zones of animal and vegetable life, one of the foremost biologists of the age, Professor Ernst Haeckel, has elected to establish yet a third kingdom of the organic world, to which he has relegated not only all dubious types, but also many concerning whose animal or vegetable nature not so much as a doubt exists. This proposed new organic kingdom, denominated by its founder the "Protista," is, with the exception of the Ciliata, Spongida, and Tentaculifera, made to include all the members of the Protozoa embraced in the previously submitted scheme, and in addition to these, the assemblage of undoubted vegetable organisms forming the tribe of the Diatomaceæ. This attempt to cut the Gordian knot by the interpellation of a third and intermediate kingdom, is by no means happy. Even if this latter possessed in itself the elements of stability, the difficulty would be in no ways lessened, but simply augmented, as there would be now two lines of demarcation, one between the Protista and vegetable forms, and the other between the Protista and the animal series, to be defined in place of the pre-existing single one. The Protista, however, as a group separate from both the animal and vegetable kingdoms, has no real existence, there not being, with the exception of the Diatomaceæ, a single family or generic type included in Haeckel's tabular view of his new kingdom that cannot with tolerable, if not absolute certainty, be referred to the former of these two sections.

As a subordinate group of the Protista, Professor Haeckel has further proposed to found the class of the "Monera" for the reception of all those types, externally corresponding with ordinary Rhizopoda and Radiolaria, in which as yet the possession of a distinct endoplast or nucleus has not been demonstrated, and which are consequently regarded by him as exhibiting an essentially lower type of structure. The progress of modern scientific discovery has, however, so curtailed the boundaries of this supposed *Moneran* class, that further exploration in the same direction bids fair to deprive its illustrious founder of all interest in it beyond that of an empty title. Up to a very recent date the members of the extensive and important order of the Foraminifera were presumed to exhibit this specially simple structural type, and were in consequence relegated by Haeckel to, and formed the most important constituent of, his class Monera. Following Haeckel's lead, such a position among the so-called Monera is allotted to the Foraminifera in Professor Huxley's 'Anatomy of the Invertebrata,' though in a supplement to the same work (p. 658), the discovery of distinct nuclei in many genera of this order by the independent investigations of Schultze and Bütschli is alluded to as carrying with it the necessity of their withdrawal from this position.* A similar demonstration of the possession of nucleolar structures in the few remaining organisms relegated to this group will not improbably result from their further careful examination, with the assistance of the special treatment resorted to in the case of the Foraminifera. Finally, it is altogether questionable whether the presence or absence of a nucleus or endoplast can be accepted as furnishing a distinct and reliable character even for specific diagnosis. This structure, as shown at greater length in the chapter devoted to the organization of the Infusoria, is evidently in many instances an accompaniment only of the matured and reproductive phase.

Dismissing as entirely unnecessary and untenable, the proposed substitution by Professor Haeckel of an intervening kingdom of the Protista, it has been elected here to fall back upon the old lines, and to indicate as nearly as may be, the most salient features of distinction adopted, though perhaps somewhat arbitrarily, in this volume for the separation of the animal and vegetable series. The purpose of this treatise being the description and exposition of the structure and life-history of those

* The presence of nucleus-like bodies in the Foraminiferal type *Halyphysema Tumanowiczii*, Bwbk. (*Squamulina scopula*, Carter) has likewise been noted and figured by the present author in an article on the nature and affinities of this species, published in the 'Annals and Magazine of Natural History' for July 1878; such discovery being confirmed by Professor E. Ray Lankester's subsequent investigation of this form reported in the 'Quarterly Journal of Microscopical Science' for October 1879.

microscopic organisms only which exhibit easily recognized animal characteristics, some one or more tangible clues to such facile recognition have to be enumerated. The primary basis for such distinction here selected is, as in the case of the landmarks enumerated for the convenient subdivision of the Protozoic sub-kingdom itself, associated with the phenomena of nutrition. Excepting in a few small aberrant groups, distinguished mostly by their endoparasitic mode of existence, and possessing in consequence an abnormal and retrograde type of structure, all those forms referable to the animal section of the series, exhibit in a conspicuous and readily verified manner, their capacity to ingest solid particles of food, and their dependence upon such solid food ingestion for the growth and display of their various vital functions. Among the more highly organized Protozoa, a special organ of ingestion or oral aperture forms a characteristic and permanently recognizable structural feature, while in others there is no such special organ, the food being incepted indifferently at any part of the periphery, the actual process of its seizure and ingestion, or the recognition of the presence of externally derived pabula within the substance of the parenchyma or endoplasm being in these instances requisite for the satisfactory determination of the question. In those low-organized unicellular plants, on the other hand, which at first sight, on account of their closely corresponding form and motile properties are apparently indistinguishable from their animal congeners, the act of food injection is never witnessed, nor is its presence to be detected within their inner substance. Nutrition here, as among the higher ranks of the vegetable kingdom, is effected by the absorption of the requisite pabulum in a purely liquid state.

With relation to its chemical aspect, the composition of the nutrient matter assimilated respectively by animal and vegetable organisms is found again to be essentially distinct. All animal forms at present known are absolutely dependent on other proteaceous, or, so to say, "ready manufactured" organic matter for their food supply. Plants, on the other hand, while in a few exceptional cases, such as the so-called "insectivorous species" and certain fungi, capable of sustaining life on similar formed protein, manufacture this substance themselves out of the crude material distributed in the liquid or gaseous condition in the fluids which they imbibe. Plants thus fulfil the rôle of builders up or *constructors* from the inorganic of organic materials, while animals are, without exception, the *consumers* or breakers down of this same substance.

Accessory to the very important nutritive feature of distinction above submitted, there remain yet certain other characteristics that may be cited as of supplemental though subordinate utility in predicating the animal or vegetable nature of a given low-typed organism. Chief among these, and having a psychological rather than a physiological bearing upon this question, has to be mentioned the characters afforded by the respective modes of locomotion exercised by the separate representatives of these two groups in a like fluid medium. It is necessarily only between the flagellum-bearing members of these latter, including in the plant series the independent unicellular Protophytes, and the so-called zoospores or antherozooids of Algæ and Confervæ, and in the animal one chiefly the Pantostomatous and some Eustomatous Flagellata, that a difficulty in determination is likely to arise. To one accustomed, however, by a long practical acquaintance with the characteristic motions of these minute beings, there is at once recognizable a certain, so to say, method in the manner of the locomotion associated with the animal organism which is under no circumstances encountered in the case of the plant. In the latter instance, citing as examples the motile phases of *Volvox*, *Chlamydomonas*, or *Protococcus*, it will be found that they swim, as it were, blindfold through the water, stumbling and striking against their fellow forms or any other object that may be opposed to their aimless course. In the animal types, on the contrary, as illustrated by a *Euglena*, *Monas*, or *Heteromita*, there is no such absence of purpose in their movements ; tentative, well-controlled progress in various directions, and intelligent deviations, or, as it were, tackings backwards or to either side being continually displayed. Objects lying in their path are, again, carefully passed over or avoided, similar conduct being likewise observable in their encounter with comrades of the same or diverse species. Under these latter conditions there is often, moreover, exhibited a distinct appreciation of the society of their associates, this phenomenon being more especially alluded to in connection with the two forms described hereafter under the respective names of *Heteromita ludibunda* and *Chloraster marina.*

One other accessory character, scarcely yet, perhaps, sufficiently investigated for recording as an undeviating diagnostic feature of distinction, is connected with the presence or absence of the rhythmically expanding and contracting space, sometimes single and sometimes multiple, situated at various points—such position in a given specific form being invariably definite—within the cortical substance of the organism, and designated the contractile vesicle or vacuole. Among the representatives of the animal series, this structure, excepting in certain Opalinidæ, would appear to be constantly present, while in vegetable forms it would seem to be as invariably absent. From the explanation of the character and functions of this special organ or structure given in the succeeding chapter, it is reasonable to predicate that it is an accompaniment only of animal organization. As there shown, this pulsating vessel is continually replenished from the fluid element imbibed by the organism with the solid food-particles, or through the ciliary or otherwise produced currents, the same fluid often travelling towards and debouching into the vessel in question by well-defined canal-like channels. According to some observers, including Stein, contractile vesicles are common also to several undoubted plant forms, such as *Volvox* and *Protococcus.* The closest investigation in this direction on the author's part, and as accomplished with the aid of a magnifying power of 1– or 2000 diameters—which renders these structures distinctly visible in organisms of far more minute size—has, however, entirely failed to substantiate the presence of any such periodically contracting vesicles in the aforesaid and other allied types, though in many of these, irregularly formed and permanently conspicuous vacuoles or inter-parenchymal spaces, having no fixed location nor rhythmically contractile motions, were found to occur. These observations having been confirmed by repeated and most careful examination of the two generic types just named, the presence or absence of a contractile vesicle is now definitely accepted by the author as affording a ready means of distinguishing between unicellular animal and vegetable organisms. In those instances in which the possession of a contractile vesicle has been attributed to *Volvox globator*, as by Busk * and other investigators, it would appear probable that either *Uroglena*, *Syncrypta*, or some other of the several Volvox-like animal organisms formed the subject of observation.

* 'Transactions of the Microscopical Society,' p. 35, 1852.

CHAPTER III.

NATURE AND ORGANIZATION OF THE INFUSORIA.

PROCEEDING to the more immediate consideration of the special group or groups of organisms that form the subject-matter of this volume, it is in the first place scarcely requisite to observe that the title of the Infusoria as employed from the date of its earliest introduction up to the present time has carried with it a most wide and indeterminate meaning. Formerly utilized for the distinction of almost every microscopically minute aquatic organism, whether belonging to the animal or vegetable series, it is found to embrace for the most part in its more modern application several highly differentiated classes or sections of the sub-kingdom Protozoa, and in some cases, even yet, organisms whose true position should undoubtedly be among the representatives of the vegetable world. In accordance with the views held by the present author, the Infusoria as a group, even when restricted to forms exhibiting a decided animal organization only, scarcely possesses an intrinsic or coherent status, embracing as it does, though incompletely, representatives of all four of the primary natural sections of the Protozoa that have been previously enumerated. Adapted, however, as closely as possible to meet existing exigency, this same group or legion, as it may be conveniently denominated, corresponds as here embodied most closely with those three classes of the Protozoa included in the preceding tabular view of this sub-kingdom under the titles of the Flagellata, Ciliata, and Tentaculifera. In other words, it comprehends, with the exception of the typical Rhizopoda and two subordinate Flagellate orders of the Spongida and Mycetozoa, the whole of the representatives of the Protozoa. But for the limits of space at command, the first, if not the second, of these two last-named orders would likewise have been admitted and described *in extenso* on equal terms with their associated groups; its individual representatives, as explained at length in Chapter V., conforming in all essential structural and developmental details with those of that special order here distinguished by the name of the Choano-Flagellata. From the evidence already submitted, it is clearly apparent that the Infusoria, from whichever point of view selected, can be regarded as irregularly gathered excerpts only from that primary subdivision of the animal kingdom known as the Protozoa, and that no correct estimate of the affinities nor definition of the characters of its multitudinous representatives can be accomplished apart from their consideration as constituent integers of this one harmonious whole, as indicated in the diagrammatic plan and tabular view given in the preceding chapter. In order to meet present requirements, it has been found desirable, nevertheless, to institute the following definition of the Infusoria ; this, while according as far as possible with the broader principles of the above-named scheme, includes all, and those only, of the numerous and exceedingly diverse forms described in this volume.

DEFINITION OF THE LEGION INFUSORIA.

Protozoa furnished in their adult condition with prehensile or locomotive appendages, that take the form of cilia, flagella, or of adhesive or suctorial tentacula, but not of simple pseudopodia; zooids essentially unicellular, free-swimming or sedentary; naked, encuirassed, loricate, or inhabiting a simple mucilaginous matrix; single, or united in colonial aggregations, in which the individual units are distinctly recognizable; not united and forming a single gelatinous plasmodium, as in the Mycetozoa, nor immersed within and lining the internal cavities of a complex protoplasmic and mostly spiculiferous or other skeleton-forming cytoblastema, as in the Spongida. Food-substances incepted by a single distinct oral aperture, by several distinct apertures, through a limited terminal region, or through the entire area of the general surface of the body. Increasing by simple longitudinal or transverse fission, by external or internal gemmation, or by division—preceded mostly by the assumption of a quiescent or encysted state—into a greater or less number of sporular bodies. Sexual elements, as represented by true ova or spermatozoa, entirely absent, but two or more zooids frequently coalescing as an antecedent process to the phenomena of spore-formation.

The annexed plan of the further subdivision of the Infusoria into its component sections, classes, and orders is necessarily an abbreviation only of the tabular view of the Protozoa given at page 36, supplemented in the present instance, however, with a brief summary of the more essential diagnostic characters.

The general Morphology, Organography, Ætiology, Distribution, Reproductive Phenomena, and all other features associated with the group of the Infusoria as here defined may now be examined in detail, and under their respective headings.

MORPHOLOGY.

Unicellular Nature of the Infusoria.

As implied in the definitions of the Protozoic sub-kingdom generally, and of the Infusorial legion in particular, already submitted, any representative zooid or individual unit of the group now under consideration possesses according to the views supported by the author the morphological value only of a simple cell. This interpretation, originating in its substantial form with Carl Theodor von Siebold in the year 1845, was beyond doubt foreshadowed many years previously by Lorenz Oken, received further amplification at the hands of Schleiden and Schwann, and represents at the present date the most generally accepted estimate of the organization of the members of this class. From a very early period up to the present time, however, there have not been wanting authorities of more or less considerable eminence who have advocated on behalf of the Infusoria a

Tabular View of the Sections, Classes, and Orders of the Legion INFUSORIA.

Sections	Classes.		Orders.
A. PANTOSTOMATA. Oral or inceptive area distributed over the entire cuticular surface.	I. *Flagellata.* Appendages flagelliform.	Flagellum rudimentary, supplemented by an undulating membrane ..	1. Trypanosomata.
		Flagellum supplemented by lobate pseudopodia..	2. Rhizo-flagellata.
		Flagellum supplemented by ray-like pseudopodia	3. Radio-flagellata.
		Simply flagelliferous, no pseudopodic appendages	4. Flagellata-pantostomata.
B. DISCOSTOMATA. Inceptive area limited to a discoidal anterior region, but not constituting a true mouth.		Flagellum issuing from centre of collar-like extensile membrane ..	5. Choano-flagellata (vel Discostomata-gymnozoida)
C. EUSTOMATA. Inceptive area taking the form of a distinct mouth.		Flagellum single or multiple, no auxiliary cilia	6. Flagellata-eustomata.
		Flagellum associated with more or less numerous auxiliary cilia	7. Cilio-flagellata.
	II. *Ciliata.* Appendages taking the form of cilia.	Cilia distributed over the entire surface of the body, similar in character ..	8. Holotricha.
		Cilia distributed throughout, oral series of larger size..	9. Heterotricha.
		Cilia usually more or less diverse, confined to the ventral surface of the body	10. Hypotricha.
		Cilia not generally distributed, mostly limited to a conspicuous circular or spiral adoral wreath ..	11. Peritricha.
D. POLYSTOMATA. Inceptive areas distinct and multiple.	III. *Tentaculifera.* Appendages tentaculate.	Tentacles simply adhesive	12. Actinaria.
		Tentacles suctorial	13. Suctoria.

comparatively complex type of structure altogether at variance with the foregoing unicellular conception. Enumerated in chronological order, the first interpretation attributing a complex and multicellular structural type to these organisms was advanced by C. G. Ehrenberg, who in the year 1830 enunciated his celebrated Polygastric theory. In accordance with Ehrenberg's interpretation, the Infusoria, including both the simpler Flagellate and more highly differentiated Ciliate representatives of the series, were, as previously stated, distinguished by the possession of a variable number of distinct stomach-cavities, and of glandular and sensory organs of various descriptions, the affinities of the group as a whole being deemed by him as most nearly approximate to that of the Annelida. Founding their arguments upon a basis altogether independent of Ehrenberg's remarkable hypothesis, several authorities have since held the Ciliate division of the Infusoria to exhibit similar affinities with the lower or Turbellarian worms, the names of Oscar Schmidt and Diesing being most eminently conspicuous in this direction. According to the views of the last-named taxonomist, however, the Peritrichous group of the Ciliata exhibited a type of structure more nearly approaching that of the Polyzoa, Diesing's interpretation in this connection being likewise independently maintained by the elder Agassiz. The most powerful opposition to the unicellular nature of the Infusoria, such opposition being based upon the supposed nearer conformance of their structure to that of the Cœlenterata or zoophytes, is undoubtedly found in the conjoint writings of Claparède and Lachmann. A corresponding Cœlenterate interpretation of the affinities of this group, as illustrated more especially by the organization of the Vorticellidæ, has been quite recently advocated by Richard Greeff.

Among those authorities who, while contesting the unicellular nature of the Infusoria as advocated by Von Siebold, have substituted for it no definite and compensating alternative interpretation, may be mentioned the names of Perty, Lieberkuhn, and to a considerable extent also Stein. The crucial test respecting the disputed unicellular or multicellular structure of the infusorial body is undoubtedly, however, to be found associated with the phenomena of development. As pointed out more especially by Professor Haeckel in his 'Morphologie der Infusorien,' published in the year 1873, the entire life-history of an Infusorium, taken even in its most exalted grade of development, as represented by the higher Ciliata, is an epitomization only of the life-history of a simple cell. By the various modes of fission or duplicative division common to all representatives of the class, the infusorial zooid multiplies itself in a manner precisely corresponding with what obtains in the augmentation of the ultimate elements of all cellular structures. Again, in those more rarely observed, but still very generally occurring phenomena of sporular or internal gemmule-production, the sporoid body or embryo commences life as an undoubted simple cell, and retains this same morphological simplicity for the remainder of its existence. At no epoch of its history, from its pristine germination to its ultimate dissolution, is there any appearance of a multicellular constitution, or in the former instance, more especially, the formation of a distinct germinal layer or blastoderm, the one essential feature and index of all the multicellular animals or Metazoa. It is true nevertheless, although the circumstance has apparently as yet attracted but little notice, that many infusorial forms belonging both to the Ciliate and Flagellate sections of the group, exhibit in connection with that mode of reproduction characterized by the resolution of the primary cell or zooid into a number of sporular bodies, an aspect and plan of organization in no ways to be distinguished from the moruloid or primary segmental condition of the ovum of the Metazoa. Beyond this stage, however, the analogy, or, if it exists, the homology, entirely ceases; for whereas, in the Infusorium or Protozoon, each segment or unicellular component of the pseudo-morula becomes metamorphosed into a distinct and independent being, in the Metazoon, this primary independence is almost immediately obliterated through the recasting or reconstruction out of the primary segmental elements, or morula, of the true multicellular embryo with its characteristic inner and outer germinal layers or primordial tissues. In the case of the sponges, as shown later on, and notwithstanding the deceptiveness of external appearances, the production of similar pseudo-morulæ are associated both with the growth of the free-swimming swarm-gemmules or so-called ciliated larvæ, and also with the development in certain types of the characteristic ciliated chambers, or, as they are more usually designated, the ampullaceous sacs of the adult sponge.

Taking for granted that all infusorial structures possess a unicellular morphologic value only, the very extensive range of complexity compatible with such simple organization, as exhibited by the representatives of the Infusoria, has now to be considered. Among the majority of the older biologists, and with many even at the present day, the conception of a single histologic cell, or of an independent unicellular organism, differs widely from the one that is here advocated. With the former it was, and is, held, firstly, that such a simple cell or unicellular organism must have a differentiated bounding membrane, the cell-wall or primordial utricle; and secondly, that the same must contain a central denser and more highly refractive mass, or nucleus, which may or may not be associated with a still more minute segregated mass, the nucleolus. As demonstrated, however, by the later school of biologists, and among whom Professor Haeckel's name occupies a pre-eminent position, neither a distinct cell-wall nor a differentiated central nucleus forms an essential or invariable element of cell-organization, be such cell either an independent being, or unit, or an integral constituent only of a compound tissue. In accordance with the results of more modern investigation, the intrinsic value or potentiality of such a cell-structure resides neither in the cell-wall nor in the nucleus, but in the simple protein matter indifferently denominated sarcode or protoplasm, of which the cell-body is built up. With reference to the more or less highly differentiated organization of cell-structures and single-celled organisms, Professor Haeckel has recently proposed to introduce a special code of terminology. In connection with this he confers upon all those cells, or so-called plastids, in which no nucleus or nucleus-like structure is present, the title of simple cytodes, reserving that of true cells for those alone in which such a structure is distinctly represented. Both of these are again recognized by this authority as including two minor groups of equal value, distinguished by the presence or absence of a bounding membrane or cell-wall; the naked and membrane-bounded cytodes he has denominated respectively gymnocytodes and hullcytodes, and the nucleated cells in a similar manner, Urzellen or gymnocyta, and Hullzellen or lepocyta. This separation of the nucleated and non-nucleated unicellular structures generally, as applied to independent unicellular or Protozoic organisms in particular, forms the basis upon which Professor Haeckel has, as previously stated, proposed to establish his non-nucleated class-group of the Monera. In recognition of this same distinction, Professor Huxley, in his 'Anatomy of the Invertebrata,' has subdivided the Protozoa into the two groups of the Monera and Endoplastica; the former corresponding with the group of the same name as established by Haeckel, and the latter including that remaining great majority of the Protozoa in which an endoplastic or nucleus-like structure is distinctly visible. Such a distinction is, nevertheless, adopted by this author as a matter only of temporary convenience, he freely expressing his doubts as to whether it will stand the test of extended investigation. The outcome of such research since the publication of Professor Huxley's volume, has indeed fully justified the characteristic caution displayed by this eminent biologist; several of the more important groups of the so-called Monera, including more especially the Foraminifera, being now found to consist of nucleated structures conforming in all essential details with that larger section of the Protozoa from which it has been proposed to separate them. In accordance with the opinion maintained by the author of this volume, and as already intimated in the preceding chapter, the Monera, as a distinct class, has no substantial claim for retention, all the representatives of the Protozoa being held to possess a nucleus, or its equivalent, in their fully matured condition. In their earliest and immature state this important structure, the nucleus, is undoubtedly, however, often absent, the Protozoon, under such conditions only, conforming in structure with Professor Haeckel's diagnosis of a simple cytode or Moneron. That a unicellular animal may, on the other hand, be entirely destitute of a differentiated bounding membrane, or cell-wall, is abundantly evident. All such peripheral differentiation is clearly conspicuous for its absence in the whole of that section of the Protozoa here distinguished by the title of the Pantostomata, and in which food-substances are incepted indifferently at any point of the periphery. As already indicated in the preceding chapter, this simplest and homogeneous type of protoplasmic structure, the inseparable corollary of the Pantostomatous organism, is found associated with by far the larger portion of the entire sum of Protozoic structures, and embraces among the Infusoria proper, as here comprehended, no less than four out of the total of thirteen orders that make up the series.

Although the unicellular nature of the Infusoria is here fully accepted and maintained, it has yet to be admitted that in a considerable number of instances such unicellularity has become somewhat obscure. This is more especially observable among the order of the Ciliata, where we find several representatives of the Opalinidæ possessing an almost indefinite number of nucleus-like structures, a like complexity in this respect being also exhibited by the *Trachelophyllum apiculatum* of Claparède and Lachmann, and a few other Holotricha. Among the Hypotrichous order of the Ciliata, the nucleus is, again, rarely single, being more usually represented in duplicate. Other forms, such as *Loxophyllum meleagris* may be further quoted as illustrative of examples in which the nucleus exhibits a condition of modification midway between the two previously quoted series. This frequently recurring composite character of the nucleus has been seized upon by those who are unwilling to concede to the Infusoria the nature and position of unicellular structures, as affording substantial evidence in support of their objections. No single cell or unicellular organism, in their opinion, can possess more than a single nucleus, and where there is a multiplicity of such structures there must, they maintain, likewise be multicellularity! As explained more at length, however, later on, this structure, the nucleus, as encountered among independent Protozoic organisms, presents an amount of variation and complexity not met with in simple tissue cells, exhibiting more especially in the present connection a capacity to subdivide within, and independently of its surrounding protoplasm and peripheral cell-wall, where such exists. The distinction in both aspect and properties of the nucleus, as thus viewed, from its normal condition as the single central and essential constituent of a simple tissue cell, is so obvious that doubts have been naturally expressed as to whether the so-called nucleus of the infusorial body can be regarded as the precise equivalent of the structure that takes the same name in the latter instance. It has been further elected by Professor Huxley, in face of these doubts, to confer upon the nucleus, or its seeming equivalent as associated with Protozoic structures, the distinctive title of the "endoplast," and which title is accepted and for the future mainly adopted throughout this treatise.

The fundamental unicellular structure of Protozoic or infusorial organisms is masked in a yet entirely opposite direction, the obscurity arising in this instance from the imperfect separation of the zooids produced through the ordinary process of duplicative division. Familiar examples of this type of modification are afforded by the compound colonies of the Flagellata *Anthophysa* and *Codosiga*, and various Vorticellidæ, such as *Zoothamnium* and *Carchesium*, in all of which a greater or less number of the divided zooids remain intimately united with one another through the continuity of their supporting pedicles. In all of these examples it is nevertheless a matter of no difficulty to recognize the vital independence and essentially unicellular significance of each zooid produced by the binary subdivision of its predecessor. The entire colony stock, in either of the above-named or cognate cases, represents, in fact, the sum total of the process of segmentation of an original single cell. The only instances in which, so far as is at present known, there would appear to be a complete obliteration of the boundary lines that normally separate each unicellular element or vital area, is encountered in that singular type *Dendrosoma radians* belonging to the group of the Tentaculifera. In this we find a common repent stolon throwing up numerous trunks, which give rise to lateral branchlets that terminate each in a fascicle of suctorial tentacles similar to those borne by an ordinary *Acineta.* It can scarcely be maintained that we have here a simply unicellular organism ; each tentaculiferous branchlet is without doubt the equivalent of a typical *Podophrya*, or *Acineta* that has arisen from the longitudinal subdivision of a preceding zooid, and with which it has remained intimately and indissolubly connected. Through the process of imperfectly separated terminal gemmation, a somewhat parallel compound body is produced in the allied genus *Ophryodendron*, and more particularly in the new form here described under the name of *Ophryodendron multicapitata.* The *Podophrya gemmipara* of Cienkowski exhibits temporarily, during its characteristic reproductive state, a compound condition closely identical with that presented by the normal phase of the last-named species. In each of these last-named instances the derivation of the colony stock from a single primary cell or plastid, is self-evident, and notwithstanding the obliteration, or rather non-development, in the case of *Dendrosoma*, of all boundary lines between the individual zooids, their essential unicellular significance remains conspicuous.

Internal and External Differentiation.

Cuticular Elements or Ectoplasm.

The infusorial body in its simplest type of development exhibits a structural composition substantially corresponding with that of the lowest organized tissue cell or plastid, as defined in a previous page. There is no distinct bounding membrane or cell-wall, and no means of discriminating between the soft, semifluid constituents of the interior and exterior regions; it is throughout, and apart from the nucleus or endoplast, one continuous mass of granular, but otherwise homogeneous and undifferentiated protoplasm. The greater portion of the members of the several orders of the Pantostomata must be referred to this category. In the next step of advance, the outer or peripheral border of the protoplasmic mass, while not assuming the character of a distinct cell-wall or so-called cuticle, presents, as compared with the inner substance of that mass, a slightly more solid type of composition. The somewhat denser external layer may in this instance be conveniently denominated the "ectoplasm" and the softer inner substance the "endoplasm." The possession of this slightly denser ectoplastic in place of a distinct cuticular layer is evidenced in certain Pantostomata and in many Eustomatous Flagellata and Discostomata, which, while usually exhibiting a more or less characteristic normal outline, can revert at will to a pseud-amœboid and repent state, progressing then through the aid of variously modified pseudopodic prolongations. The possession of a well-differentiated cuticular layer, while regarded usually as the special attribute of the Ciliata, is common also to many Flagellata, being among these latter most conspicuously represented in such genera as *Euglena*, *Anisonema*, and *Polytoma*.

The development of a simple external or bounding membrane in addition to an immediately subjacent firmer ectoplasm, commonly styled under such circumstances the cortical layer, by no means, however, exhausts the cuticular organization of the Infusoria. As demonstrated by Professor Haeckel, it is possible, among the most highly organized representatives of this class, to recognize no less than four distinct layers or elements exterior to the soft, semifluid, central endoplasm, the same taking from without inwards the following plan of construction and arrangement. Outermost of all occurs that perfectly hyaline homogeneous layer with which the name of the true cuticle is most appropriately associated. It represents the formed, and consequently lifeless, cell-wall of ordinary plant and animal tissues, and is as an independent structure most readily distinguished in such a type as *Vorticella*, where, in addition to forming the outer envelope of the body proper, it is continued downwards, and constitutes the external, structureless, hyaline and elastic sheath of the characteristic retractile stalk. It is this structureless and transparent external layer, again, which enters into the composition of the more or less indurated dorsal shield or investing cuirass of *Euplotes* and *Peridinium;* while it is out of this same element, though as a secondary product, that we find derived the hardened cases or loricæ of *Vaginicola*, *Tintinnus*, and other Heterotricha and Peritricha. Immediately beneath the hyaline external cuticle is encountered, without exception, throughout that large section that takes its name from its characteristic ciliary organs, that comparatively firm, homogeneous, highly elastic and contractile layer, of which the cilia, or their variously modified representatives in the form of setæ, styles, or uncini, are the direct products or appendages, and which latter necessarily perforate the external cuticle in order to be brought in contact with the surrounding fluid. With reference to the special function of this element, Haeckel has proposed to confer upon it the title of the ciliary layer. Beneath this last-named layer is found developed in certain of the more highly organized Ciliata, though by no means with a large number, that peculiar hyaline and highly contractile fibrillate structure which fulfils for these unicellular organisms functions analogous with those performed by the muscular tissues of the Metazoa. In recognition of the special properties of this last-named element, it is referred to indifferently as the muscular or myophan layer, the latter one finding most favour with Professor Haeckel. Among the types in which this myophan layer is most conspicuously developed, may be mentioned the genus *Stentor*, in which it takes the form of closely set, longitudinally arranged, thread-like fibrillæ; *Spirostomum*, in which fibrillæ of similar aspect exhibit an oblique or spiral plan of disposition; and *Vorticella*, in which it forms a finely longitudinally striate or fibrillate sheet that invests the entire body, and is continued in a condensed and thread-like form down the centre of the pedicle, constituting the motile or contractile element of that structure. According to the recent investigations of Ernst Zeller, the cortical layers of the various species of *Opalina* are found under treatment with hydrochloric acid, as shown at Pl. XXVI. Fig. 9, to consist of closely approximated oblique or longitudinally-disposed muscle-like fibrillæ, though these latter by no means possess the highly contractile properties of the myophan element as represented in the preceding forms. The fourth and remaining elemental layer to be mentioned having, as far as is yet known, a somewhat limited distribution, is that associated with the production of the minute rod-like bodies possessing in some forms an apparently urticating, and in others a simply tactile property, distinguished by the name of trichocysts. The authority last quoted proposes to distinguish this as a separate trichocyst layer, though whether it possesses a sound claim for such distinction is at present somewhat doubtful, there being forms among the Flagellata, as for example the genus *Raphidomonas*, in which trichocysts are abundantly represented independently of any specially differentiated deeper cuticular layer. The genera *Paramecium*, *Amphileptus*, *Prorodon*, and *Nassula* yield examples in which these peculiar structures, described at length further on, may be most advantageously examined.

Internal Elements or Endoplasm.

In the majority of the Infusoria the central substance of the body, here denominated the endoplasm, but frequently also distinguished by the titles of the chyme-mass or parenchyma,—though not in this latter instance to be confounded with the similarly-named element of multicellular structures,—consists of a more or less fluid, clear or granular, but otherwise undifferentiated protoplasm. This endoplasm in most instances maintains a persistent or inappreciably varying status, but in a few others exhibits more or less constant molecular or circulatory motions, which in exceptional cases, such as *Paramecium bursaria*, may even assume an aspect and amount of regularity analogous in many respects to the cell-circulation or cyclosis of certain plants. The endoplasmic element does not, however, at all times present the simple homogeneous aspect portrayed in the foregoing paragraph. In a few exceptional types, such as *Trachelius ovum*, and *Loxodes rostrum*, though still more notably in *Noctiluca* and its allies, the entire substance of the internal protoplasm is so divided by the intercalation of variously developed vacuolar spaces as to assume a more or less complete reticulate or network-like character. Within the ramifications of this central network, the granular sarcode with the enclosed food-substances may or may not exhibit more or less regular circulatory movements, the general appearances and attendant phenomena here, as in the instances above cited, approximating again in a marked manner to those which may be observed in various plants. Such a composition and associated phenomena are, as pointed out by Professor Allman in his recent Presidential Address to the British Association (Sheffield, 1879), especially observable in those plant cells with large sap-cavities, met with in the stinging hairs of nettles, and other vegetable hairs, the internal lining of which projects into the enclosed sap-cavity thin protoplasmic strings or filaments; these, fusing with one another in various directions, form an irregular network, along which under a high power of the microscope a slow current of granules may be witnessed. As rightly observed by Professor Allman, the vegetable cell with its surrounding wall of cellulose is comparable under such conditions in all essential points with a closely imprisoned Rhizopod; the likeness, however, between a highly vacuolate infusorium and such an internally modified vegetable cell is still more striking.*

Among the examples in which the central endoplasm has been observed to exhibit motions other than circulatory, reference may be more especially made to the type first described by Ehrenberg under the title of *Monas vivipara*, here referred to the genus *Spumella*, and in which the entire body-substance within the periphery exhibits under high magnification an active vibratory motion of its enclosed granules that corresponds most closely with the purely mechanical or "Brownian movements" of finely divided inorganic particles.

Excreted Elements.

Under the above heading have to be assembled all those excreted products whose function it is to provide an external protective envelope for the defence of the enclosed animalcules, and the majority of the variously modified pedicles and other fulcra for support possessed by certain of the

* An independent observation in a similar direction has recently fallen within the author's experience, the type in question being the elegant marine diatom *Isthmia enervis*. The unicellular frustules of this species, collected and examined in the living state at Teignmouth, Devonshire, in July 1879, were found to exhibit an exceedingly remarkable internal structure. The characteristic olive-brown cell-contents or endochrome was found to be collected for the most part into a more or less extensive central spheroidal mass, from which radiating and frequently branched granular thread-like prolongations of the same substance extended to and united with the periphery. Submitted to high magnifying power (700 diameters) both the central mass of endochrome and its radiating prolongations were shown to be composed of an aggregation of minute brown ovate or spindle-shaped corpuscles immersed in or held together by a colourless and more fluid plasma. In the radiating and reticulate extensions from the central mass these corpuscles were sometimes quiescent, but more often were seen travelling in slow and regular order to and fro between the centre and the periphery; the general aspect under these conditions corresponded so nearly with the characteristic granule circulation of certain Foraminifera and other Rhizopoda that it was difficult to realize that it was a unicellular plant and not a Protozoon under examination. In the most actively moving cells almost the whole of the ovate corpuscles were deployed upon, and in motion along, the radiating filaments, while in the most quiescent examples both filaments and corpuscles were withdrawn into the central mass.

attached or sedentary species. Among the former are necessarily included those variable and often exceedingly beautiful vase-like or tubular structures upon which the titles of sheaths or loricæ are most usually conferred, and likewise those investments of simple mucus subservient in a similar manner as a dwelling house for the habitation and protection of the one or many animalcules who are engaged in its construction. Within the category of "excreted structures" have also most essentially to be included those hermetically closed indurated cysts or envelopes exuded by almost every known type of animalcule under certain uncongenial conditions, and also very frequently as an accompaniment of the phenomena of binary division or sporular reproduction. The excreted structures pertaining to these last-named special purposes possessing an altogether independent significance, they are treated of separately later on under the respective titles of "encystment" and "sporular multiplication."

In all of the foregoing cases it is evident that the secreted structure is the direct product of exudation or simple separation from the external layer or ectoplasm of the contained animalcule, and is indeed in many instances scarcely to be distinguished from the outermost or true cuticular element of the several layers of the ectoplasm already described at length. Instances in which the closest affinity may be said to subsist between these two structures are afforded by, and specially referred to, in the account given of the members of the genus *Lagenophrys* and of *Opercularia nutans*. In its simplest form, and yet at the same time partaking of the character of an independent exuded structure, the secreted envelope has a purely gelatinous consistence, and corresponds essentially in nature and aspect with the exuded mucilage that constitutes the common envelope of various bacterial growths in the characteristic "glœa" phase of their existence, and is similarly associated with many other low-organized plants or Phytozoa. Instances among the higher or Ciliate group of the Infusoria, in which a simple mucilaginous investment takes the place of an indurated sheath or lorica, are of comparatively rare occurrence, the genera *Ophrydium*, *Ophionella*, *Chætospira*, and certain species of *Stentor*, yielding the most prominent exceptions. Among the Flagellata such mucilaginous investments, and more especially when pertaining to colonial or sociably aggregated types, are far more frequent, such genera as *Uroglena*, *Protospongia*, *Spongomonas*, and *Phalansterium* being especially noteworthy in this direction. The transition from a simple gelatinous sheath to a comparatively hardened test or lorica is very gradual, and is well exemplified among the members of the genus *Salpingœca*, in several of which, as, for example, *S. ampulla*, the development of the highly characteristic lorica from a primary simple mucilaginous exudation has been attentively observed. The composition of the loricæ throughout the various orders and families of the infusorial class is found to exhibit a very uniform character, being represented in most cases in its matured state by a more or less brittle material, having an apparently chitinous consistence. In the majority of instances these loricæ are perfectly transparent, permitting a free view of their enclosed constructors, but in some few, and notably in association with the genera *Cothurnia*, *Vaginicola*, and their allies, the loricæ assume with age a deep chestnut hue, and are more or less completely opaque. Certain of the representatives of the foregoing group are further distinguished by their possession of a supplementary simple operculum or more complex valvular structure, which, upon the withdrawal of the animalcule, closes the aperture of the lorica, and effectually protects the animalcule from molestation from without. The greatest diversity in form exhibited by the protective cases or loricæ of the infusorial animalcules is undoubtedly met with among the more simply organized Flagellate section. Here we have several families, as, for example, the Trachelomonadidæ, Dinobryonidæ, and Salpingæcidæ, notable for the diversity of contour exhibited by the domiciliary structures secreted; those appertaining to the one last named being particularly worthy of mention, as including forms which vie for elegance in outline with the classic vases and amphoræ of ancient Greece. Within this family, and also in that of the Dinobryonidæ, more complex loricate types occur than among any as yet known Ciliata, many loricæ in such instances remaining united to one another, and forming more or less extensive branching structures, highly suggestive of the horny and chambered polyparies of the Sertularian zoophytes and Polyzoa; for these last-named aggregations of ordinary simple loricæ the distinctive title of "zoothecia" has been adopted by the author. Although it mostly happens that the texture of the lorica is purely horn-like or chitinous, it is sometimes found, as in *Codonella*, and among certain members of the genus *Tintinnus*, that a more or less considerable amount of sand-grains or other extraneous particles are incorporated within its substance. In a still more limited series of types, e. g. the genus *Dictyocysta*, sharing with *Tintinnus* a pelagic habitat, the shell or lorica is purely siliceous, variously perforate or fenestrate, and, in the absence of its characteristic occupant, is scarcely to be distinguished from the elegantly latticed siliceous shells of certain Polycystinæ. As mentioned in the account given of that family group, there are strong grounds for suspecting that the investing cuirass of certain pelagic Peridiniadæ is likewise of a siliceous nature.

The investing loricæ of the Infusoria represent by no means the entire sum of the structures produced by excretion. Among both the Ciliata and Flagellata are found compound tree-like growths or "zoodendria," that exhibit a highly complex type of organization. Reference is more especially made here to such an excreted compound pedicle as occurs in *Anthophysa vegetans*, a full account of the formation and mode of development of which is placed on record in connection with the account given of that species. In this particular type it was shown by experiment that the ramifying supporting stalk is built up by excretion, from the posterior region of the associated animalcules, of the residual particles of the substances first incepted for nutrient purposes mingled with some amount of cohesive mucus, or so altered by deglutition as to present a homogeneous, horn-like consistence; each fine longtitudinal stria recognizable in the branching stalk under normal conditions, indicating, again, the integral portion contributed towards the formation of the whole by the separate members of the terminal uvella-like colony. In certain other recently discovered forms, as, for example, Stein's new genera *Rhipidodendron* and *Cladomonas*, a more or less extensively branching tubular structure or "zooaulon" is built up, into the composition of which, in the first-named genus more especially, many hundred tubules not unfrequently enter. Each of these separate tubules represents in either case the excreted product of the single animalcule or zooid which is found occupying its distal extremity, and which is undoubtedly formed in a manner corresponding closely with that of the pedicle of *Anthophysa*, though in this instance the excretion of digested particles and mucus takes place throughout the greater portion of the area of the periphery, instead of being limited only to the posterior region of the body.

Encystment.

The phenomenon of encystment or cyst-development, briefly referred to in a preceding page, represents so important a factor in the life-history of the infusorial animalcules as to demand separate and extended notice. As there intimated, this encysting process is found to exhibit many distinct and independent phases. In the first, and most general of these, encystment may be defined as a mere conservative act resorted to by any independent infusorium in the presence of conditions unfavourable to its welfare, such as the change of temperature, or the drying up of the surrounding water, or other inhabited medium. In this simply "protective encystment," as instanced by *Paramecium*, *Trachelius*, and other free-swimming types, the animalcule loses its accustomed activity, and settling down in some chosen spot becomes, after a short duration of purely rotatory movements, perfectly quiescent. The cilia now gradually disappear, the animalcule at the same time contracts into a more or less perfect spheroidal form, and exudes from its entire periphery a soft, mucilaginous envelope, at first visible only as a delicate bounding line, but which hardening by degrees assumes the nature of a transparent, membranous or shelly capsule. Although in most instances these protective cysts present a simple spheroidal contour and smooth homogeneous surface, several prominent deviations are to be found. Thus in some instances this cyst or capsule is double-walled, the exterior wall being, as shown by Auerbach in the case of *Oxytricha pellionella*, soft and granular, and the inner one membranous and elastic. In *Stentor cæruleus*, again, the cyst (Pl. XXIX. Fig. 15) is flask-shaped, and provided at its upper extremity with a close-fitting operculum-like lid. In *Euplotes charon*, as shown by Stein, this same structure presents numerous longitudinally disposed, serrated, crest-like elevations, which communicate to the capsule a somewhat melon-shaped outline. A corresponding type of form with certain modifications, the areas between the longitudinal ridges being transversely striate or otherwise ornamented, is common to the encystments of various Vorticellidæ, while a somewhat similar one, having the elevated crests transversely placed, recurs in the Acinete type *Podophrya fixa*. In many species, such as *Stylonychia pustulata* and *Pleurotricha lanceolata*, the exterior surface of the spheroidal cyst is closely studded with more or less irregular papilliform elevations. In all these instances of simple or protective encystment, the animalcule upon the return of favourable conditions assumes once more its normal aspect, and, breaking through the walls of its temporary prison-house, resumes its customary active habits. It is undoubtedly to the possession of this simple self-protective faculty that the extensive distribution and prolonged vitality of many infusorial forms is mainly due. Where the ponds, ditches, or other tracts of fluid containing such animalcules become entirely dried up, these latter run no risk of extermination. Throwing out around them their transparent envelopes, they remain in a quiescent or torpid state until the reappearance of the previous congenial surroundings, or, taken up by the passing breeze, are wafted away in the form of dust until conditions are encountered corresponding sufficiently with those under which they originally flourished.

The encystment of the second order to be mentioned is of comparatively rare occurrence, and, instead of being associated with a simple conservative function, is an accompaniment of, or rather the prelude to, the phenomenon of multiplication by binary division, and may for this reason be most appropriately denominated "duplicative encystment." The preliminary manifestations and aspect of the constructed cyst correspond essentially with those recorded of the simply protective form; but the animalcule enclosed within its capsule, instead of resolving itself into a quiescent and inert mass, divides itself by the ordinary mode of increase by transverse fission, the two halves shortly after making their exit through the walls of the cyst, smaller in size, but in all other respects corresponding structurally with the single pre-existing zooid. Encystment of this special type, in conjunction with other noteworthy data, has been observed by Claparède and Lachmann of the Holotrichous form *Amphileptus meleagris*. As recorded in detail later on, this animalcule is essentially predatory in its habits, and is addicted to preying upon the stationary and defenceless zooids of the Vorticellidan genus *Epistylis*, in the same manner that the Myxopod *Vampyrella* feeds upon the frustules of the Diatom *Gomphonema*. In a like manner also, having gorged itself to satiety, the devouring *Amphileptus* builds its cyst on the apex of the supporting stem of its latest victim, and there undergoes the metamorphosis above described. Duplicative encystment is recorded by Stein of *Glaucoma scintillans*, and in accordance with the observations of that authority occurs also in *Colpoda cucullulus*, in combination with that variety of the process next described.

The third, and remaining form of encystment to be enumerated, closely approaches in many instances the one last mentioned, while in others it exhibits widely distinct features. Like the preceding, it is connected with the phenomena of reproduction, but the encysted animalcule multiplies itself not merely by the process of binary fission, but by the subdivision of the encapsuled mass into a greater or less number of spore-like bodies which, after a more or less prolonged quiescent state, develop to the parent form. This type of encystation may be most appropriately denominated "sporular encystment," and the cyst or capsule secreted in such instances, a "sporocyst." Details of this special mode of multiplication are given in the section devoted to the subject of reproduction, and it is only requisite here to indicate one important point in which such sporular encystment departs widely from both of the preceding kinds. In each of these latter the cyst or capsule produced is the product of a primarily single and independent animalcule, but in the one now alluded to it very frequently, though not invariably happens, that such a cyst is the product of two primarily amalgamated or conjugated zooids. In certain cases, even, as, for example, *Heteromita uncinata*, as many as three or four conjugated animalcules build up the characteristic sporocyst. This special sporular form of encystment is, with but few exceptions, limited to the Flagellate class of the Infusoria.

Locomotive and Prehensile Appendages.

All of the variously modified appendages possessed by the several orders of the Infusoria, used indifferently for the purposes of locomotion or prehension, are to be regarded as mere extensions of the body-protoplasm; sometimes, as in most Flagellata, they are produced directly from the external surface of the ectoplasm, and in others, as the Ciliata, from the deeper or cortical layer of that element. In certain Tentaculifera the characteristic tentacle-like appendages would seem to originate in close proximity to the central or endoplasmic region. With the exception of the organs last mentioned, which would appear to most nearly represent specialized modifications of the pseudopodia of the Radiolaria, the transition from one to the other of the several types of appendages borne is most distinct and gradual. In this manner, flagella can be characterized only as isolated and more or less elongate cilia; while the divers forms of setæ, styles, and uncini possessed most abundantly by the Ciliate section of the series, can be regarded as variations only, in separate directions, of similar simple cilia. Viewed from an independent standpoint, and as is requisite for the purposes of technical diagnosis, the term of "cilia" may be conveniently restricted to such short, slender, vibratile appendages as constitute the ordinary locomotive organs of a *Paramecium*, or the more or less convolute adoral ciliary wreath of a *Vorticella*. With the name of "setæ" are to be associated the slender, hair-like, more or less flexible but non-vibratile appendages that clothe the entire body of a *Pleuronema*, that are developed girdle-wise, and fulfil a special leaping function in the genus *Halteria*, or that in an isolated form constitute a hair-like caudal termination in the genera *Uronema* and *Urotricha.* "Styles" and "stylate appendages," differing from the organs referred to the last-named category in their greater comparative bulk and thickness, are most abundantly represented among the Hypotrichous sub-order of the Ciliata, being developed in well-defined groups or series on the ventral aspect of such genera as *Oxytricha* and *Stylonychia,* and being represented as a single terminal caudal style among the members of the family Dysteriadæ. Of uncini, which also occur chiefly among the Oxytrichidæ, it may be said that, except for their usually shorter and curved or claw-like shape, they coincide entirely in character and function with the ordinary stylate structures, and act in combination with them as most efficient ambulatory organs. It is undoubtedly among the members of this family group that the cilia attain their highest and most luxuriant development, in many species all of the four typical variations of these appendages being borne by a single individual. Here, too, in certain species, such as *Stylonychia pustulata, S. mytilus,* and *Euplotes patella,* we find the styles and setæ departing altogether from their ordinarily simple character, and assuming a more or less branched and often elegantly feathered or fimbriate character. Furthermore, as recently pointed out by Sterki, the adoral series of cilia among these Infusoria differ considerably from vibratile cilia of the ordinary type. These modified cilia are much flattened or compressed, and appropriately receive from him the distinctive title of "membranellæ."

In addition to the cilia and their various modifications as above enumerated, there have to be included in the list of locomotive and prehensile appendages now under consideration, the diverse forms of membranes, some vibratory or undulating and others quiescent, which, either as isolated structures or in combination with cilia or flagella, compass or assist in compassing the objects more usually relegated exclusively to one or other of these last-named structures. As has been previously submitted (see p. 38), an undulating membrane may be regarded from a developmental aspect as the root or primal form only of the adoral fringe of cilia; in certain other directions, however, it develops an entirely independent type of structure. Commencing with the lowly organized Trypanosomata, where it is found to constitute the sole organ of progression, it makes its next appearance as a supplementary locomotive organ in the Flagellate genera *Trichomonas* and certain species of *Hexamita.* By far the most remarkable development of a membraniform appendage in connection with the Flagellate section of the Infusoria, is undoubtedly represented by the singular infundibular membranous expansion or "collar," with its characteristic circulating currents, distinctive of the order here distinguished by the title of the Choano-Flagellata, and met with elsewhere throughout the entire organic series only in association with the class Spongida, whose intimate relationship with these Flagellata is thus indubitably established. The marvellous mechanism of this collar-like membrane, and its utility in combination with the centrally enclosed flagellum as a most efficient snare for the capture of food-substances, will be found fully discussed in the systematic description of this special group. Among the Ciliata, an equal or even greater variation in the form and functions of their membraniform appendages may be enumerated. In one remarkable type, *Torquatella*, referred, however, with some diffidence to the Ciliata, a terminal frill or collar-like expansile and contractile membrane represents the only organ of locomotion and prehension. In *Pleuronema*, *Uronema*, and *Bæonidium*, a delicate hood-shaped membrane is let down in front of the mouth when the animalcule is feeding, forming thus a bag-like trap, into which food-particles are swept by the adoral ciliary currents. In *Lembus* and *Proboscella* the same purpose is accomplished by the assistance of a more or less prolonged crest-like membrane, which is produced from the anterior extremity alongside of the adoral groove to the ventrally located oral aperture. As a supplementary element to the ordinary adoral fringe of cilia, a band-like undulating membrane is of constant occurrence in association with the Heterotrichous and Hypotrichous genera, *Condylostoma*, *Blepharisma*, *Onychodromus*, and *Stylonychia*, while in *Euplotes patella*, and in various species of the genus *Stentor*, the adoral fringe itself commences its existence as a similar simple band-like membrane. In the Holotrichous family of the Ophryoglenidæ, again, embracing some dozen genera, all of the members are characterized by the possession of a small flap or clapper-like membrane, which is enclosed within, or projects to a less or greater distance beyond the oral fossa.

It is obvious that the locomotive and prehensile appendages of the Tentaculifera, including *Acineta* and its allies, depart widely in form and function from those pertaining to the more ordinary Ciliate and Flagellate groups, approaching more nearly in this respect the pseudopodia of the Radiolaria. This affinity is more especially apparent in such types as *Ephelota trold* and *Hemiophrya gemmipara*, in the former of which none, and in the latter a portion only, of the tentacle-like organs exhibit the more frequent tubular and suctorial character, being simply prehensile, and in some instances invertile. In the genus *Ophryodendron* the single or several extensile proboscidiform tentacula, with their associated terminal fibrillæ, exhibit a complex type of structure whose true significance yet requires elucidation. Notwithstanding, however, the humble Radiolarian affinities apparently indicated by the most simply organized members of this group, it has yet to be borne in mind that the embryonic forms of all the species, as yet investigated, are more or less completely clothed with fine vibratile cilia, a circumstance which would seem to betoken an adult type of organization in advance even of that possessed by the permanently ciliate group usually accepted as representing the highest section of the Protozoic sub-kingdom. The more important bearings of the organization of the Tentaculifera in this connection will be again referred to.

Oral Aperture or Cytostome.

It is necessarily only in connection with the members of the Eustomatous section of the Infusoria, including the three orders of the Flagellata-Eustomata, Cilio-Flagellata, and Ciliata, that a true oral aperture—or, as Haeckel designates it in contradistinction to the oral opening of the multicellular animals, a "cytostome"—is met with, food-substances in the remaining sections being incepted indifferently over the whole or a more or less widely dispersed area of the peripheral surface. Where, as above indicated, such a distinct oral aperture is represented, a considerable amount of variation is found to subsist with relation to its contour and associated structure. With the great majority, the oral aperture takes the form only of a simple orifice, or of a tubular passage, through which direct intercommunication is established between the surrounding medium and the inner or deeper endoplasmic region of the animalcule's body. Most frequently this oral aperture is permanently conspicuous, but not unfrequently, as in the genera *Dinomonas* and *Trichoda*, it happens that this structure is to be detected only at the moment when food is being swallowed, its lateral walls at all other times closing so completely upon each other as to leave no passage visible. As might be anticipated, when the walls of the oral passage are loose and elastic, as in the above-named types, this orifice is capable of great distension, the food mass devoured being frequently but little inferior in size to the body of its captor. The first manifestation of a complex organization in connection with the oral aperture is indicated by a simple thickening or induration of the lining wall; this thickening in certain types, such as *Trachelophyllum apiculatum*, takes the form of well-developed longitudinal rugæ, while in others, such as *Chilomonas paramecium*, this region has been lately shown by Bütschli to be both longitudinally and transversely plicate. Among the majority of the Dysteriadæ, as also in association with many of the Prorodontidæ, a distinct corneous tube, that may be isolated from the surrounding body-plasma, is substituted for the simple indurated oral passage characteristic of the last-named series; this structural type leads again directly to that considerable assemblage of forms in which, in place of such a simple corneous tube, a tubular fascicle of rod-like teeth or stylets is enclosed within, but remains at the same time capable of protrusion at will beyond, the oral fossa, and is employed by the animalcule for the purpose of grasping and engulphing its accustomed prey. This special type of oral armature is, so far as it is at present known, possessed only by the Ciliate section of the Infusoria, occurring, however, in three out of the four leading groups or orders of this division, as represented by the genera *Prorodon* and *Nassula* among the Holotricha, *Chilodon* and *Phascolodon* among the Hypotricha, and apparently in the solitary case of *Polykrikos* in the group of the Peritricha.

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The most remarkable type of oral armature possessed by the series of organisms now under consideration is, undoubtedly, met with in the *Dysteria armata* of Professor Huxley, in which the simple corneous tube or tubular rod-fascicle of its nearest associates is, as fully recorded in the description given of this specific form, replaced by a series of corneous plates and styles of such diverse and complex character that considerable doubt was entertained at the date of its discovery as to whether the organism might not be more correctly relegated to the section of the Rotifera. Following upon the oral aperture, it not unfrequently happens that a secondary tubular passage, conveniently though incorrectly termed the "pharynx"—it being in no way homologous with that structure as developed in Metazoic organisms—penetrates still deeper into the substance of the central endoplasm, and serves as a channel for the conduct of incepted food-substances to this region. An example of such a prolonged pharyngeal passage, its distal termination at the same time exhibiting a somewhat remarkable hook-like curvature, characterizes Cohn's genus *Helicostomum*. In many instances, such as *Climacostomum* and the type last named, this pharyngeal prolongation is entirely smooth throughout, while in others, such as *Nyctotherus* and *Metopus*, it is more or less distinctly ciliate. The most complex form of oral and pharyngeal organization is, however, met with in certain of the Peritrichous representatives of the Ciliata. Here, as demonstrated by Greeff, more especially in the cases of *Epistylis flavicans* and *plicatilis*, the prolonged and thickly ciliated pharynx is followed by an almost equally long but exceedingly slender and non-ciliate tubular canal, or so-called "œsophagus," whose distal termination is suspended freely in the central fluid endoplasm. At the point of junction of the pharynx with the above narrower canal-like prolongation this latter structure exhibits a peculiar bulb-like dilatation into which the food-particles fall after their passage through the wider superior portion, and are there moulded into the characteristic pellet-like masses which are to be seen regurgitating through the substance of the body. The foregoing type of oral and œsophageal organization has been recently shown by Wrzesniowski to obtain in *Ophrydium versatile*, and is apparently common to all the members of the Vorticellidan family. In the genus *Didinium*, the inner lining of the oral region can be protruded to a considerable distance, after the manner of a proboscis, for the purpose of food-capture; a like, though somewhat less pronounced, structural modification is met with in *Mesodinium*.

Anal Aperture or Cytopyge.

The results of recent investigation have tended to demonstrate that a distinct anal aperture, or as Haeckel denominates it the "cytopyge," for the discharge of fæcal substances, exists in at least all of the Eustomatous section of the Infusoria, while in not a few of the Pantostomata, such a distinct aperture is, although not distinctly developed, most clearly foreshadowed. Among these latter, reference may be made more especially to such types as *Anthophysa vegetans* and *Oikomonas obliquus*, in both of which the excrementitious particles are rejected at the posterior region of the body, and are in the former instance intimately interwoven with the substance of the branching stem. Even among the Ciliata, where this organ attains its most pronounced development, it is, except during the passage of rejectamenta, rarely conspicuous. An exception to the above rule is, however, afforded by the members of the genus *Nyctotherus*, where it is permanently recognizable as a posteriorly located thick-walled, tubular passage, that penetrates to a considerable distance into the substance of the body. As pointed out by Professor Huxley,* the tract along which the food passes in this Infusorium is so circumscribed through the delimitation of the pharynx, anal passage, and very short intermediate area of fine granular endosarc or endoplasm, that it may be not inappropriately described as possessing a rudimentary intestinal canal. In common with *Nyctotherus*, the anal orifice is more usually terminal or subterminal, but may, as in *Stentor* or *Follicularia*, have a lateral location, or as in the large group of the Vorticellidæ, it may open upon the anterior extremity in close vicinity to the oral aperture.

Contractile Vacuole or Vesicle.

In close association with the anal or excretory aperture—the functions of which it in many instances would seem to assist in performing—has to be described that early recognized organ, sometimes single and sometimes multiple, presenting in the generality of species the aspect of a clear, rhythmically expanding and contracting spheroidal space, most generally distinguished by the title of the "contractile vesicle." A very considerable diversity of opinion has been, and is even yet, maintained with relation to the true structure and function of this very important organ. By Ehrenberg it was first described as a spermatic gland; Spallanzani and Dujardin attributed to it a respiratory function; Lieberkuhn and Claparède and Lachmann recognized in it a rudimentary heart or circulatory organ; while in accordance with the views of Stein and Oscar Schmidt, the functions discharged by it are excretory and correspond most nearly with that of the renal organ of the higher animals, and the excretory water-canals of the Turbellaria. As maintained more recently by Professor Haeckel, it seems, however, most reasonable to infer that the functions performed by the contractile vesicle of the Infusoria partake of a twofold character, being both respiratory and excretory. One of the most important points for consideration in the determination of the functions of this organ, is the long-disputed question as to whether or not it maintains a free communication with the outer water. By the majority of earlier and many recent writers, including among the latter Claparède

* 'Invertebrate Anatomy,' p. 105.

and Lachmann, it has been affirmed that no such intercommunication exists, and that the organ consequently partakes of the character of a closed vessel. Among the first to arrive at a contrary decision and to declare that the contents of this vacuole were at the time of collapse or "systole" discharged externally, may be mentioned the names of Oscar Schmidt and Mr. H. J. Carter, strong confirmatory evidence in the same direction being likewise contributed by Professor E. Ray Lankester, in his "Remarks on *Opalina* and its Contractile Vesicles," published in the 'Quarterly Microscopical Journal' for the year 1870. Since that date testimony has been forthcoming from a variety of sources establishing beyond question the existence of the intercommunication above indicated, its precise pore-like character being further described and figured by Wrzesniowski in association with the genera *Enchelyodon* and *Dendrocometes*. In the last-named type, furthermore, a delicate tubular canal has been found to proceed from the spheroidal vesicle and to penetrate the thick cuticular investment. A second disputed point, almost equal in its consequence and bearings to the preceding, was for a long while connected with the precise structure of the contractile vesicle, and more especially as to whether or not it possessed a distinct bounding membrane. By Ehrenberg, Siebold, Claparède and Lachmann, and also by Mr. Carter, the presence of such a definite wall or bounding membrane to this vesicle has been maintained; a contrary view, however, being advocated by Dujardin, Perty, Stein, and the majority of recent investigators. In accordance with the opinion of these latter, no such bounding membrane exists, the vesicle in this respect presenting no higher structural differentiation than the various non-contractile or irregularly contractile vacuoles or lacunæ that occur so abundantly in the protoplasmic element of both animal and vegetable cells. The non-possession by the contractile vesicle of any bounding membrane is now amply proved through the tendency exhibited by this structure in certain species to split up into a variable number of minor vesicles, which may again unite in an irregular manner with one another. This phenomenon has been especially demonstrated by Wrzesniowski in connection with the Holotrichous type *Trachelophyllum apiculatum*. The non-occupation by the contractile vesicle of this species of a permanently fixed position has likewise been elicited by this authority, he having observed that during the discharge of fæcal matter from the terminal anal aperture the vacuole is forced backwards to a very considerable extent to permit of its free passage.

The constant and free intercommunication of the contractile vesicle with the outer water or other inhabited fluid medium, and the composition of this structure as a mere rhythmical pulsating vacuole or lacuna in the cortical layer of the ectoplasm, possessing no distinct bounding membrane, being here accepted as fully established, further details with relation to the functions and more prominent variations it assumes in various infusorial types may be proceeded with. In its simplest form, and as represented in the majority of the Infusoria, the contractile vesicle exhibits at the period of its fullest expansion or "diastole," a merely spheroidal contour, and becoming entirely lost to view at the moment of collapse or "systole." The time occupied between the consecutive pulsations of this organ is found, under normal conditions, to present a constant average among individuals of the same species, varying from a few seconds only in certain forms to over sixty or even one hundred seconds in other types. Undoubtedly, in many cases the characters afforded by the pulsations of this vesicle yield a useful accessory feature for specific diagnosis, and the registration of such characteristics, in connection with the technical description of each specific form, would be of value. Passing on to the more complex phases of this structure, reference may first be made to those types in which the otherwise simply spheroidal contractile vesicle is supplemented with two or more lateral sinuses or lacunæ, the contents of which flow together immediately upon the contraction or systole of the central vacuole and assist materially in the re-expansion of this central part. An instance in which two symmetrically bilateral accessory sinuses are combined with a central vesicle, exhibiting in this case a broadly pyriform outline, has been ascertained by the author to occur in *Urocentrum turbo*, a similar modification being likewise characteristic of the homomorphic species *Calceola* (*Peridinium*) *cypripedium* of Professor H. James-Clark. Examples in which a greater and variable number of similar lateral or peripheral sinuses are found along with the central vesicle, imparting to it under certain conditions a characteristic rosette-shaped configuration, are afforded by such forms as *Follicularia ampulla*, *Trachelophyllum apiculatum*, and *Didinium nasutum*. It is, however, in such types as *Paramecium aurelia* and *Ophryoglena flava* that this special modification of the contractile vesicle attains its most complex development. Here, it is found that the supplementary sinuses present a narrower or more linear contour, and exhibit, as a consequence of their radiate plan of disposition around the central vacuole, an elegant and highly characteristic stellate aspect. In *Paramecium* there are usually from five to seven or eight of such radiating sinuses, while in the case of *Ophryoglena*, Lieberkuhn has reported the existence of no less than thirty. Examined carefully with the assistance of the higher powers of the microscope, it has moreover been demonstrated by the authority last quoted, and also by Mr. Carter, that these lateral sinuses extend as slender radiating and frequently branching canals throughout the entire cortical layer. A still more conspicuous canal-like system that anastomoses with a main or central contractile vacuole, may obtain. This special type of organization, while occurring in a considerable number of infusorial forms, is perhaps most prominently illustrated by the various representatives of the genus *Stentor*. Here, the main and spheroidal dilatation of this organ is situated a little below the peristomal ciliary wreath, to the left hand of the ventral aspect, and closely adjacent to the anal aperture. From this spheroidal dilatation, as first pointed out by Lachmann, a single long and more or less tubular, canal-like diverticulum extends, inferiorly, down the left side of the animalcule to within a short distance of the adherent foot; while another similar canal, departing from the superior region of the same vacuole, extends in an annular form round the entire circumference of the peristome. As recently demonstrated by Wrzesniowski, an almost identical configuration of the contractile vesicle occurs in *Ophrydium versatile*, an anterior annular canal without the posterior diverticulum obtaining also in several other Vorticellidæ. Among the numerous examples in which the contractile vesicle takes the form of a simple lateral canal-like prolongation, exhibiting the normal spheroidal dilatation at its point of discharge, with occasionally one or more minor bulbous dilatations at various portions of its course, may be mentioned more especially such genera as *Spirostomum*, *Loxophyllum*, and *Climacostomum*. In a yet more considerable assemblage of species the contractile vesicular system is remarkable for what may be denominated its dispersed type of representation. With these, instead of presenting a simple, well-defined centre, with perhaps one or more associated canal-like diverticula, a variable and often indefinite number of similar independently pulsating vacuoles are developed at various separate points. It is thus that in *Paramecium* and *Panophrys* two such separated pulsating centres occur; in *Chilodon*, *Chlamydodon*, and many Acinetidæ, simple spheroidal contractile vacuoles, varying in number from three or four only to as many as twenty, are variously and mostly irregularly distributed throughout the cortical substance; while in a few rarer instances, such as *Bursaria truncatella*, *Trachelius ovum*, and the *Prorodon margaritifera* of Claparède and Lachmann, these independent contractile centres are so abundant as to be almost past enumeration. One other characteristic modification of the compound contractile vacuolar system is exemplified by *Amphileptus gigas* and certain Opalinidæ, in which an even serial or linear distribution of these vesiculæ is exhibited. In all the examples above cited the animalcules named belong to the Ciliate section of the infusorial class. A plurality of contractile centres is not unfrequently, however, associated with the representatives of the Flagellata. Examples in connection with this group are yielded by the important order of the Choano-Flagellata, among whose members two or more comparatively large posteriorly located contractile vesicles are almost invariably presented, while in certain species of *Oikomonas* and *Anisonema*, two equal-sized and in the former case alternately pulsating vacuoles have been observed by the present author. In *Anisonema acinus* and *Entosiphon sulcatum*, Stein, again, has indicated in his recently published volume that the normally single and subspheroidal contractile vesicle develops, at diastole, lobate peripheral sinuses, which impart to the entire structure a rosette-like aspect resembling that already referred to in connection with various Ciliata.

Such being the most prominent external configurations of the contractile vesicle, in both its simple and compound type of development, it yet remains to indicate the more important function in the economy of the infusorial body that it may be predicated to fulfil. Beyond doubt, the leading function of the contractile vesicular system is excretory, in the getting rid of the comparatively vast amount of fluid constantly brought into the body through the ciliary or other currents in combination with the incepted food-material. As is conspicuously evident when watching the feeding process in a *Vorticella* or other highly organized Infusorium, each spheroidal pellet or isolated fragment of incepted pabulum, regurgitated through the yielding endoplasm, is enclosed within an equal or even more extensive mass of water, and which liquid, without some special outlet for its discharge, would soon accumulate to an extent incompatible with the well-being of the animalcule. In this relation, the contractile vesicle with its tributary canaliculi and lacunæ, clearly visible in certain instances and doubtless existing in all, enacts the part of a highly elaborate and efficient drainage system, collecting the superabundant fluid from every part of the body-plasma, and discharging it after its reception into the single or several more or less spheroidal, reservoir-like centres beyond the cuticular periphery. That the considerable quantity of water thus brought constantly into intimate contact with the body-plasma, and as it were circulated throughout every portion of its substance, plays an important rôle in the reoxygenization of its molecular constituents, and thus fulfils a rudimentary respiratory function, may be likewise consistently premised, as also that by the time this same water has circulated through the animalcule's tissues, and has debouched into the reservoir or contractile vesicle from which it is eventually discharged, its chemical composition has become materially altered through both the loss of oxygen and the increment of carbonic acid and other waste material. It is possible that the pale pink hue, mostly prevalent in the contents of the expanded vesicle, owes its presence to such chemical reaction, and it presents at any rate a point worthy of future investigation.

Vacuolar spaces possessing no rhythmically pulsating properties, sometimes constant in position, at others sharing in the movements of the parenchyma, and not unfrequently exhibiting slowly contractile motions which terminate in their permanent obliteration, are constantly met with among the Infusoria. In some few instances this vacuolation, as more fully related at page 58, is developed to such an extent that the entire endoplasmic substance presents a mere trabecular or network-like appearance. This extreme type is especially prominent in the Flagellate group of the Noctilucidæ, and attains a closely parallel degree of development in the Ciliate forms *Trachelius ovum* and *Loxodes rostrum*.

Nucleus or Endoplast, and Nucleolus or Endoplastule.

These important organs, while possessing a stronger claim for consideration, perhaps, in that section specially devoted to the description of the reproductive structures and phenomena, represent in themselves such highly characteristic elemental factors, and exhibit among the various members of the class such varied characters and configuration, that their independent treatment is rendered necessary. The morphological correspondence of the nucleus or endoplast, as it occurs among the simplest and lowest organized Infusoria, with the nucleus or cytoblast of the ordinary animal or vegetable tissue-cell, is so conspicuously obvious as to render extended comment needless. Among the higher representatives of this group, it, nevertheless, manifests so wide a divergence in various directions from this simple and primitive condition as to render desirable the employment of some equally appropriate but at the same time sufficiently distinctive and independent title. This widely felt desideratum has been happily recognized and provided for by Professor Huxley, whose recently introduced term of the "endoplast" in place of that of the nucleus when applied to Infusoria or other Protozoic structures is, as previously related, adopted by the author. The simplest representative type of the infusorial endoplast, and the one which corresponds most closely with the nucleus of the ordinary organic cell, is met with most abundantly among the Flagellate section of the series, but is also represented in not a few of the higher Ciliata. In this initial phase of development it exhibits a simply spheroidal contour, and may or may not enclose a central endoplastule, the homologue of the histologic nucleolus. The first step towards a departure from this primitive condition is manifested by the tendency of the endoplast, as illustrated by the Flagellate genus *Euglena* and its allies, to lose the spheroidal and to assume a more or less ovate outline. A still more attenuate and somewhat sausage-like configuration is exhibited by the endoplast appertaining to the Ciliate genera *Balantidium* and *Nyctotherus*, a further element of divergence being here introduced, however, through the fact that the endoplastule or so-called nucleolus is not contained within the substance of the endoplast, but is adherent exteriorly to its lateral periphery: this special phenomenon, entirely opposed to what obtains with reference to the nucleolus of the ordinary tissue-cell, occurs repeatedly among the Infusoria. The most pronounced development of the elongate type of endoplast is found associated with the Peritrichous group of the Vorticellidæ, and where in many cases it assumes a remarkably attenuate, ribbon-like aspect. Such a ribbon-like or almost filiform configuration of the endoplast is more especially characteristic of the genus *Ophrydium*, and is also represented, though in a less marked degree, in the Heterotrichous form *Bursaria truncatella*. In intimate connection with the band- or ribbon-like type above described, has to be enumerated that branched variety of this structure common to many of the Suctorial Infusoria, or Acinetidæ, and also that modification of the elongate form of the endoplast, similarly band-like in the earlier stages of its development, but which in the mature condition of its existence exhibits a more or less uniform series of constrictions or strangulations. In its most characteristic phase of development, as prominently illustrated by the genera *Stentor*, *Condylostoma*, and

Spirostomum, these constrictions of the endoplast are so evenly developed as to impart to it the aspect of a symmetrical moniliform or necklace-like structure, that may be composed, as shown by Stein in the case of *Spirostomum ambiguum*, of no less than twenty-five or thirty ovate or bead-like segments. Although, as hereafter shown, each ovate element of this elongate endoplast becomes ultimately separated and represents the germ or embryo of a new zooid, any distinct separation between them is rarely recognizable during the normal and mature condition of the animalcule, each consecutive fragment being, for the most part, joined closely and intimately to the one next adjacent. In occasional instances, however, it may be observed that certain of these ovate or bead-like constituents are separated for intervals equal to about one-half of their total length, such interval being bridged over by a slender thread-like connecting filament. This special form of endoplastic configuration, occurring as an exception to the evenly moniliform type of the several last-named genera, is found to foreshadow or pretypify in a very feeble manner the normal and persistent characteristic of certain other species. Special reference is made here to the endoplastic structure demonstrated by Wrzesniowski to obtain in *Loxodes rostrum* and *Loxophyllum meleagris*. Under ordinary conditions, the endoplastic system appears to be represented in these types by a number of nodular bodies, either ovate or spherical, distributed irregularly throughout the cortical substance. Examining the same with the aid of reagents and the higher powers of the microscope, it was found, however, by this author that all of these endoplastic nodules were united to one another by a slender and transparent connecting filament—or, as it may be conveniently denominated, a "funiculus"—the distances between each constituent nodule, and consequent length of the connecting thread, in the case of *Loxophyllum*, often exceeding by many times the length of the nodules.

One important modification of endoplastic development, as yet unreferred to, is presented by those species in which this special structure actually exhibits the isolated fragmentary or multiple configuration apparently, but not really, existing in the two last-named forms. The endoplast, in this multiple or compound type of organization, is further found to present as considerable a series of variation as is associated with that of the contractile vesicle in its multiple condition previously described. Thus, in a large series of animalcules, embracing more especially the members of the Hypotrichous family of the Oxytrichidæ, this structure is invariably represented by two elongate-ovate endoplasts, the one usually situated a little in advance of, and the other a little posterior to, the centre line or transverse axis of the animalcule's body. In yet a few other forms belonging to this family group, such as the *Onychodromus grandis* of Stein, there are normally four such endoplastic elements, these, however, not unfrequently being doubled again through the redivision or fission of each component element. From this simple manifestation of the compound endoplastic formula, every phase of gradation is encountered, until at length, and notably in certain species of *Opalina*, as recently demonstrated by Engelmann and Ernst Zeller, the number of endoplastic elements almost exceeds computation, and takes the form of exceedingly minute spheroidal corpuscles associated with a central endoplastule distributed everywhere throughout the substance of the cortex. It is almost needless to remark that in each of these compound phases the infusorial endoplast differs essentially from the ordinary tissue nucleus, which is there invariably represented in its simple and single form. By those who contest the unicellular organization of the Infusoria, this frequent occurrence of a multiplicity of endoplastic elements has, as previously observed, been referred to as yielding the strongest evidence of multicellular structure. Such testimony is, however, entirely neutralized when correlated with the fact that this element has to be regarded as differing essentially in a variety of aspects from the nucleus of the simple histologic cell, one of the more important of these being its capacity to multiply indefinitely within, and independently of, the circumambient cell-wall or its equivalent. In connection with this phenomenon, and as more fully explained in the section devoted to the reproductive features of the class, the infusorial endoplast, in both its attenuate band-like, and compound aspect, has to be regarded in the light of a specialized proliferous stolon, adapted for the production under certain conditions of a greater or less number of embryonic zooids, and as a supplement to that more normal mode of increase by duplicative division or fission which resembles the only reproductive faculty possessed by the ordinary tissue-cell. One feature of importance presented by the infusorial endoplast remains to be enumerated. In accordance with the results of the most recent investigation, and in connection with which the names of Greeff and Bütschli have especially to be mentioned, it has been demonstrated beyond question that in its more complex form this structure is enclosed within a delicate and hyaline bounding membrane or pellicle, which may, perhaps, be most appropriately compared, physiologically and so far as its structureless nature is concerned, with the similarly transparent and structureless pellicle ensheathing the constituent elements of ordinary muscular tissue, known as the "sarcolemma." It is apparently of this hyaline supplemental envelope alone that the slender and transparent filamentous cords, or funiculi, are composed that hold in union with one another the otherwise disjointed fragments of the compound endoplast, as represented in the genera *Loxodes* and *Loxophyllum*.

That marked disparity of aspect and significance recorded of the infusorial endoplast, as compared with the ordinary histologic nucleus, is found to extend likewise to the nucleolus or endoplastule. In all ordinary tissue-cells this special structure is found to constitute an integral and essential constituent of the nucleus, of which organ it presents the appearance merely of a central, more solid, and opaque spheroidal fragment. With the majority of the Flagellata and some few Ciliata, such as *Pleuronema* and its allies, and many of the Chilodontidæ, a similar contour and relationship with the associated nucleus or endoplast is maintained ; but among the greater portion of the representatives of this last-named group an altogether different plan of arrangement is found to obtain. The nucleolus or endoplastule is, in these, no longer immersed within the substance of the nucleus or endoplast, but attached to its external periphery, or, it may be, completely isolated from it. Familiar instances of such simple lateral attachment of the endoplastule are afforded by the genera *Paramecium*, *Balantidium*, and *Nyctotherus ;* this phenomenon, however, attains its most conspicuous development among the Oxytrichidæ and other Hypotricha, in which the endoplast, as before stated, is usually represented in duplicate, and each independent element accompanied by a sometimes adherent and sometimes detached, minute, oval endoplastule. In *Stylonychia mytilus*, mostly pending the process of multiplication by binary subdivision, two or even three endoplastular fragments are sometimes found associated with a single endoplastic element. The most abnormal conditions and aspect of the endoplastule are perhaps, however, developed in the Hypotrichous form *Loxodes rostrum*, and in which, as shown by Wrzesniowski, the endoplastic system is represented by a dozen or more spheroidal elements, held in intimate union with each other, but at distant intervals, by a connecting thread-like cord. Within the centre of each of these spheroidal fragments a distinct central endoplastule was made visible through the employment of reagents ; while, in addition, a supplementary but external series of similar endoplastule-like bodies was found attached, in some instances singly to the external surface of the endoplast, and sometimes to the connecting cord or funiculus. In that series of Infusoria including chiefly the Vorticellidæ and Stentoridæ, in which the endoplast presents a ribbon-shaped or band-like outline, the endoplastular element is mostly represented by scattered granular fragments, one or more of which become enclosed within each of the segmental portions into which the endoplast becomes separated during the process of reproduction by internal gemmation, described later on. The several interpretations concerning the true significance of the endoplastule, as advocated by different authorities, being more fully discussed in the section devoted to the reproductive manifestations of the class, it suffices to add here that where this structure is developed externally to, or separate from, the accompanying endoplast, recent investigation has not yielded evidence in support of its fulfilling the part of a male generative organ or testis, as hitherto generally supposed, but rather indicates that its nature and import are essentially identical with those of the endoplast itself, and whose place and functions it ultimately supplies.

An approximate estimate of the innumerable modifications of the endoplast and endoplastule of the infusorial body as now enumerated may be obtained on reference to the supplementary plate (Pl. XLIX.) devoted especially to the illustration of these and kindred structures.

Colouring Matters.

Under the above denomination necessarily fall those pigmentary substances which in their diffused state impart, in many instances, a supplementary characteristic and easily recognized feature of distinction, and also those anteriorly located coloured corpuscles, of diverse size and number, so conspicuously represented in the families of the Euglenidæ and Chloromonadidæ. To these latter structures, on account of their aspect and position, a visual function was not unnaturally attributed by the earlier authorities, Ehrenberg first figuring and describing them as veritable optic organs, while at the present day they retain the title of eye-like pigment-spots. It is now, however, generally conceded that these characteristic structures are altogether innocent of the exalted function first assigned them, and that their true structure and composition are merely oleaginous or pigmentary, according essentially with the isolated coloured corpuscles possessed by numerous undoubted unicellular plants or Protophytes. The unessential nature of these bodies, and the entire absence from them of all the phenomena usually exhibited by so complex and highly organized a structure as an eye, is amply demonstrated by the exceedingly variable conditions under which they make their appearance, even among individuals of the same species. Thus, while in *Euglena viridis* one such characteristic eye-like pigment-spot represents the normal development, two or even three such corpuscles not unfrequently occur, while in yet a third series it may be entirely suppressed. Although these characteristic pigment-corpuscles are most abundantly represented among the members of the Flagellata, they occur occasionally among the Ciliate section, as prominently illustrated in the genus *Ophryoglena*, while according to Claparède and Lachmann, such a structure is likewise present in the earlier and free-swimming condition of *Freia* (*Follicularia*) *elegans*. The Flagellate genus *Distigma* would seem to be the only type among the Infusoria in which two pigmentary corpuscles are persistently developed, in all other forms a single one only being normally present. Excepting in the case of *Ophryoglena*, in which the pigment-spot is almost black, a brilliant crimson or scarlet hue is found to predominate. No trace of these supplementary coloured corpuscles have been yet recorded in association with the representatives of the Tentaculifera.

Colouring matter in a diffused state, or as forming an integral element of the entire body-substance, while not very generally developed, constitutes in certain types a conspicuous and highly characteristic feature. The Flagellate group of the Euglenidæ, distinguished for the brilliant green hue of the entire subcuticular parenchyma, affords perhaps the most pre-eminent examples of such diffuse coloration. The chlorophylloid nature of the pigmentary matter, or "endochrome" as it may be appropriately designated in these instances, is so evident that its presence has long been held to indicate their essentially vegetable nature, and but for the recent demonstration by Stein and the present author, of a well-developed oral aperture and accompanying capacity to ingest solid food, would yet furnish a solid argument in support of such interpretation. Between the green colouring matter of an *Euglena* and that of a Palmellaceous plant or protophyte, such as *Protococcus*, there would appear to be absolutely no distinction, the same substances in both cases exhibiting, furthermore, a tendency, at a certain epoch of their existence, to assume a more or less conspicuous red or crimson tint. This last-named phenomenon is especially characteristic of the type figured and described by Ehrenberg under the title of *Astasia* (*Euglena*) *sanguinea*, the rapid change of colour from green to red in which has doubtless given rise in many instances to the legendary accounts in rural districts of the conversion of standing water into blood, and has even been suggested by Ehrenberg as yielding an intelligible interpretation of that mysterious "turning of the waters into blood," which distinguished the visitation of the first Egyptian plague. Green colouring matter closely allied to, if not absolutely identical with the chlorophyll of vegetable organisms, is found, though in a more distinctly granular or less diffuse state, in many other infusorial groups. Instances in this connection are afforded by various *Peridinia*, but especially by *Paramecium chrysalis*, in which the greater part of the chlorophyll-like endoplasmic granules exhibit, as previously related, a characteristic circulatory motion. In the green variety of *Stentor polymorphus* it has been shown by Professor E. Ray Lankester that the absorption-bands yielded on examination with the microspectroscope, correspond closely with those given by the green colouring matter of *Hydra viridis* and *Spongilla*, and indicate the presence of an essentially chlorophylloid body. Various other species of *Stentor* are also remarkable for the brilliant colouring of their inner parenchyma, the pigmentary matter being distributed in a granular form throughout its substance, and exhibiting in some cases, such as *S. castaneus*, under a high magnifying power, two distinct and easily recognized tints. The most anomalous hue yet recorded is, perhaps, associated with *Stentor cæruleus*, in which the dispersed pigment-granules are of a brilliant and intense blue. Submitted to spectroscopic analysis, the absorption-bands yielded by the bodies of this species, either singly or *en masse*, were found, by the author above quoted, to differ so remarkably from those of any other known organic substance, that he has proposed to distinguish it by the suggestive title of "stentorin." *

In a number of animalcules, equalling if not exceeding what may be termed the chlorophyllaceous series, the parenchyma is found to yield a colouring matter—mostly diffuse, as in the green colour of an *Euglena*—the fundamental hue of which is brown, but varies from pale amber or orange to a deep olive. In this latter instance the aspect of the pigmentary matter closely approaches that of "diatomin" or the essential olive-brown

* "On Blue Stentorin," E. Ray Lankester, 'Quart. Journal Micro. Science,' April 1873.

colouring matter of the Diatomaceæ; while in the pale and more decidedly yellow examples, a nearer approximation is perhaps made to "phycochrome," or to the yellow colouring matter of various lower algæ. Among the most conspicuous examples of this yellow and brown-coloured series may be mentioned the majority of the Cilio-Flagellate group of the Peridiniidæ, and a very considerable proportion of the Tentaculifera or Acinetidæ. Similar yellow or olive pigment matter is likewise met with among a large number of typical Flagellata, such as *Dinobryon*, *Microglena*, and *Chrysopyxis*, but is remarkable in all these types for its limitation to two lateral band-like areas—a circumstance which has been accepted by the author as justifying their collection into the single family group here distinguished by the title of the Chloromonadidæ.

As illustrations of Ciliate forms in which the colouring hue presents abnormally marked features, reference may be made more especially to the *Leucophrys* (*Holophrya*) *sanguinea* of Ehrenberg, in which the parenchyma is of a bright crimson colour, and *Nassula ornata*, in which numerous vesiculæ of a brilliant violet tint are found distributed throughout the same element. In this latter instance, however, the colouring matter does not represent an essential constituent of the body-substance, but is due to a reaction of the associated juices upon the ingested food-material. An interesting example of the occurrence of fine granular matter, differing in colour from the surrounding protoplasm, is yielded by the *Monas* (*Spumella*) *vivipara* of Ehrenberg, in which such granules are exceedingly minute, of a bright red hue, and exhibit a constant vibratory and apparently purely mechanical or "Brownian" movement. Minute coloured granules of a brilliant crimson hue are also found embedded in the contractile element of the stem of *Vorticella picta*.

Although possessing no claim for consideration as supplementary colouring substance, it may be most appropriately remarked here that in all of the exceedingly minute collar-bearing monads, or Choano-Flagellata, a pale glaucous or fluorescent hue prevails, that assists materially in the recognition of their presence, even where the magnifying power employed is insufficient to render the characteristic membranous collar clearly visible. A similar pale green or glaucous tint is exhibited also by many species of Bacteria, and would appear to represent the predominating refractive index of abnormally minute protoplasmic bodies.

Accessory Structures—Trichocysts.

First in importance among the supplementary and non-essential elements associated with the Infusorial economy, have to be described those remarkable bodies, recurring under a variety of aspects and conditions, known as "trichocysts." These structures exist in their most characteristic form in the very cosmopolitan species *Paramecium aurelia*, taking there the form of minute and exceedingly slender rod-like bodies, or fibrillæ, crowded together and distributed in an even layer immediately beneath the cuticle throughout the whole extent of the cortex, their disposition with respect to the external periphery being everywhere perpendicular. Under certain conditions, including the application of artificial stimuli, such as weak acetic acid, these trichocysts become suddenly elongated, and their distal ends piercing the overlying cuticle stand out like fine, stiff, hair-like setæ, beyond the cilia, around the entire circumference of the animalcule, frequently becoming entirely separated from their base of attachment. The names of Ehrenberg and Oscar Schmidt are most usually associated with the earliest discovery of these special structures, the first-named authority having recorded their presence in *Bursaria* (*Panophrys*) *vernalis* so long ago as the year 1832, and in which connection they are figured and described as minute prismatic rod-like bodies embedded beneath the cilia in the body-substance. By Oscar Schmidt, in the year 1849, similar rod-like bodies were reported to occur in *Bursaria* (*Panophrys*) *leucas*, and *Paramecium aurelia*, their close correspondence with the rod-like bodies possessed by various Turbellaria being indicated. It has been recently elicited, however, by the present author that the existence of these trichocysts in *Paramecium aurelia* was discovered, and their characteristic aspect when extended figured and described, by our distinguished countryman John Ellis, more than a century ago, and at a time when microscopical science was quite in its infancy. With the imperfect magnifying apparatus employed by this investigator it was not possible to recognize the fine vibratile cilia by which the ordinary motions of the animalcule are accomplished, a circumstance which led him to attribute such a special function to the bodies in question; this, however, in no way detracts from his merit as their first discoverer. Ellis's account of these trichocysts being of high intrinsic as well as classic interest, its reproduction *in extenso* is herewith appended. After recording his discovery of the locomotive organs, or cilia which he denominates "minute fins," in various species of Infusoria, which he sagaciously compares with the natatory organs or cilia then recently described by Linnæus as characteristic of the Cœlenterate genus *Beroe*, he proceeds to say:—

"I have lately found out, by mere accident, a method to make their fins (cilia) appear very distinctly, especially in the larger kind of animalcula, which are common to most vegetable infusions, such as the Terebrella (*Paramecium*); this has a longish body, with a cavity or groove at one end, like a gimlet. By applying a small stalk of the horseshoe geranium, *G. zonale*, Linn., fresh broken, to a drop of water in which these animalcules are swimming, we shall find that they become torpid instantly, contracting themselves into an oblong-oval shape, with their fins extended like so many bristles all round their bodies; the fins are in length about half the diameter of the middle of their bodies. Before I discovered this experiment, I tried to kill them by different kinds of salts and spirits, but though they were destroyed by this means, their fins were so contracted that I could not discover them in the least. After lying in this state of torpidity two or three minutes, if a drop of clean water is applied to them, they will recover their shape and swim about immediately, rendering their fins again invisible."

From the foregoing account, as it appears in the 'Philosophical Transactions,' vol. lix., for the year 1769, there cannot be the slightest doubt that the bristle-like "fins," made suddenly to appear by the application of the acrid geranium juice, are identical with the fine setaceous trichocysts characteristic of the species described on a preceding page, any doubts that might exist upon this subject being at once dissipated on reference to the characteristic illustrations of the animalcule accompanying Ellis's description, and embodied in Table VI., Fig. 5, *a*, *b*, *c*, and *d* of the volume quoted. In the above connection John Ellis has, however, not only to be accredited with the first discovery of these supplementary structures, but, through the application of the special means by which he effected such discovery, he takes rank as one of the first to make successful use of reagents, now so widely employed in the elucidation of the more minute histology of the Infusoria. In this direction, nevertheless, and as recorded at page 114, Ellis was to some extent anticipated by another Englishman, Sir Edmund King, at so early a date as the year 1693.

The demonstration of the precise nature of trichocysts, and the connection with them of their now generally recognized and characteristic title, belongs to a comparatively recent epoch. In this instance also, however, an Englishman is to the fore, such demonstration and titular denomination having been accomplished at the hands of the present distinguished President of the Linnean Society, Professor G. J. Allman, who, in the 'Journal of Microscopical Science' for the year 1855, described at considerable length the more minute characters and phenomena presented by these bodies as met with in *Bursaria* (*Panophrys*) *leucas*. Here, as recorded by him in the publication quoted, the trichocysts, now so-called for the first time, were found to exhibit the aspect of minute fusiform bodies embedded thickly and on a perpendicular plan of arrangement, as in the manner already described of *Paramecium*. Under external irritation, such as the drying away of the surrounding water, the application of acetic acid, or forcible compression, they became similarly and suddenly transformed into long, fine, hair-like filaments or setæ, which projected from the whole periphery. The rapidity with which the transformation from the fusiform to the filamentous condition was effected, combined with the greater minuteness and transparency of the objects examined, hindered for a considerable while the recognition of the exact manner in which the process was accomplished. At length, by carefully crushing examples and isolating the trichocysts in their normal and fusiform condition, it was found that these latter, after the lapse of a few seconds, became all at once changed with a peculiar jerk, as if by the sudden release of some previous state of tension, and assumed through this change a minute spheroidal shape. After remaining in this condition for two or three seconds longer, a spiral filament was next observed to become rapidly evolved from the sphere, apparently through the rupture of a previously confining membrane, the filament winding itself with such rapidity that the eye could scarcely follow it, and being finally extended straight and rigid on the field of the microscope, under the form of a very fine and attenuate acicular crystal. In their most completely extended state these bodies were found to consist of an elongate and rigid spiculum-like moiety, acutely pointed at one extremity and continuous at the opposite end into an excessively fine filiform appendage, less than half the length of the spiculum; this second portion was usually observed to be bent at an angle upon the first, and to be more or less curved at its free end. The considerable structural resemblance that subsists between the trichocysts of the Infusoria as just described, and the cnidæ or thread-cells of the Cœlenterata or Zoophyte class, was at the time recognized by Professor Allman, and the circumstance has been cited on various occasions as producing strong evidence against the more recently advocated unicellular nature of the Infusoria. The non-validity of this argument is, however, at once made manifest on regard being given to the fact that the thread-cells, even as they occur among the Cœlenterata, do not possess the independent morphologic value of simple cells, many such being frequently enclosed within the bounding membrane of a single cellular element, and of which they are therefore to be regarded as the secreted product. In other words, as maintained by Professor Allman, "the formative Cœlenterate cell may in this respect be compared with the entire body of the Infusorium." According to Bütschli, the trichocysts in certain forms, including a species of *Nassula*, emit a filament at each extremity of the previously enclosing capsule instead of at one end only, as in the more normal case last described. This investigator has suggested that such a double emission is probably exhibited by the trichocysts of all Infusoria, and which in that case affords a means of distinction between these latter and the genuine thread-cells of the Cœlenterata; this hypothesis has not, however, been confirmed by more recent investigation. The trichocysts of abnormal size, exhibiting an entirely irregular distribution, reported by Bütschli of *Polykrikos Swartzii*, are apparently, as explained in the account given of the species, accidentally engulphed thread-cells only of some neighbouring Cœlenterate organism. Although more generally trichocysts occur, as in the cases of *Paramecium* and *Ophryoglena*, as an even and crowded series beneath the entire cuticular surface, in others, such as *Litonotus* and *Loxophyllum*, they present a limited and definite plan of distribution. Thus, in the former genus they form a conspicuous linear series confined entirely to the ventral aspect of the proboscidiform anterior prolongation, while in certain representatives of the latter they exhibit a partly linear and partly fasciculate arrangement. Although with but few exceptions the special bodies now under consideration are entirely limited to the Ciliate section of the Infusoria, Stein has recently shown that the *Monas* (*Raphidomonas*) *semen* of Ehrenberg possesses these structures variously distributed throughout the cortical region, but most abundantly along the anterior border, while a doubtful case of their occurrence in a marine Acinete form has been recorded by Lachmann. Opinions with respect to the functions of the trichocysts of the Infusoria are not entirely in accord, some relegating to them, as with the thread-cells of the Cœlenterata, an offensive and defensive, and others a simply tactile property: the balance of evidence would appear to be in favour of the former interpretation.

Amylaceous Corpuscles.

Those bodies of an apparently amylaceous or starch-like nature, included under the above title, possess a very limited distribution, occurring, so far as is at present known, only among the Flagellata and in relationship with the family of the Euglenidæ, already cited as most conspicuously distinguished for the possession of eye-like pigment-spots. In the genus *Euglena*, which is especially remarkable for the development of these structures, they are found, moreover, to present a distinct and varied form in the separate species, which consequently derive from their possession supplementary characteristics of some value for specific diagnosis. The more ordinary contour of these amylaceous corpuscles is oblong or elongate-quadrate, but varies in such types as *Euglena acus* and *E. deses* to bacillate, or even acicular. In some forms, such as *E. spirogyra* and *E. oxyurus*, there are more usually only two such corpuscles, one at each extremity, of large size, and exhibiting a more opaque centre and pellucid external zone, while in the two first-named types they are more generally numerous, and present a homogeneous and semi-opaque consistence. In certain instances they appear to multiply by division within the animalcule's body, and, contrary to the structures previously described, appear to lie loose within the central endoplasmic element, instead of being enclosed inside the cortical layer or ectoplasm. The precise nature and significance of these peculiar bodies have yet to be elucidated.

Decomposition or Diffluence.

Some remarkable phenomena connected with the manner in which, under various uncongenial conditions, the soft sarcode bodies of the Infusoria become more or less rapidly disintegrated, require brief notice. Artificially, through the addition to the water of a little ammonia or other reagent, or naturally, by permitting the same water to evaporate, certain species possessing a non-indurated integument, such as the representatives of the genera *Oxytricha*, *Trichoda*, and *Enchelys*, may be observed to fall bodily to pieces, or, decomposition commencing at one point gradually spreads throughout the entire organism, granular or globular portions becoming successively detached, until at length the entire body has been as it were consumed. At any point, however, by the addition of a fresh supply of oxygenated water, this action of decomposition may be permanently arrested, and the animalcule, or such larger portion or portions of it that remain, redevelop within the course of a few hours to the size and form of the normal zooid. In *Vorticella*, *Paramecium*, and other hard-skinned Infusoria a closely similar phenomenon of decomposition is manifested under like conditions through the extension at various points of the cuticle of globules of sarcode, this process, if not artificially or otherwise arrested, continuing until the entire endoplasm has become dissipated. Among the more minute monadiform animalcules a parallel form of disintegration is preceded by the assumption of an entirely irregular and mostly amœbiform contour, closely corresponding with such as accompanies the processes of fusion or encystment; the type *Monas diffluens*, figured and described later on, affords a suitable example of this last-named phase. Collectively, the very appropriate name of "diffluence" has been applied by Dujardin to these several closely identical modes of decomposition here enumerated. Similar phenomena, however, as they occur among the Ciliata were long before observed by O. F. Müller, who described them under the several titles of "molecular effusion" and "dissolution." In certain exceptional instances, including notably *Halteria grandinella* and its allies, an apparent modification of the process of diffluence is exhibited by the animalcule bursting suddenly to fragments in its mid career, without any accompanying visible causes of irritation.

Reproductive Phenomena.

Binary Division or Fission.

This mode of reproduction represents not only the earliest recognized and most widely distributed, but undoubtedly that also by which under normal conditions the specific infusorial form is most abundantly propagated. As in all of the manifold structural aspects previously discussed, the infusorian body reproduces, with diverse modifications, the structural and functional features only of a simple cell, so likewise this special mode of multiplication is found to be a mere reflex of the ordinary reproductive phenomena exhibited by the cellular elements or units of all higher tissue structures. In these, from the most simple to the most complex, the increase in size or growth of the tissue is effected through the indefinite increase by binary or duplicative division of the specific type of cells of which it is composed. The astonishingly rapid growth of certain cellular tissues or structures, through such constantly repeated binary division of the constituent cells, is too familiar for recapitulation, and almost equally extraordinary figures are attained in connection with the multiplication of the independent unicellular bodies of the Infusoria through this simple process. Thus, Ehrenberg long since computed that in the case of *Stylonychia mytilus*, no less than one million of independent beings were derived through the simple and repeated fission of a single zooid in the course of ten days, while in that of *Paramecium aurelia*, he reckoned that as many as 268 millions might be similarly developed within the space of a single month. Substantial evidence of the prodigious numbers that may be produced by this simple reproductive mode is afforded by the various species belonging to both the Ciliate and Flagellate sections of Infusoria that are characterized by their sedentary and colonial mode of growth, each colony-stock under such conditions representing the sum total of the repeated binary subdivision of a primary single unicellular zooid. *Ophrydium versatile* constructs in such a manner aggregated masses, derived primarily from a single animalcule, that vary in size from that of a walnut to a child's head, while *Epistylis grandis* similarly produces on submerged plants, or the walls of an aquarium, what appear to the unassisted vision as homogeneous slime-like masses of many feet in extent. Correspondingly derived colonial aggregations, though on a somewhat smaller scale, are encountered among the several Flagellate genera *Dendromonas*, *Spongomonas*, *Phalansterium*, and *Anthophysa*, while in the group of the Spongida, that must be regarded as peculiarly modified colonial aggregations of such Flagellate types as *Codosiga* and *Phalansterium*, a composite structure is produced by a chiefly though not entirely similar process, which in many cases far exceeds in bulk the extensive colonies of the several Ciliate forms first quoted.

The phenomena of multiplication by binary division or fission are found to manifest several characteristic modifications. With the majority of species such division takes a cross-wise or transverse direction, a groove or constriction making its appearance towards the centre of the body, and becoming gradually deeper and deeper, until at length the anterior and posterior halves become entirely separated from one another, each swimming off as an independent animalcule, and such organs as might be wanting to either separated moiety becoming rapidly developed. In a somewhat smaller, but still pretty considerable assemblage of types, the process of fission is manifested in a precisely opposite or longitudinal direction. Such a plan of multiplication is more essentially characteristic of the large group of the Vorticellidæ, and those representatives of the Flagellata, in which, as with many of the former, a compound tree-like colony-stock is built up. Illustrations among these latter are especially afforded by such genera as *Codosiga*, *Dendromonas*, and *Rhipidodendron*. The compound zoothecium of *Dinobryon*, while at first sight apparently constructed by means of a similar reproductive formula, is the product of transverse fission, each anteriorly separated zooid utilizing the wall of the lorica it quits as the fulcrum of attachment of its own independently constructed domicile. The most remarkable modification of longitudinal fission is perhaps furnished by the collared Flagellate genus *Desmarella*, and in which the variable number of zooids developed by this process remain laterally attached in such a manner as to form a more or less elongate necklace-like series. In the genus *Vorticella* and its allies, as hereafter recorded, the process of fission is always preceded by the closing up and entire obliteration of the primary oral system, two new ones subsequently appearing in its place.

In a third, but comparatively very small number of Infusorial forms, neither a transverse nor longitudinal mode of fission is met with, but one that takes an entirely oblique direction. The Ciliate genera *Stentor* and *Lagenophrys*, and the new Flagellate type described in this volume under the title of *Anchomonas sigmoides*, are among the most noteworthy examples of this somewhat aberrant process. Although it usually happens that all of these various phenomena of multiplication by simple binary division now enumerated are accomplished during the active life of the animalcule, it not unfrequently happens that a quiescent or encysted condition, as described at page 63, is specially entered upon for the fulfilment of this purpose. Illustrations of this developmental phase are afforded by *Amphileptus meleagris*, *Otostoma Carteri*, *Euglena viridis*, and many other Flagellata. The appearances exhibited in certain of these cases more nearly coincide, however, with the sporular conditions discussed later on. In all instances, it would seem that the duplication of the infusorial body by the process of binary division is, as with the similar multiplication of the cells of ordinary tissue structures, accompanied, or rather preceded as an initial act, by the subdivision of the nucleus or endoplast. Other organs, such as the contractile-vesicle and oral or anal structures and appendages, are not so divided, but are independently developed in that moiety in which previous to subdivision they were unrepresented.

External and Internal Gemmation.

The phenomenon of reproduction by "external gemmation," although represented in tolerable abundance among the present organic group, occurs by no means so generally as was formerly supposed. Up to within a comparatively recent date that larger or smaller bud-like body, not unfrequently found attached to the lateral periphery of various members of the Vorticellidæ, and also the secondary pendent zooid, which, while first attached to, finally breaks away from the parental stem, were premised to be examples of such gemmation. In both of these cases, however, the so-called gemmule is derived through a modification of the process of binary fission, previously described, from an ordinary zooid, though in the former instance the association is fortuitous, and, as hereafter shown, has a peculiar significance. Instances of true external gemmation are, nevertheless, afforded by such types as *Spirochona*, and apparently also *Lagenophrys* among the Ciliata, while among the Tentaculifera, *Hemiophrya* (*Podophrya*) *gemmipera* and the various species of *Ophryodendron*, more especially *O. multicapitata*, supply prominent examples of this phenomenon. In the majority of the cases mentioned it has been recently demonstrated that a diverticulum of the endoplast accompanies the outgrowth of the body-substance, forming the characteristic bud, and becomes separated off and enclosed within the latter on its detachment from the parent stock. The most remarkable modification of external gemmation is afforded perhaps by certain Opalinidæ, in which, as exemplified by the *Anoplophrya prolifera* of Claparède and Lachmann, a long series of buds are developed simultaneously at the posterior extremity, and become successively detached from the parent zooid after the manner of the buds or "proglottides" of a cestoid worm. A highly remarkable modification of the process of external gemmation is exhibited by the Flagellate type *Noctiluca miliaris.* Here, as demonstrated more especially by the recent investigations of Cienkowski, the entire subcuticular protoplasm becomes broken up into nodular fragments which are protruded upon the external surface under various conditions of disposition, and are finally liberated from the parent sphere as simple monadiform bodies.

"Internal gemmation" in its most typical condition may be described as a modification only of the previous process. As in the latter case a portion of the endoplast is separated off and enclosed within a portion of the parent substance, but the gemmule or so-called embryo thus produced is retained within the parental body until matured, in place of remaining affixed to its outer wall. Such typical internal gemmation is most abundantly represented among the Tentaculifera, as instanced by the more ordinary *Acinetæ*, and various species of *Podophrya* and *Dendrocometes.* A modification of this form of internal gemmation is also undoubtedly represented among those numerous types of the Ciliata, such as *Stentor, Spirostomum,* and many Vorticellidæ in which embryos or, more correctly speaking, internal gemmules become separated from the more or less elongate endoplast, which may be properly characterized in this connection as an internal proliferous stolon. In all of these last-named cases it is, however, necessary to remark that the internal gemmules so formed are constructed entirely from the substance of the endoplast, and contain no fragment of the surrounding body-substance. In that peculiar form of reproduction recently recorded by Stein of various Euglenidæ, Anisonemidæ, and other Flagellata, in which young are produced through the enlargement and subdivision of the endoplastic element into one or more germinal masses, the phenomena manifested closely correspond with those last related, but at the same time lead the way to that more general mode of propagation among the Flagellata which is next described.

Sporular Multiplication.

Under the above-named denomination are correlated by the author all those reproductive phases connected with the assumption by the individual animalcule of a quiescent or encysted condition, accompanied by the subsequent partition of the entire primitive mass into a greater or less number of spore-like bodies. In those instances in which the sporuloid bodies so produced may be easily reckoned, and do not exceed the numbers of two, four, eight, sixteen, or thirty-two, they may be appropriately termed "macrospores," while in those instances in which there is an excess of this last-named number, and may be described as innumerable, they may be conveniently denominated "microspores." In extreme cases many thousands of these last-named bodies may be included within the parent capsule or "sporocyst," their individual calibre being so minute as to be inappreciable even with the highest constructed powers of the compound microscope. Whether microspores or macrospores, each segmented particle ultimately develops to the parent form. The demonstrated existence to any considerable extent of this sporular form of multiplication is connected with the results of the most recent investigation, many of the facts testifying to the universal prevalence of such phenomenon being now published, indeed, for the first time. Among the higher orders of the class Infusoria sporular reproduction is comparatively rare, being as yet almost unknown among the groups of the Tentaculifera, while in that of the Ciliata a few stray instances can alone be cited. It is in that lower section of the class distinguished by the flagelliform character of their locomotive appendages that spore-formation attains its most vigorous development, it representing among these, in fact, in many instances the most general and prolific form of propagation. Quoting those few instances in which spore-production in its true sense occurs among the Ciliata, mention may be made of *Colpoda cucullulus*, in which, as demonstrated by Stein many years since*—though then reported as cases of simple encystment—the encapsuled zooids became divided into two, four, or eight spore-like bodies or macrospores, each having a separate membranous investment; these give exit to animalcules of smaller size, but which in other respects preserve all the characteristics of the parent form. Phenomena closely corresponding with those related of *Colpoda* have also been observed by Mr. Carter in the Holotrichous genus *Otostoma*, and still more recently by the author previously quoted in connection with *Prorodon teres* and *Panophrys flava*. The only instance as yet placed on record in which an encysted Ciliate animalcule becomes divided into segments so numerous as to fall within the denomination of microspores is afforded by the type recently described by Fouquet under the title of *Ichthyopthirius multifiliis*, the encapsuled zooid in this instance dividing up into at least several hundred spore-like fragments. The products of these spores, when first excluded from their cyst or capsule, differ considerably from the parent animalcule, but by degrees acquire an identical aspect and character. Arriving at the Flagellate section of the infusorial class, the difficulty is rather to indicate types in which a sporuloid phase does not more or less frequently intervene. In consequence of the searching scrutiny that has been directed of late years upon this previously all but neglected group, the life-histories and reproductive phenomena of its members are in many instances more completely known than that of the more highly organized Ciliata.

* 'Die Infusionsthiere,' 1854.

The investigator, to whom credit is due for first demonstrating the sporiparous mode of multiplication among the Flagellata, and for indicating with reference to such peculiarity the close approach made by this group to the Palmellaceæ and other Protophytes, is without doubt Professor L. Cienkowski, who in the year 1865 * figured and described at length such sporular multiplication in connection with his *Monas* (*Heteromita*) *amyli*, various species of his newly founded genus *Pseudospora*, and several types of ordinary Rhizopoda. Although he discovered such developmental phenomena, Cienkowski, however, scarcely attributed to them the interpretation here adopted, the quiescent or encysted condition and transitional amœboid phases being treated by him as more essential and characteristic than the motile flagelliform bodies issuing from the spores, named by him "zoospores," and which certainly represent the typical form of expression of the species in its most mature condition. Not only, however, did Cienkowski recognize the respective natatory or flagelliform, amœboid or repent, and quiescent or sporular conditions of the above-named types, but he also witnessed the conjugation or coalescence in several instances of two or more zooids during the amœboid stage, and the construction by them of a single sporocyst. In connection with this last-named phenomenon, he sagaciously recognized the close approach made to the construction of the compound plasmodium of the Myxomycetes, at that time the subject of special observation by de Bary and himself, and to a certain extent, also, anticipated the more prominent points in the life-history of certain monadiform species revealed a few years later through the painstaking investigations of our own countrymen, Messrs. Dallinger and Drysdale. Full details of the somewhat varying phenomena presented by the diverse types examined by these two authorities being recorded in connection with the systematic descriptions of the Flagellata given further on, and among which may be more especially cited such forms as *Monas Dallingerii*, *Cercomonas typica*, and *Heteromita uncinata*, it will suffice here to indicate that Messrs. Dallinger and Drysdale established in every instance the interpolation among the ordinary mode of multiplication by binary division of a spore-producing phase, accompanied by the assumption of the individual zooid of a resting or encysted state. Preceding such encystment a transitory repent amœboid condition was usually exhibited, and was in most instances accompanied by the coalescence of two or more such amœboid units. In certain cases the sporular bodies so produced were of such a size and number as to fall under the category of macrospores, while in a few others they were of such excessive minuteness and corresponding numbers as to defy individual definition with the magnifying power of 15,000 diameters brought to bear upon them with the aid of a $\frac{1}{50}$-inch objective. These three leading phases in the life-history of a Monad, as above enumerated, and which may be respectively denominated the active flagelliferous, the transitory amœboid,

* 'Arch. f. Mik. Anat.,' Bd. i.

and the quiescent sporocyst states, the first yielding the essential and specific form, are now found to obtain throughout the majority of the Flagellata. Simultaneously with, and in many instances anterior to, the publication of Messrs. Dallinger and Drysdale's researches, corresponding phenomena had been observed and duly recorded by the present author in relation with the representatives of the Choano-Flagellata or collar-bearing section, and other more simply organized Flagellata. Like results have also accompanied his more recent investigations, while confirmatory evidence in the same direction is abundantly afforded in the magnificent volume devoted to the illustration of the Flagellata generally, lately published by Professor Stein. As examples of the persistence of the three above-named characteristic phases in the group of the Choano-Flagellata, reference may be more especially made to the systematic descriptions and accompanying figures of such species as *Salpingœca amphoridium*, *S. fusiformis*, and *Codosiga botrytis*, in all of which the transitory amœboid phase is particularly remarkable. In all those Eustomatous Flagellata which, like *Phacus* and *Anisonema*, possess an indurated cuticle, the assumption of an amœboid condition would not be possible, and the animalcule previous to encystment and spore development merely loses its flagella, and assumes a quiescent state. In *Euglena* and its allies, including *Eutreptia*, the animalcules exhibit a transitory amœbiform, or, more correctly, a gregarine-like repent state immediately preceding the process of encystment. With the representatives of the two last-named genera it is further worthy of note that the initial condition of existence on emerging from the spore is likewise amœbiform and non-flagelliferous. Among the Choano-Flagellata this earliest stage is simply flagellate or monadiform, there being no trace of the characteristic collar, while in a larger series, including the majority of the Pantostomata, such initial phase, in all but size, corresponds essentially with the parent zooid.

Sexual or Genetic Reproduction.

Sexual reproduction in the broad acceptation of the term as belonging to the propagative phenomena of the higher animals or Metazoa, or, as up to within a comparatively recent date maintained by Balbiani and others to obtain among the members of the higher Ciliate section of Infusoria, and in either case involving the concourse of true and independently developed sexual cellular elements—ova and spermatozoa—remains, so far as it concerns all or any members of the class or classes now under discussion, entirely undemonstrable. Nor, the essentially unicellular nature or value of the infusorial organism, as here advocated, being once firmly and incontestably established, can a contrary verdict be anticipated! Notwithstanding, however, the apparently uncompromising verdict pronounced in the foregoing sentence, it will presently be shown that these Protozoic organisms, in essence if not in fact, fulfil a rôle of reproduction that corresponds most closely with this important function as it is met with in all Metazoic or multicellular structures. As already maintained in the description of that more common phase of multiplication which takes the form of constantly repeated binary division, the Infusoria through such mode of increase merely repeat in a separate and independent manner that process of cell-multiplication which characterises the normal growths of all tissue structures. By-and-by, however, in the case of the Metazoon or tissue organism, an epoch is arrived at when the component cells cease to exhibit their previous duplicative energy, the consequence being the gradual decay and ultimate dissolution or death of the entire organism. But for the interposition of a special and more or less periodical regenerative act, this termination of the life of the individual would also, sooner or later, involve the extinction of the race or species. Such a regenerative act, and the further survival of the race, is, however, here accomplished through the fusion or union of one of that congeries of cells out of which the compound organism is composed with one other exteriorly derived cell liberated from another organism or congeries of cells pertaining to the same specific type. The result of such fusion between these two, denominated respectively the germ-cell and sperm-cell, or, in other words, the ovum and spermatic cell or element, is the capacity conferred upon the former of once more proceeding with the duplicative process, and repeating that cycle of cell-aggregation or tissue-construction followed by the parent organism. In a precisely similar manner, the infusorial body, after repeated duplicative multiplication, arrives at a condition in which the strain or race is too exhausted for the further maintenance of this process, and without the intervention of some supplementary regenerative operation would become extinct. By, however, the coalescence or fusion of one of these individual cells or animalcules with an elemental cell or animalcule derived from a neighbouring race or strain, the capacity to continue the duplicative process is revived, and the further duration of the race secured. The two animalcules thus uniting with one another correspond to all intents and purposes with the coalescing germ-cell and sperm-cell, or ovum and spermatozoon of the higher tissue organisms, the only essential point of divergence being in the subsequent changes manifested; the organism in the latter instance exhibits a tendency to build out of the cells amassed by the duplicative process, more or less complex coherent tissues, while in the former each cell so produced maintains a separate and independent existence.

Among the extensive series of types included in the infusorial classes, the phenomenon of "conjugation," "fusion," or "zygosis," as it is variously called, and which undoubtedly represents the sexual or genetic reproductive process of the higher animals in its most simplified or elementary form of expression, exhibits certain well-defined modifications. With the majority of the more highly organized Ciliata, such conjugation has to be denominated, as compared with the form next described, transient and incomplete, being, as illustrated by the generic type *Paramecium*, accompanied by the following manifestations. Two previously independent and free-swimming zooids meeting one another, become locked together through the close application and apparently intimate union or coalescence of their two oral or ventral surfaces, the aspect presented by the united couple coinciding closely with that of longitudinal fission as it occurs among many familiar types, and for which simple reproductive process it was originally mistaken by Ehrenberg and other early writers. This process of conjugation or fusion has in the present species been observed to extend over a period of five or six days, the two united animalcules swimming about in the interim with an amount of ease and activity scarcely inferior to that exhibited by the single and independent zooids. The genera *Bursaria*, *Blepharisma*, *Chilodon*, *Cyrtostomum*, and many other forms, exhibit conjugative phenomena closely identical with those presented by *Paramecium*, while in *Stylonychia* it would appear, according to Engelmann, that both the transient and the complete form of conjugation may be met with among individuals of the same species. In the normally stationary or attached genus *Stentor* the conjugative process is also transient, the contiguous animalcules, according to Balbiani, becoming temporarily united by their anteriorly located oral areas. A similar transient conjugative act has likewise been reported to obtain among the members of the genus *Podophrya*, but, as shown by the author in the case of *P. mollis*, such apparent act is not unfrequently attributable to the less complex process of multiplication by binary division.

The form of conjugation to be next enumerated is characterized by its complete and permanent duration. Two animalcules or zooids in this case become, as it were, so completely melted or welded together, that their previous individuality is entirely obliterated. Among the Ciliate section of the Infusoria, this special complete or entire conjugative phase is almost exclusively restricted to the Peritrichous family of the Vorticellidæ, but recurs occasionally in alternation with the partial or transient one in *Stylonychia* and other Hypotricha. The most prominent development of this permanent or complete type is undoubtedly met with in the Flagellate section of the series throughout the whole of which, as at present known, it would appear to constitute the one and only conjugative process. Most usually, among these Flagellata, this complete conjugative act is accompanied with the assumption by the coalescing individuals of an outline entirely at variance with the normal specific aspect. The flagella or other appendages are in this instance entirely withdrawn, and pseudopodic processes, like those of an *Amœba* or *Actinophrys*, extended for locomotive or prehensile purposes from various parts of the periphery. Succeeding such conjugation among the Flagellata, it most usually happens that the sporular reproductive phase, described on a preceding page, is immediately entered on, though that such conjugation is not imperatively associated with this spore-production has been demonstrated by the present author, in connection with *Heteromita angustata*, and various other species. As elicited by the recent investigations of Messrs. Dallinger and Drysdale, it occasionally happens that the coalescence of three or four or more metamorphosed or amœbiform Flagellate animalcules takes the place of the more ordinary conjugation of two zooids only. In this latter instance, as illustrated by the biflagellate type *Heteromita uncinata*, a close approximation is made towards that multiple coalescing process by which out of a number of similarly metamorphosed or flagellate zooids the compound amœbiform plasmodium of the Mycetozoa is built up ; a modification of this phenomenon would also, as hereafter shown, appear to accompany the construction of the compound locomotive gemmules, or so-called "ciliated larvæ" of the Spongida.

While the interpretation of the sexual or genetic reproductive phenomena of the Infusoria embodied in the earlier portion of this present section adapts itself most nearly to the data elicited by the most recent investigators, among whom the names of Engelmann and Bütschli are especially noteworthy, it by no means represents the one regarded with the greatest favour prior to the publication of the discoveries of these authorities, nor even yet, perhaps, the one at the present day most extensively maintained. From almost the earliest epoch of their history, the probable propagation of infusorial animalcules by a sexual or genetic process analogous to that which obtains among the higher animals has now and again been suggested. Such an interpretation was thus, though inaccurately, attributed by Sir Edmund King, in the year 1693, to the ordinary process of transverse fission witnessed by him in a species of *Euplotes*, while O. F. Müller, in his 'Animalcula Infusoria,' 1786, figured and described that conjugative process or genetic union of *Paramecium aurelia* since generally admitted, so far as the external features are concerned, to be substantially correct.

Passing over, for the present, that far-fetched and long since abandoned hypothesis advanced by Ehrenberg, in which the contractile vesicle was regarded as a spermatic reservoir engaged in the continued fecundation of closely associated ova, the far more practicable and intelligent one originating with Balbiani in the year 1858 may be cited. By this accomplished investigator it was at the foregoing date first pointed out that the hitherto supposed instances of longitudinal fission, as figured and described by Ehrenberg, of *Paramecium bursaria* and other free-swimming Ciliata, had nothing to do with such a duplicative process, but were indicative of a genetic union or conjugation between two individual zooids. Balbiani further maintained that the nucleus and nucleolus during such conjugative process became transformed into veritable sexual organs, of which the nucleus or endoplast, dividing up into a number of spheroidal fragments, performed the function of an "ovary," and the nucleolus or endoplastule in the same way, after first assuming a longitudinally striate aspect, and then separating into a number of rod-like spermatic elements, fulfilled that of a testis or "seminal capsule." During the process of conjugation, lasting in this species, according to Balbiani, five or six days, the nucleoli or seminal capsules were respectively exchanged, the so-called ovules in each animalcule being thus mutually fertilized on a plan corresponding with that exhibited by the Helicidæ and other monœcious Gasteropoda. These phenomena of fusion or genetic union, first reported of *Paramecium*, were recorded by the same observer as occurring in a variety of animalcules, and were soon, so far as the external circumstances were concerned, found to obtain very generally, but under varied conditions, the union being sometimes transitory and in others permanent, throughout the whole infusorial class. Among the authorities who, after devoting themselves specially to the investigation of this organic group, have arrived at conclusions confirming the discoveries of Balbiani, and have relegated to the nucleus and nucleolus the same respective genetic functions, may be mentioned the names of Kölliker, Stein, Claparède, and Lachmann, and, in a slightly modified manner, also Mr. Carter. This last-named author, however, previous to the discoveries of Balbiani,* attributed the production of spermatic elements to the nucleus, and that of germs or ovules to the general body-substance.

An examination may now be made of those recent discoveries of Engelmann and Bütschli which have resulted in the introduction of an entirely new train of thought respecting the reproductive properties of the Infusoria. After a prolonged and independent research, these two authors have, while admitting the conjugative process, been compelled to reject *in toto* Balbiani's interpretation assigning to the endoplast and endoplastule respectively the functions of an ovary and testis. The characteristic striated aspect exhibited by the endoplastule during conjugation is declared by them to be in no way connected with the production of spermatic elements, but to represent the normal aspect of both this structure and the nucleolus of the ordinary tissue-cell prior to the act of subdivision. Nuclei, in both animal and vegetable cells, are further maintained by them, and confirmed by the observations of Hertwig and Strassburger, to frequently exhibit a similar striated appearance and general likeness to the so-called "seminal capsules" of the Infusoria. Briefly epitomized, the general conclusions arrived at by Bütschli with reference to the conjugative process of the Infusoria are as follows:—During such process the original nucleus or endoplast in both animalcules breaks up into a number of fragmentary portions, and becomes lost among the endoplasm or general body-sarcode. By-and-by an entirely new endoplast is constructed through the gradual assemblage and union with each other of fragmentary particles having a similar general derivation, this newly found endoplast being single and common to the two in such instances as *Vorticella*, where conjugation or fusion is complete and permanent, while two or more, according to the normal number, are reproduced where such conjugation is, as in *Paramecium*, partial and transient. In the case of *Stylonychia mytilus* it is further affirmed

* H. J. Carter, "Notes on the Freshwater Infusoria of Bombay," 'Ann. and Mag. Nat. Hist.,' Ser. ii. Nos. civ. and cv. 1856.

by Bütschli that the endoplast of each individual divides, during conjugation, into four fragments, which, becoming rounded into a form corresponding with the so-called "ovules" of Balbiani, are cast out of the body as "waste matter." The same destiny is likewise attributed by him to one out of the four fragments into which the endoplastule becomes divided—two remaining to represent the normal complement of these structures, and the residual one assuming first a more considerable volume and transparent aspect, and ultimately redividing and constituting the two new nuclei or endoplasts. The endoplastules in all cases preceding subdivision assumed a fusiform shape and striated character, but in no instance was an interchange of these structures between two conjugated animalcules witnessed, as was affirmed to take place by Balbiani. Qualitatively, the endoplastules of the Infusoria are regarded by Bütschli as differing in no way from the endoplasts, and into which latter, in accordance with his observations, they not unfrequently develop. The idea that embryos are developed independently from the endoplast is entirely rejected by this author, the significance attached by him to this structure being simply that of the nucleus of an ordinary animal or vegetable cell. The only reproductive faculty conceded to the Infusoria by Bütschli is that of division or gemmation, the conjugative act being associated by him only with the conference of renewed power or vital energy for the continuation of the dividing process. The superficial analogy existing between the complete conjugative process, as exhibited in the genus *Vorticella*, with the union of the ovum and spermatozoon of the higher animals, is accorded by this author, but hermaphroditism or sexual differentiation, as a constant and essential feature of the representatives of this organic group, is entirely denied. The unicellular nature of the Infusoria is necessarily maintained, in the most thoroughgoing and forcible interpretation of the term, in connection with Bütschli's foregoing exposition of the reproductive features.

Engelmann's latest independent investigations in this direction, while resulting—contrary to his earlier researches—in an entire acquiescence with the views of Bütschli, so far as the reconstructive properties of the endoplast and the total rejection of the embryonic theory are concerned, exhibit certain points of difference. Thus, although the nucleus or endoplast is regarded by him in most instances as the equivalent simply of the nucleus of the histologic cell, this same structure is in certain cases, such as *Stylonychia* and *Euplotes*, interpreted as representing a female element, while the accompanying nucleoli or endoplastules are further stated to be exchanged between two conjugating individuals, and held to exert a possible fecundating influence in the building up of the new nucleus. In the case of *Vorticella*, where conjugation or zygosis is complete, the usually smaller detached zooid, whether derived by fission or gemmation, that encounters and buries itself in the substance of a larger sessile individual, is regarded as a male zooid, and the latter sessile one as the female; in this sense the Vorticellidæ and other types exhibiting similar phenomena are deemed to be essentially hermaphrodite. Conjugation under any circumstance is, however, interpreted by Engelmann as productive of a mere revitalizing or rejuvenating power, enabling the unicellular organism to continue its normal mode of multiplication by binary division. During all conjugative processes, the disintegration and subsequent reconstruction of the endoplastic element, and the assumption by the endoplastule of a striated aspect, reported by Bütschli, is entirely corroborated.

While inclined to acquiesce with the views of Engelmann and Bütschli now briefly recorded, so far as their interpretation of the conjugative process is concerned, and, as previously intimated, to attribute to this process a chiefly revitalizing or rejuvenating function as implying the most logical possible interpretation of the reproductive phenomena exhibited by unicellular organizations, the present author is not prepared to follow these authorities in that part of their argument which involves the disassociation of the endoplast with any function beyond that possessed by the nucleus of an ordinary tissue-cell, or to deny to the Infusoria any faculty of reproduction beyond that of binary division. The one alternative is most intimately, and indeed inseparably, involved with the other, and in this connection sufficient consideration has certainly not been granted by Bütschli and Engelmann to the results practically, and not merely theoretically, obtained by other workers in the same field. That the endoplast does, under certain conditions, exhibit phenomena entirely distinct from those presented by the simple histologic nucleus, and that the Infusorial organism can propagate its kind by means other than those of simple fission, has been already demonstrated in the section devoted to external and internal gemmation, and is conspicuously manifested in such types as *Hemiophrya gemmipara* among the Acinetidæ, in which ramifying diverticula of the endoplast ascend into the anterior bud-like extensions of the body-substance and become separated off, and enclosed within the same, when the latter are severed from the parent organism; phenomena of an essentially similar kind are likewise presented by the gemmiparous *Acineta mystacina* and various species of the genus *Spirochona*. There is, further, no sufficient reason for doubting the accuracy of the observations first made by Eckhard in the year 1846, and since confirmed and extended by Claparède and Lachmann, concerning the production of internal embryos in *Stentor cæruleus* and *polymorphus*, these embryos being developed individually from a single element or node of the characteristic moniliform endoplast. Where such embryos have been reported, Engelmann and Bütschli have dismissed them as merely externally derived parasitic forms, mostly Acinetæ, referable to the genus *Sphærophrya* of Claparède and Lachmann, synonymous with Engelmann's genus *Endosphæra*. Such in many cases they undoubtedly are, and notably in those supposed embryonic forms associated by Stein with the several types *Stentor polymorphus*, *Bursaria truncatella*, and *Stylonychia mytilus*; these unmistakable parasitic forms represent, however, but a small and altogether unimportant minority. Undoubted evidence of the production of embryos through the breaking up of the substance of the endoplast is afforded, in addition to the instances already cited, by Haeckel, in his account and illustrations of the pelagic form *Codonella campanella*, and by Balbiani, in connection with his most recent investigations of the Müllerian type *Didinium nasutum*. In the genus *Euglena* and its allies, the production of embryos through the increment in size and splitting up of the substance of the endoplast has been amply demonstrated by Stein and Carter, and is confirmed also by the observations of the present author. As a last illustration of this production of germs or embryos through the subdivision of the endoplastic element, may be cited Professor Allman's account of the development of a species of *Epistylis*, communicated to the meeting of the British Association, held at Brighton in the year 1875. In this case individuals possessing a normal development of the ordinary band-like endoplast were observed to undergo encystment, the enclosing membrane becoming after the lapse of a few days so opaque as to preclude a clear view of its contents. Upon breaking the capsule open, however, it was found that the endoplast had increased prodigiously at the expense of the surrounding plasma, presenting the aspect of a long and much convoluted cord, while in still more advanced phases this cord-like endoplast had separated into a number of ciliated and free-swimming germs whose contour, as in the case of *Didinium nasutum*, most closely resembled the adult form of *Trichodina* (*Halteria*) *grandinella*. Reproductive phenomena, closely corresponding with those just described, have been recently reported by Everts of *Vorticella nebulifera*.

Before finally dismissing the subject of the production of embryos from the substance of the endoplast, a protest must undoubtedly be lodged against Bütschli's assertion that the fragments into which it becomes separated during or after conjugation, are merely cast out of the body as waste matter. Such an unprofitable destiny is not usually found associated with so essential a structure, and in place of the purely negative evidence adduced, it is equally probable, and far more logical, to presume that these detached fragments represent germs which ultimately develop to the parent forms, as in the case of the endoplastic fragments of *Stentor*, *Vorticella*, *Euglena*, and other types already alluded to. Whether or not the conjugation or fusion of two individual animalcules exerts a direct influence upon the sporular or gemmiparous reproductive phases, in addition to the more ordinary binary segmental one, is as yet scarcely determinable, though that in the first-named case it commonly, if not more usually, precedes spore-production is made evident through the investigations of Messrs. Dallinger and Drysdale, added to those of the present author, in connection with a considerable number of Flagellata.

With respect to the actual act of conjugation, fusion, or zygosis, as it is variously denominated, it is worthy of remark that where such conjugation is complete and permanent, as in the family of the Vorticellidæ, and so far as known, in all the members of the Flagellata, the coalescing units are frequently of diverse size and contour, the one larger and more rounded, and the other smaller and more attenuate. The inference to be derived from this circumstance, combined with the fact that in the conjugative process the smaller unit mostly, if not invariably, becomes absorbed by or immersed within the substance of the larger, is unavoidable. The larger unit takes the place of the female element, and in itself figuratively and physiologically represents the monocellular unimpregnated ovum ; the smaller one to an equivalent degree is identical with the male element or spermatozoon, and through its union with the female one communicates to the latter that re-vivifying influence expressed through a capacity to prolong the reproductive function, and whether that function takes the form of binary division, gemmation, or spore-production, the diœcious generative type may certainly be said to be represented in its most elementary condition. With those animalcules, on the other hand, such as *Paramecium* and *Bursaria*, in which conjugation is simply transient and incomplete, and where both conjugative factors meet and part on equal terms, both the male and female elements, if such are represented, are necessarily united in each individual zooid, and the generative system is as distinctly and essentially hermaphrodite or monœcious.

Affinities of the Infusoria to the Higher Zoological Groups.

Among the very extensive, and in some respects heterogeneous, assemblages of animal forms associated in this volume under the comprehensive title of the Infusoria there is necessarily encountered a series of races or types that not only differ very widely from one another, but which occupy, so far as it is possible to predicate, a very different rank or position with relation to the outlying representatives of the organic series. Being accepted, as already explained, as simple unicellular organisms or Protozoa, no comparisons possessing a homologic value can necessarily be instituted between the Infusoria and any members of the more highly organized and multicellular Metazoa. It remains, however, to be shown that, while no such direct homological comparisons can be established, there permeates throughout the ranks of this extensive group a substratum of superficial or homoplastic resemblances whose existence it is impossible to ignore. Regarded from this point of view, the Infusoria will be found, like an architect's puny and homogeneous clay or plaster model, to, as it were, anticipate and pre-typify the elaborate edifice of multiple and diverse materials afterwards erected or eliminated from this same primary simple plan. In yet another direction it is likewise capable of demonstration that a very considerable number of infusorial animalcules foreshadow or typify in a corresponding manner, in either their isolated or socially aggregated condition, the separate or associated cellular elements out of which the higher tissue-structures or Metazoic organisms are built up. The likeness in this last instance is necessarily far more substantial than in the preceding case, and, as the comparisons instituted are as between cell and cell or equivalent appendages of such cells, all likenesses of this description may in the strictest parlance be termed homologous resemblances. Some of the more prominent examples that fall within this last-named category may be first enumerated. Commencing with the Infusorial group, in its simplest or most lowly organized condition, or in the first place descending yet a step lower, and selecting a simple Rhizopodous Protozoon, such as an Amœba, it is impossible not to recognize that we have here the morphological equivalent or homologue of a tissue-cell in its most elementary condition, as represented by a colourless blood-, lymph-, or ganglionic-corpuscle. The likeness in this instance is, furthermore, not simply one of form; in the case of the blood- and lymph-corpuscles, reptant movements accomplished by the extension and contraction of pseudopodic appendages, and similar to those of the independent Rhizopod, are also freely manifested. It is from such a similar simple repent amœbiform body that many of the flagelliferous members of the Infusorial class take their origin, as demonstrated by the author in the case of *Euglena*, *Eutreptia*, and many Choano-Flagellata, while the retrogression to such a simple elemental type is a familiar phenomenon among the representatives of this same section immediately antecedent to the process of either encystment or coalescence. Proceeding with an examination of the flagelliferous section of the Infusoria in its normal conditions of development, we find at the bottom of the series the curious genus *Trypanosoma* distinguished in the case of *T. Eberthi* by a long attenuate body, around which is spirally disposed a most delicate frill-like membrane, whose active vibrations fulfil the function of locomotion. It is a remarkable fact that an essentially similar type of structure characterizes the exceptionally shaped monocellular spermatozoons of *Triton*, *Bombinator*, and other tailed and tailless Amphibia, as originally figured by Wagner and Leuckart, Unker, and Von Siebold. Spermatozoa in their normal and most familiar form consist merely of a more or less rounded anterior extremity or head, and a dependent flagelliform appendage or tail, and have been recently compared by Professor Huxley * to a simple cell of which the larger and more solid anterior part represents the nucleus, and the dependent tail only the very fully developed and much attenuated peripheral protoplasm. This more normal and simple form of the spermatozoal element is abundantly represented in the class now under consideration. Such simple uniflagellate types as *Monas* and *Petalomonas* exhibit in their adult state of development a type of structure essentially corresponding with that of an ordinary spermatozoon, while the *Heteromitæ*, the majority of the Choano-Flagellata, and numerous Eustomatous Flagellata commence their existence as simple uniflagellate spermatozoon-like organisms. In the case of *Heteromita lens*, as also in that of the swarm-gemmules of the flagelliferous Spongozoa, it is, moreover, noteworthy that in their initial condition of free-swimming existence the individual

* Biological Lectures, South Kensington, Session 1879–80.

unicellular zooids are aggregated together in clusters, closely resembling the sperm-bundles of various higher animals, the same being similarly derived from the repeated cleavage or fission of a primarily single unit. Illustrations of the homoplastic likeness that subsists between certain Infusoria and the more complex forms of spermatozoidal structures are afforded by the *Heteromitæ* in their adult and bi-flagellate condition, in which they resemble in a remarkable manner the so-called "zoospores" or "antherozooids" of various cryptogamic plants, while in the Polymastigous forms *Pyramimonas* and *Chloraster* the modification presented is almost identical with that which obtains in the spermatic elements of *Homarus* and other Podophthalmous Crustacea.

The next recurring structural homotype in the ascending scale as represented by independent Infusorial organisms with relation to the differentiated elements of a compound tissue-structure, is met with in the remarkable multiflagellate type discovered by Professor Haeckel, and which has received from him the title of *Magosphæra*. In this instance the isolated zooids of the normally compound globose colony present a somewhat elongate pyriform contour, and bear at their truncate anterior extremities a number of long whip-like appendages or flagella. A type of structure in all ways comparable with the zooids of *Magosphæra* is repeated in the ciliated epithelium-cells of all higher tissue organisms, from which, compared separately, they are scarcely to be distinguished. One more illustration in connection with the present line of comparison remains to be cited. Many Flagellata, such as *Spongomonas*, *Phalansterium*, and *Uroglena*, are distinguished for their excretion of a glairy gelatinous matrix, within the substance of which the separate units multiply by the process of binary segmentation, and gradually extend the limits of their common domicile. A similar building up by excretion of a common gelatinous matrix, and the extension of the boundaries of the mass by repeated fission within the same, is the essential characteristic of the cartilage cells of both Vertebrata and Invertebrata. The comparison here instituted is, however, still more striking in the case of *Nostoc* and other allied plants. In these latter the condition of simple nucleated cells, imbedded like those of cartilage cells in the midst of a common gelatinous matrix, is generally exhibited, while in that of the Infusoria it obtains only during the duplicative process.

As might have been anticipated, it is among the lower or flagelliferous section of the Infusoria only that are encountered those forms that find their counterpart in the component elements of the higher tissue-structures now enumerated; in a similar manner it will be found that those homoplastic prototypes of certain Metazoic organisms, taken as a whole, exist only among the ranks of the more highly differentiated Ciliate and Tentaculiferous divisions of the group.

Before proceeding, however, to an enumeration of these more highly differentiated homoplasts, it has to be shown that both the Flagellate and

Ciliate sections of the Infusoria share between them one typical developmental phase, which is usually regarded as an essential factor only of the Metazoa. Among all these organisms the first developmental step exhibited by the simple unicellular reproductive cell or ovum is the division of its mass by the process of segmentation or repeated binary fission, the secondary result of which subdivision is the production of a more or less spheroidal aggregation of simple cells or blastomeres, upon which has been bestowed, in reference to its mulberry-like aspect, the characteristic title of a "Morula." Such a Morula is, however, not limited to the Metazoa. As demonstrated in the chapter devoted to the reproductive phenomena of the Infusoria, certain Ciliata, such as *Colpoda*, *Otostoma*, and *Ichthyophthirius*, and an innumerable host of the Flagellata, exhibit in their developmental cycles an essentially corresponding embryonic type. In no point can the segmented cell-mass or Morula of the Metazoon and Protozoon be distinguished, and it is only in the succeeding phases of development that the distinction becomes apparent. Through the disintegration or falling to pieces of the Protozoic Morula, each individual cell or segmented element mostly commences an independent existence, while in that of the Metazoon they remain permanently united and initiate new and complex metamorphoses. Exceptional and highly instructive instances among the Protozoa, in which the Morula condition may be said to be retained as the characteristic adult life form, are afforded by the subspheroidal colony-stocks of *Magosphæra*, *Synura*, and *Syncrypta*, and in a modified manner also by the spheroidal clusters or "cœnobia" of *Anthophysa vegetans*, *Codosiga botrytis*, and other sedentary types. The compound Radiolaria, *Collosphæra* and *Sphærozoum*, &c., may also probably be correctly interpreted as modifications of the moruloid type. Although any direct comparison between the Protozoic and Metazoic organisms beyond this Morula stage would be inconsistent, certain most remarkable homoplastic resemblances invite attention. Commencing with the lowest order of the Ciliate group, and selecting as an illustration one of the mouthless Opalinidæ, it will be at once recognized that there is here presented a form which, on a simplified and monocellular scale, most distinctly foreshadows or epitomizes the structural type exhibited by the so-called "Planula," or ciliated larva, developed by Metazoic organisms, as the direct outcome of the embryonic Morula already described. Like a typical *Opalina*, these Planulæ are characterized by the possession of a more or less ovate body, which is covered throughout its surface with fine vibratile locomotive cilia. In neither case is there any trace of an oral aperture, so that both animals may be described as closed, externally ciliated sacs. In the Planula this closed sac is composed of multicellular elements, arranged in two distinct superimposed layers, the ectoderm and endoderm, while in *Opalina* the entire homoplastic counterpart is fashioned out of a single cell. It is a significant fact, however, that in this latter instance the organism has been recently demonstrated to be multinucleate, a fact in itself suggestive of latent or potential multicellular composition. In the same way that the Opalinidæ may be said to foreshadow the Planula type of organization, it might be suggested that the ordinary stomatode Ciliata, and more especially the multinucleate species, anticipate the next progressive developmental phase of the Metazoic embryo, as represented by the typical "Gastræa" or "Gastrula." The only advance in organization exhibited by this last-named type as compared with the Planula is, that intercommunication between the central cavity and the outer world is now effected through the breaking away of the apical extremity of the primitive closed sac, this apical perforation or "cytostome" constituting the primitive mouth or oral aperture.

As a rule, the Ciliate Infusorium develops, in addition to an oral orifice, a second or anal aperture, but in many it is not distinctly represented; in these the conformity to the Gastræa type is necessarily all the more complete. By Professor Haeckel, to whom the scientific world is chiefly indebted for the discovery of the three several "Morula," "Planula," and "Gastrula" developmental phases of the Metazoic series, it has been suggested that, in accordance with the laws of evolution, these successive transitory phases doubtless represent the permanent conditions of as many primitive and pre-existing Metazoic organisms, to which might be attached for convenience the hypothetic titles of "Arche-Morula," "Arche-Planula," and "Arche-Gastrula." From the foregoing data it is very evident, however, that such archetypes are even yet in existence, and may be successfully sought for among the representatives of the Protozoa.

Entering now upon an examination of those few instances in which representatives of the Infusoria appear to pre-typify, not embryonic or transient, but fully matured conditions of certain lower Metazoa, attention may be first directed to those forms, such as *Paramecium* and *Ophryoglena*, in which the subcuticular layer abounds with the minute evertile structures known as trichocysts. As already pointed out many years previously by Kölliker, Oscar Schmidt, and other authorities, the correspondence between such types and certain of the lower Annelida or Turbellaria is, so far as the general form and the possession and disposition of their trichocysts is concerned, most conspicuous, so that on a simple monocellular scale these Infusoria may be said to foreshadow or pre-typify these simple Annelids. It has been suggested by Louis Agassiz, and also by Diesing, that the typical Vorticellidæ, with their closely approximated oral and anal apertures and well-developed pharyngeal tube, indicate a considerable conformance with the fundamental organism of the Polyzoa—the last-named authority, indeed, transferring this section of the Infusoria to that series. In its originally implied sense it is necessarily impossible to maintain such a proposed affinity, but in a more remote manner, regarding such animalcules as modifications of unicellular zooids in the direction indicated, it may perhaps be accepted. While, as already intimated, *Paramecium* and its allies would appear to pre-typify the Turbellaria, another more lowly organized group of the Ciliata exhibits an entirely distinct and highly interesting affinity. The group in question is that of the Opalinidæ. The simpler members of this section have been already compared with embryonic Planulæ, but in certain of the more highly modified representatives of the family the homoplastic resemblance to the similarly endoparasitic tape-worms or Cestoidea is most marvellous. Both are distinguished for the entire absence of an oral or anal aperture, and are in this respect imperforate saccular bodies. Both occasionally develop horny hooklets or an acetabulate appendage at the anterior extremity wherewith to ensure a permanent adhesion to the internal viscera of the host infested. Both, moreover, share in common a special mode of reproduction, which, while it recurs among the higher Annelida, is met with nowhere else among the Protozoa. Reference is here made to that peculiar form of terminal gemmation exhibited by the *Opalina* (*Anoplophrya*) *prolifera* of Claparède and Lachmann, and several other allied forms, and in which a long series of buds or segments are produced at the posterior extremity, and become successively liberated, like the segments or "proglottids" of an ordinary tape-worm.

The affinities, real or apparent, of one important section of the Infusoria, that of the Tentaculifera, remain to be discussed. At first sight, this group, including *Acineta* and its allies, would seem to stand by itself and to present no special homoplastic points of agreement with any Metazoic type. It is proposed here, however, to show that in more respects than one these suctorial animalcules epitomize most conspicuously, though on a simple unicellular scale, the structural plan of the lower Hydrozoa. To illustrate this resemblance, the Hydroid Polypite in its simplest form, as represented by the so-called "Dactylozooids" recently discovered by Mr. H. N. Moseley,* to play so important a part in the life-economy of *Millepora*, *Stylaster*, and other coral-building Hydrozoa, may be selected. Such a Dactylozooid or Polypite presents the aspect of a long, slender, sinuous body, provided with numerous simple or knobbed tentacles, but is entirely devoid of any mouth or stomach. The function of these Polypites is simply to seize food and convey it to the mouth-bearing polypes or "gastrozooids." There can be little doubt, however, that these rudimentary or secondary Polypites represent the primary and independent zooids of some more ancient stock, and the question naturally arises how in such a case did they ingest food ? In reply, it may be submitted that all that is needed is a perforation of the extremity of each separate tentaculum, such as normally exists in many Cœlenterata, combined with the capacity of incepting food at these orifices. It is this slight modification, furthermore, that is alone required to produce an organism fundamentally corresponding with that of an ordinary suctorial *Acineta*, and whose only means of communication with the outer world is similarly through perforations of the extremities of its prehensile tentacles. In one genus of the Acinetidæ, *Hemiophrya*, it is further worthy of remark that certain of the tentacles only, and those the inner ones, are devoted to the ingestive function, while those

* H. N. Moseley, "On the Structure of *Millepora*," 'Phil. Trans. Roy. Soc.,' vol. clxvii. (1877).

forming the peripheral series are simply prehensile, and catch and convey food to the central ones.

Should a type be discovered possessing, in addition to the peripheral or prehensile series, only one central ingestive tentacle, in place of the three or four that more usually obtain, and which would consequently occupy that position in relation to *Hemiophrya* that is maintained by *Rhyncheta* with respect to *Podophrya*, there would be undoubtedly presented an organism directly comparable with an ordinary gustatory Hydroid Polypite. The homoplastic correlation of the Tentaculifera with the Hydrozoa can be still further extended. In the compound type *Dendrosoma radians*, for example, we meet for the first time, and, as far as yet known, with the only existing instance among the Protozoa in which is produced a decumbent creeping stolon and an erect branching stalk, essentially analogous with the so-called creeping "hydrorhiza" and erect "hydrocaulus," which form the common "cœnosarc" of the ordinary Hydroid Zoophytes. The phenomena of development in this group yield yet another highly suggestive co-ordination in a similar direction. As previously stated, the larval condition of the Cœlenterata generally, including the Hydrozoa, is a free-swimming, mouthless, ciliated sac, named a Planula, with which certain of the Opalinidæ have been indirectly compared. It is a noteworthy fact that the larval condition of the Tentaculifera is also in all cases a free-swimming and mouthless ciliated sac entirely different from the parent organism, whose cilia become similarly obliterated on the assumption of the normal sedentary state.

In addition to the foregoing enumeration of the several apparent homoplastic affinities here suggested as subsisting between the various sections of the Infusoria with relation to certain Metazoa, or to the more simple elements of the same, the morphologic relationship or position of these several groups or sections with respect to each other remains to be summarized. The main lines or phyla of evolution, from the lowest and most simplified factors in the series as represented by such types as *Mastigamœba* or *Monas*, by diversely branching and frequently intercalating tracks, up to the highest members of the class, has been already discussed at length, and diagrammatically illustrated in a preceding chapter. The more intricate question, however, as to which special group or sub-order of the Infusoria generally, or of the Ciliata and Tentaculifera in particular, claims precedence as exhibiting the most highly differentiated structural type, has yet to be decided. More usually this most advanced position has been conceded to the Peritrichous sub-order of the Ciliata, including chiefly the Vorticellidæ, whose higher structural plan is held to be manifested through the reduction and concentration of the ciliary appendages so as to form a simple circular or spiral adoral wreath. Viewed also with respect to the closely approximated positions of the oral and anal apertures, and to the high organization of the pharyngeal apparatus, the evidence would appear to be altogether in favour of the Peritricha.

In certain important points, nevertheless, it will be found that another sub-order, that of the Hypotricha, commends itself equally as a candidate for recognition. It is, for instance, undoubtedly among the representatives of the genera *Stylonychia*, *Euplotes*, and other Oxytrichidæ that we find the most elaborate differentiations of the Ciliate type, certain of the numerous and diversely modified groups of appendages being severally set apart for the accomplishment of the special functions of food-collection, natation, and even ambulation. Such forms, although not indicating any homoplastic affinity, as in the previously cited cases, with the Metazoic series, undoubtedly represent the as yet known most highly specialized type of a simple unicellular animal or Protozoon, and exhibit in this respect, as compared to the other sections of the Ciliata, a type of organization parallel to that which obtains among the higher Insecta with relation to the Annelidous or Myriapodous groups of the Arthropoda. It is not, however, in either of these more highly specialized divisions that the phylum of evolution onwards and towards the yet higher groups of the organic world is to be sought. Such differentiated types represent merely the most advanced and terminal series of an entirely divergent and independent branch or outgrowth from the parent stock. In yet another point, the Hypotrichous sub-order of the Ciliata would seem to lay claim to a higher grade of organization than that possessed by the Peritricha. In their phenomena of reproduction the processes of conjugation, as exhibited by these two sections, are conspicuously distinct, being in the case of the Peritricha complete and permanent, as with the Flagellata and lower Protophytes, while with the Oxytrichidæ, and also certain Holotricha, such as *Paramecium*, the conjugative act is only transitory, the two conjugated individuals finally separating and renewing their independent existence. The approximation in the latter instance towards the genetic reproductive process of the Metazoic series, and in the former case towards the simpler vegetative one known as "zygosis," as it occurs among the lower plants, is self-suggestive, and affords an additional element for consideration in summing up the evidence in favour of the higher organization of these respective groups.

The apparent affinities of the Tentaculiferous class of the Infusoria with reference to the Metazoic series has been already discussed, but not so those that obtain between the Tentaculifera and the Ciliate division of the same group. Excepting for the data yielded by the phenomena of development, no direct relationship indeed would seem to subsist between the two, neither cilia, flagella, nor any recognizable modifications of those appendages being characteristic of the adult forms. In place of such organs these animalcules possess suctorial or prehensile tentacula, which, as explained at length on a previous page, more closely approach, in their simplest condition, the extensile ray-like pseudopodia of *Actinophrys* and other Radiolaria. The free-swimming larvæ or embryos of all Tentaculifera are, nevertheless, characterized by the possession of a more or less complete covering of cilia. These cilia are found in different genera and species to exhibit three separate plans of distribution, which are further remarkable as coinciding essentially with those three patterns of ciliary distribution exhibited by the three Ciliate orders of the Holotricha, Peritricha, and Hypotricha. Thus, the simple forms *Urnula epistylidis*, and *Acineta linguifera*, furnish examples of Holotrichous ciliated embryos; *Podophrya fixa* and *P. cyclopum*, Peritrichous; while in those of *Dendrocometes paradoxa*, *Ophryodendron abietinum*, and *Hemiophrya gemmipara*, such ciliation essentially corresponds with that of the Hypotrichous series. Paying due regard, therefore, to the morphologic axiom that the embryonic history of the higher species foreshadows or epitomizes the adult state or states of others lower in the organic scale, the deduction is unavoidably arrived at that the Tentaculiferous group of animalcules represents a series of organisms occupying a position morphologically higher than that of any of the Ciliata, and all of the leading divisions of which latter are passed through or structurally represented by the Tentaculifera during their earlier or embryonic state. It is a further noteworthy fact that the embryos presenting a Holotrichous pattern of ciliation are met with in association with the simplest representatives of the Acinetidæ, while in the most complex ones, such as *Hemiophrya* and *Ophryodendron*, it assumes the Hypotrichous type. This last-named circumstance may be cited as further correlative testimony towards the evidence already adduced in support of the higher organization of the Hypotricha as compared with the Peritricha. The innumerable intercalating relationships and affinities that serve to bind together and unite in one harmonious whole the several orders of the Ciliata, are discussed at length in connection with the preliminary definitions given of each respective subdivision of the class.

Taking the evidence now submitted in its complete form, and having regard to the innumerable intricacies exhibited in the organization and development of the class Tentaculifera, the position of the highest factor in the Protozoic sub-kingdom is herewith accorded to it, and the anticipation at the same time submitted, that future investigation will serve to establish on a still more substantial basis the affinities between this group and the more elementary factors of the Hydrozoic series.

Distribution of the Infusoria.

Although, taken as a whole, and as already intimated in general terms in the opening paragraph of this volume, the Infusoria exhibit practically no limit to their distribution, it will be found on a closer examination that many out of the various groups, families, and genera present a certain fixed order of diffusion. Among these, some may exclusively inhabit salt water, and others fresh, the several secondary conditions of both these latter elements, whether fresh or stagnant, being also productive of special forms or types. Water in its various conditions, as above indicated, by no means represents, however, the total limit of infusorial dissemination; several groups are distinguished for their exclusively endoparasitic habits, the alimentary and circulatory systems of various Vertebrata and Invertebrata, including that of man himself, being often the unconscious entertainers of infusorial guests. As the result of the most recent investigation, one considerable group is found associated with offensively putrid fish and other animal macerations, while in a totally opposite direction, as discovered by the present author, and recorded in the chapter devoted to the subject of Spontaneous Generation, the limpid water of condensed dew or falling rain as it settles on the grass provides a microcosm for the maintenance of a still more extensive series.

Passing in brief review several of the more abnormal habitats now enumerated or recorded in the succeeding chapters, those infusorial organisms distinguished for their salt-water predilections may be first noticed. Although as yet our knowledge of the marine species of Infusoria may be said to be but imperfect, many generic and family groups may be cited as belonging almost entirely if not exclusively to this category. Commencing with the higher Ciliate division, the free-swimming pelagic forms *Tintinnus*, *Codonella* and *Dictyocysta*, and the sedentary type *Follicularia*, are especially prominent. In the last-named genus, a single fresh-water species, *F. Boltoni*, has, however, been quite recently discovered. Other genera, such as *Lembus*, *Metacystis*, and *Blepharisma*, while essentially marine, are more notably littoral or stagnant sea-water types. To this last-named group have also to be referred the two Hypotrichous family divisions of the Chlamydodontidæ and Ervilliidæ, and the three separate genera *Styloplotes*, *Uronychia*, and *Epiclintes*. Among the Cilio-Flagellata, the genus *Ceratium* is almost entirely marine; *C. longicorne* and *C. kumaonense* being the only known fluviatile forms, while the allied genera *Prorocentrum*, *Amphidinium*, and *Dinophysis* are exclusively pelagic. *Noctiluca* and *Leptodiscus* may be selected from the Flagellate section as the most conspicuous pelagic types, the several genera, *Glyphyidium*, *Anchonema*, and *Conchonema*, being in a similar manner characteristic of sea-water in its stagnant or putrid state. The section of the Tentaculifera is pretty evenly balanced between salt and fresh water habitats; two genera, *Ophryodendron* and *Ephelota*, are, however, so far as known, exclusively marine. Although the foregoing generic and family groups are here quoted as typically characteristic of the marine infusorial fauna, they are by no means cited as constituting an exhaustive summary. It will be further found that a very considerable percentage of the more ordinary fluviatile types of the Ciliata have likewise their marine representatives, and as familiar examples of which may be mentioned the greater number of genera of the extensive family groups of the Vorticellidæ, Oxytrichidæ, and Euplotidæ, not a few species among these, indeed, such as *Ophrydium versatile* and *Uronema marinum*, being notable for their indifferent salt and fresh water habitat.

In an enumeration of those animalcules whose distribution pertains to neither of the two last-named elements, but is for the most part inextricably interwoven with that of various more highly organized animal types, upon whose vital juices they are dependent for their existence, the most prominent position has undoubtedly to be awarded to the mouthless Opalinidæ. All of the various specific and generic types of this important family group are found leading an endoparasitic existence within the alimentary canals, in some instances of various Amphibia, such as newts, frogs, and toads, and in others of various aquatic Annelida, these latter being in several instances marine. Among the Peritricha, the two genera *Ophryoscolex* and *Entodinium* are notable for their limitation to the stomachal cavities of various ruminants, while the Heterotrichous form *Balantidium coli* honours the rectal passage of the human subject with its presence. Other species belonging to the last-named genus, as also its near allies *Plagiotoma* and *Nyctotherus,* limit their attentions in a similar manner to various worms and other lower Invertebrata. The two generic types *Conchophthirus* and *Ptychostomum* form noteworthy examples of the parasitic series, being both found inhabiting the mucilaginous body-slime of various terrestrial Mollusca. The more recently discovered *Ichthyophthirius multifiliis* is remarkable for its attachment to the cuticular surface of young trout, and often causes severe losses to the French fish cultivators by reason of its depredations.

Although the Tentaculiferous section of the Infusoria yields but few examples of endoparasitism, one single genus, *Sphærophrya,* is characterized by its passing the earlier stages or chief portion of its existence within the internal substance or endoplasm of various other animalcules. The Flagelliferous section of the class yields, so far as endoparasitic habits are concerned, a series of examples little inferior in extent and interest to that of the Ciliata. It is to the ranks of this group that have to be assigned the actively motile organisms recently discovered by Mr. T. R. Lewis in the blood of healthy rats, and described hereafter under the title of *Herpemonas Lewisi.* One species of *Trichomonas* has as yet been found only in fluid obtained from the human vagina. *Bodo urinarius* inhabits human urine, while the several species of *Lophomonas* infest the intestinal tracts of the cockroach and other Insecta. The two specific forms here referred to the order of the Trypanosomata undoubtedly represent the Flagellate Protozoa in their most rudimentary condition, and are respectively inhabitants of the blood of frogs and other Amphibia, and the rectal passages of ducks, geese, and other domestic poultry. As intimated in the systematic description of these types, it is possible that they represent developmental conditions of the same organism.*

Apart from the large number of Infusoria that exhibit ecto- and endoparasitic habits, it will be found that a very considerable series, while

* An extensive notice of the essentially parasitic representatives of the Infusoria is embodied in an article contributed by the present author to the 'Popular Science Review' for October 1880.

invariably attached to other living organisms, are not maintained at the expense of the essential juices of these latter, but simply occupy with respect to them the position of co-lodgers or messmates. The very appropriate title of "commensals" has been recently employed by Prof. P. van Beneden to distinguish those organisms among the higher Metazoic series which pass a similar co-associated, non-hurtful, and often mutually dependent existence, and that of "commensalism" for the distinction of the peculiar pseudo-parasitic life habits which they exhibit. As might be anticipated, the phenomenon of commensalism is exhibited among the Infusoria chiefly by those types that lead a fixed or sedentary existence, and is notably conspicuous among the Peritrichous Vorticellidæ. From these may be selected as examples various species of the several genera *Epistylis*, *Zoothamnium*, *Opercularia*, *Cothurnia*, *Scyphidia*, and *Spirochona*, a very large number of which are found in company only with certain species of aquatic Insecta, Crustacea, or Mollusca.

As free or unattached messmates or commensals, reference may be more especially made to the family of the Urceolariidæ, including *Trichodina pediculus*, notable for its intimate relationship with the fresh-water Hydra, and which position it shares with the Hypotrichous form *Kerona polyporum*. Other animalcules of the same family, exhibiting closely corresponding habits, are represented by the two genera *Urceolaria* and *Trichodinopsis*, while a near ally, *Licnophora*, has been found as yet as a commensal only of certain marine Planarians. The genus Ophryodendron, among the Tentaculifera, furnishes in the two species *O. sertularia* and *O. multicapitata* marked examples of pseudo-parasitic life, the former being a common guest of both Sertularian zoophytes and the little hairy crab *Porcellana platycheles*, while the latter, recently discovered by the author, has as yet been found attached only to the limbs and carapace of a species of sessile-eyed crustacean. Descending to the division of the Flagellata, commensalism, so far as is at present known, would appear to be most abundantly represented among the mostly sedentary collar-bearing section of the Choano-Flagellata, where it is further noteworthy that the majority are found attached, as commensals, to the peduncles or loricæ of other higher Infusoria. In this manner *Salpingœca minuta* is found in society with the flagellate type *Dinobryon sertularia*, while *Salpingœca convallaria* grows on *Epistylis anastatica*, and *Monosiga Steinii* on *Vorticella convallaria* and *Epistylis plicatilis*, itself a commensal of the common pond-snail.

While the foregoing summary of some of the more abnormal areas of distribution of the Infusoria subserves the purpose of indicating to the student and collector of this group of beings the localities in which to seek with success for certain specific or generic types, a brief space devoted to an enumeration of the most favoured habitats of the non-aberrant types will probably be welcome. In this direction it need scarcely be indicated that weedy ponds, and slowly running water, containing an abundance of aquatic plants, present both the most accessible and most remunerative hunting grounds. Arrived here, the collector should be careful to secure more especially portions of all the more finely divided plants, such as *Myriophyllum* and *Ceratophyllum*, these affording favourite fulcra of attachment for the sedentary species belonging both to the Ciliate and Flagellate sections of the class, and being especially suited in consequence of their slender contour for subdivision and transference to the glass slide or zoophyte trough for examination. Living plants, however, by no means exhaust the category of material to be secured. Dead leaves, from adjacent trees, that have fallen into the water, and are passing rapidly into decay, are often covered on their lower surfaces with the extensive slime-like colonies of *Vorticella campanula* or *Epistylis grandis.* Specimens of the almost always numerously represented Entomostraca, *Cyclops* and *Canthocamptus*, or higher crustacean forms such as *Asellus* and *Gammarus*, as likewise all larvæ of aquatic Insects, Mollusca, and even Annelida, should be brought home and diligently examined, for some one or more of the many parasitic or pseudo-parasitic species recently referred to. The family of the Daphniadæ or "water-fleas," as exceptions, are rarely the entertainers of infusorial guests.

Ponds of smaller pretensions, presenting only a superficial layer of duckweed, or stagnant ditches with a surface of brilliant green or other coloured slime, may always be visited with advantage. In the latter instance, some representative of the social Euglenidæ, or possibly Peridiniidæ, is usually to be encountered ; while in the former one the pendent rootlets of the floating duckweed will in most cases be found to support a perfect forest-growth of *Vorticellæ* and other Infusoria. Restlessly wandering among the floating leaves of this gregarious plant, numerous Oxytrichidæ, Tracheliidæ, and not unfrequently *Urocentrum turbo* will reward research, while the interstices of the decaying leaves may be examined for examples of the singular genera *Stichotricha* and *Chætospira.* In the ponds of our metropolitan parks and commons that so abound with various aquatic Ranunculi, the various species of brilliantly coloured *Stentors* or "trumpet-animalcules" are commonly met with, their social colonies often forming thin coloured incrustations on the minutely divided leaflets of the plants in question that are conspicuously visible to the unassisted eye. Lastly, in connection with fresh-water habitats, the upland ponds and marshes abounding with *Sphagnum*, *Drosera*, and other bog-plants, are rich hunting grounds that have as yet been but very imperfectly examined, and may be expected to yield a rich infusorial fauna to the investigator. As the result, indeed, of a few brief hours recently spent by the author on the outskirts of Dartmoor, the two new and highly remarkable Flagellate types, described later on under the titles of *Rhipidomonas Huxleyi* and *Spongomonas sacculus*, were obtained.

For the collector sojourning at the seaside, an almost equally unexplored hunting ground is thrown open. Some of the most prolific habitats in this instance are afforded by the living polyparies of the Hydrozoa and

Polyzoa that may be gathered at low-water mark or dredged from the sea-bottom. These in almost all instances produce an abundant harvest of *Zoothamnium alternans* and other attached Vorticellidæ, Acinetidæ, and Flagellata, being in this respect far more prolific than the neighbouring sea-weeds, though certain of the finer divided varieties of these will be found to yield their characteristic types. Many free-swimming species may be secured by a careful surface-skimming of the smaller rock-pools, and more especially such as are invaded by the sea only during the spring tides and are left undisturbed through the intervening intervals. As in pond collecting, the innumerable small Crustacea, Annelids, and other animal organisms with which the sea abounds, should be carefully examined for parasitic forms. For the capture of the less familiar pelagic types, including representatives of the families of the Noctilucidæ, Peridiniidæ, Dictyocystidæ, and Tintinnidæ, the use of a boat and muslin towing-net must be resorted to.

Concerning the geographical distribution of the Infusoria, we cannot be said at present to possess anything approaching a comprehensive knowledge. The infusorial fauna of but few countries or even districts has as yet been thoroughly investigated, while whole continents remain of which it may be said that absolutely nothing whatever is known. From such data as are at present available, nevertheless, and as might be anticipated with reference to organisms occupying so humble a position in the organic scale, it is made manifest that generic, and in many cases even specific, forms exhibit a most diffuse and practically cosmopolitan area of distribution. Thus, a number of types belonging to identical or indistinguishable specific forms are found to occur on the European continent, in England, North America, and the neighbourhood of Bombay. Arctic, temperate, and tropic climes yield, so far as at present explored, no more widely divergent types than are to be encountered within adjacent districts. Even the marine species as a rule exhibit no clear and well-defined demarcation, for the most part including the same generic and in not a few instances specific sorts identical with those obtained from fresh water.

Of the dissemination of Infusoria in time, or in other words their geological distribution, there is, as a necessary consequence of their mostly soft and perishable nature, scarcely a trace preserved. The hard coverings or loricæ of a few species have, however, been recognized by Ehrenberg in the Cretaceous deposits, and referred by him to the genera *Chætotyphla* and *Ceratium*. The siliceous loricæ of the Peritrichous genus *Dictyocysta* occur also in company with the pelagic Polycistina of the Tertiary formations, and there can be but little doubt that the Infusoria in their simplest condition represent one, if not the most ancient, of the stock-forms of the organic series. Accepting, in fact, the Spongida as representatives of the Choano-Flagellata, a subject-matter which is fully discussed in a succeeding chapter, the Flagellate section of the infusorial series is distinctly traceable through every marine deposit from the present day back to the Cambrian and even the Laurentian section of the Palæozoic epoch.

Preservation of Infusoria.

Up to within the last few years no attempts aiming at the preservation of Infusoria in a condition approaching that which they exhibit in their living state appear to have been successful. Ehrenberg and other early investigators succeeded by careful desiccation in securing some shadowy semblance of the pristine form of a few Ciliata, such as *Paramecium* and *Pleuronema*, but for histologic purposes it is scarcely requisite to state that types so preserved are practically worthless. Such progress has, however, been made within the last half of the present decade in the discovery of reagents and preservative fluids for the treatment of all organic tissues, that the securing of permanent slides of the majority of infusorial types is at the present day a mere matter of manipulation. That medium which lays claim to the foremost position in the ranks for the conservation of animalcules in their normal state, is undoubtedly osmic acid. Previously utilized as an ordinary histologic reagent, it was first recommended to the author by Professor Huxley in the year 1877 for the purpose now under consideration, and is at the present time very generally employed. Applied either in the form of vapour or as a solution in distilled water, having a strength of from one to two per cent., the results obtained are most remarkable. All structures, such as cilia, cirrhi and flagella, the internal endoplast, and in *Euglena* and its allies the colours also, are preserved, the animalcules, excepting for the absence of motion, being scarcely distinguishable from the living organisms. With certain of the more exceptionally contractile forms, such as *Stentor* and *Oxytricha*, it is, as recommended by M. A. Certes, better that the osmic acid should be employed in the direct form by placing a drop of the solution on the covering glass before laying the latter upon the slide containing the Infusoria; this plan indeed has been found by the author to be the most effectual and simple of application in the majority of instances. For the *Vorticellæ* the employment of a more concentrated solution of the acid than the one above mentioned is recommended. As pointed out by M. Raphael Blanchard,* and also by M. Certes, colouring reagents, such as hæmatoxylin, eosin, and picrocarmine,† may be advantageously used in combination with osmic acid, and assist greatly in developing the presence and form of the nucleus or endoplast. The animalcules thus killed may be fastened down as permanent preparations, without the addition of any other preservative, and afford valuable material for future reference and comparison. It will be found that the smallest and most delicate flagelliferous species are equally amenable to this course of treatment, preserving their flagella, and even, in the case of the Choano-Flagellata, their delicate sarcode collars, in a life-like form. As attested to in a succeeding chapter, the employment

* 'Rev. Internat. Sci.,' iii. 1879.

† In using this medium, the addition of one part of glycerine and one part of distilled water is recommended by M. Certes.

by the author of this medium for the investigation and preservation of the similar collar-bearing sponge-monads has been attended with the most satisfactory results. In addition to osmic acid, divers other conservative reagents, accompanied with variable success, have been recently introduced. Among these may be mentioned rectified pyroligneous acid, a drop or two of which may be applied in the same manner as the medium last described. Also, a concentrated solution of iodine prepared according to the formula prescribed in Huxley and Martin's 'Elementary Biology,' and embodied in the appended footnote.* The least portion of this fluid added to that containing the Infusoria has been found by the author to act in a manner almost identical with that related of osmic acid, and in some instances even more efficiently. This medium possesses the additional advantage of yielding no deleterious exhalations, which have to be carefully guarded against in the use of osmic acid. An equally efficient and entirely harmless medium for the preservation of Infusoria is, according to M. G. du Plessis,† afforded by a saturated solution of permanganate of potash ; this last-named chemical being recommended by another authority ‡ in combination with chromic oxydichloride acid in the proportions of 25 per cent. chromic acid, 5 per cent. permanganate, and 50 per cent. water. Staining agents, such as the anilin blue or diamond fuchsin, in proportionate parts of, in the first place, one part of the anilin solution to 200 parts of distilled water, plus 800 parts of pyroligneous acid, are reported to act well in the resolution of otherwise obscure endoplastic structures. A 1 per cent. solution of acetic acid is also of important use for this purpose, but on account of its corrosive properties is not available as a medium for conservation.

In many instances, and more especially for the preservation of the retractile-stalked simple and compound Vorticellidæ, the employment by the author of very weak dilute spirit, about one part of spirit to ten of water, has been attended with the most successful results, the stems retaining under such treatment their stalks in every condition of contraction and expansion, and their ciliary discs everted as in life. According to Mr. J. E. Lord,§ the pelagic type *Noctiluca miliaris* may be preserved by mounting in cells filled simply with pure sea-water.

Sir John Ellis's claim for notice as one of the earliest employers of reagents in the investigation of infusorial organisms, the medium utilized being the acrid juice of geranium leaves, has been already mentioned at page 82. Brief reference was at the same time made to the still earlier experiments, in a similar direction, instituted by Sir Edmund King, details of the methods and materials he resorted to being, however, reserved for enumeration under the present heading. Such earliest authentic record, as contributed by Sir E. King to the 'Philosophical Transactions,' No. 283,

* "Prepare a saturated solution of potassic iodide in distilled water ; saturate this solution with iodine ; filter ; dilute to a brown sherry colour."

† 'Science-Gossip,' March 1879.

‡ T. C. in 'Science-Gossip,' May 1879.

§ 'Science-Gossip,' No. 173, 1879.

for the year 1693, embodies the following highly interesting data. Having recorded the results of the application to Infusoria, with a needle's point, of various substances producing no very important effects, he says—"Tincture of salt of tartar (*tartaric acid?*) put with them in the same manner kills them more immediately, but yet they will be first so sick or so affected, call it what you please, as you may see by a surprising convulsive motion, they will grow faint and languid apace, and you may see them fall to the bottom of the drop upon your object plate, dead but in their own shape that they were in before you applied your needle, and will neither be flat as with spirit of vitrol, nor cylindrical as with common salt liquor; but lie dead in the same shape as before you put in your needle with the salt of tartar.—Sack will kill them, but not so speedily as the other liquors."

Methods of Investigation.

To the working microscopist a hint or two will probably prove acceptable with reference to the mechanical means that may be most advantageously resorted to in the investigation of the structure and life-histories of the more minute, and comparatively unfamiliar, representatives of the Infusorial series. These, as typified by the several orders of the class Flagellata, necessarily demand in conjunction with the high-power object-glasses that are indispensable for their correct appreciation, more delicate methods of manipulation.

A chief obstacle encountered in the employment of these short-focussed lenses presents itself at the outset in the matter of penetration. However thin may be the covering glass employed, it rarely fulfils the needs of the investigator, and mostly causes both inconvenience and loss of time on account of its extreme brittleness. Where the objects under examination are attached to more solid substances, such as the stems of water plants, this rigidity and brittleness of the covering glass hampers progress in a most provoking manner, and materially restricts the limits of clear vision. The unsuitability of ordinary covering glasses for the special investigations here alluded to, was long since recognized by the present author, and a substitute provided that has been productive of the most satisfactory results. The material utilized for this purpose was no other than the one extensively employed, previous to the introduction of specially prepared glass, for the permanent mounting of microscopic objects. This substance, represented by ordinary talc as extensively used for gaselier shades, may with a little practice be split into laminæ of such extreme tenuity that they may be blown away with the lightest breath, while for perfect evenness and transparency they will compare favourably with the finest manufactured glass. With the employment of these talc-films the investigation of Infusoria with the $\frac{1}{16}$, $\frac{1}{25}$, or even the $\frac{1}{50}$-inch objectives becomes a comparatively easy task. The material in question possesses the further considerable advantages of bending readily and permitting the object-glass to be brought close down on the more remote objects in the microscopic field, while it may be cut with the scissors to any required size or shape.

In the investigation of the Flagellata, or indeed of any Infusoria in which it is sought to arrive at an accurate knowledge of the life or developmental history of any given type, it is desirable that the same individual zooid or animalcule should be continuously examined. An important mechanical obstacle that has to be overcome in the conduct of such continuous investigation, which may extend over many hours or days, results from the rapid evaporation of the water or other fluid from beneath the covering glass, combined with the necessity of keeping it constantly replenished. Various mechanical appliances for accomplishing the desired end have been introduced by Recklinghausen, Leuckart, and other Continental workers, none of these, however, being equal in efficiency to that employed by Messrs. Dallinger and Drysdale, during their famous "Researches into the Life-history of the Monads," figured and described in the 'Monthly Microscopical Journal' for March 1874. The illustrations given of this apparatus with accompanying explanations are reproduced in the plate devoted to mechanical appliances at the end of the atlas to this volume, and may be thus briefly described. It consists firstly of a plain glass stage, about the one-tenth of an inch thick, fitted so as to slide on in place of the ordinary sliding stage of the microscope. From the left-hand anterior border of this stage a projecting arm is produced which carries a socket for the reception of a small glass reservoir about $1\frac{1}{2}$ or 2 inches deep. The glass stage being too thick to work through with an achromatic condenser and high powers, a circular aperture of sufficient size is cut through it, and a piece of thin glass cemented on its upper surface. A piece of blotting-paper is now cut coinciding in form with the glass stage, but slightly smaller, and with a tongue-like projection that lies along the projecting arm and dips down into the glass reservoir. A circular aperture of larger size than the covering glass employed is cut out of the centre of this paper, such aperture, where a $\frac{1}{4}$-inch cover is made use of, being preferentially the $\frac{11}{16}$ of an inch. The foundation of the moist chamber is now complete, and it only remains to provide the bounding walls. This Messrs. Dallinger and Drysdale accomplish by means of a piece of glass tubing, about $1\frac{1}{2}$ inch in diameter, cut to $\frac{3}{4}$ inch in length. Across one end of this tubing a thin sheet of caoutchouc is next firmly stretched and securely tied, and a small hole perforated in its centre. The tubing with its free edge, which should be carefully ground, is now placed concentrically upon the glass stage, over the aperture in the blotting-paper, and the object-glass racked down upon the perforation in the caoutchouc. The caoutchouc should be sufficiently thin to offer no impediment to the action of the fine adjustment, while it at the same time clasps the object-glass firmly round its central perforation and in combination with the lowermost or free edge resting on the blotting-paper, constitutes a practically air-tight chamber. Everything is now in working action and it only remains to add the material to be examined and to fill the reservoir with water. The water from the reservoir soaking through the bibulous paper keeps the air-tight chamber constantly moist, and evaporating faster from its contained free circular edge, prevents loss of moisture from beneath the covering glass. The water in the reservoir will maintain the moist chamber in the above conditions for many days and will require replenishing only at distant intervals.

Where uninterrupted observation is not demanded, but simply the chronicling of the more important developmental phases of some sedentary or encysted type, and where in the interim the microscope is probably required for the examination of other objects, it will be found convenient to transfer the slides containing the animalcules to an ordinary moist chamber which may be extemporized out of a tumbler or small bell-glass inverted upon a plate containing a few folds of well-saturated bibulous paper. By a registration with a graduated scale on the mechanical stage, or by a rough drawing of the bearings of the type to be re-examined with relation to surrounding objects, it may be with facility refound for subsequent observation. An efficient moist chamber for the same purpose, and, as is often needed, for the transfer of a slide containing living Infusoria from place to place, is ready to hand in the shape of an ordinary wide-mouthed pomatum bottle, with some moistened blotting-paper at the bottom ; the height inside being a little over three inches allows the cork to be thrust down upon the slide, thus keeping it firmly in one position.

The ingenious chambers constructed by Professor Tyndall for the reception of test-tubes in connection with his experiments on atmospheric germs, fully described in the succeeding chapter, and illustrated side by side with Messrs. Dallinger and Drysdale's apparatus, at Pl. L., offer special facilities for the effectual isolation and continued examination of specific infusorial types.

CHAPTER IV.

SPONTANEOUS GENERATION.

THE solution of the yet smouldering, and but a few years since fiercely incandescent, question of "spontaneous generation" is so inextricably bound up with an extensive knowledge and correct appreciation of the vital phenomena of the microscopic beings that form the subject of this volume, that it is felt by the author that a grave error of omission would be committed were not a few pages set apart for its consideration. Spontaneous generation, "*generatio æquivoca*," or as it is now more widely designated "abiogenesis," is by no means an invention of to-day or yesterday. It dates back to the classic times of Plutarch, Virgil, and Aristotle, by which three brilliant leaders and expositors of the world's highest wisdom it was seriously maintained that eels grew out of mud, bees from putrefying flesh, and rats through the vitalizing properties of the sun's rays, without any intervening parental agency. Spontaneous generation as enunciated at the present day is the same in essence if not in fact as when evolved and launched upon the seething waters of scientific controversy over two thousand years ago. Then as now, or now as then, the point sought to be established by its exponents was or is, that organic beings can be and are under certain conditions generated or newly created out of dead organic or purely inorganic material, independently of any pre-existent parent, egg, or germ. With the revival of the arts and scientific culture which distinguished the latter half of the seventeenth century, the theory of spontaneous generation as applied to the grosser forms of animal life, and accepted as an article of creed from the days of antiquity, was attacked and finally disposed of through the labours of such careful investigators as Redi, Réaumur, and Schwammerdam. By the first-named of these authorities, more especially, the maggots found in putrid meat and hitherto supposed to be generated spontaneously, were shown by a combination of careful experiment and inductive reasoning to be the progeny only of flies which had previously deposited their eggs upon it. Reasoning from the constantly observed presence of flies round decaying meat previous to the appearance of the maggots, Redi concluded that these winged insects were the progenitors of the same, and took steps to prove it. Placing meat in a jar and covering it so carefully with paper that flies could not obtain access to it, he found that although putrefaction set in, no maggots were developed, while at the same time these organisms appeared abundantly in similar jars of meat left purposely uncovered. Substituting fine gauze for the paper coverings, the flies were soon attracted by the emanating odour, but being unable to get at the meat deposited their eggs upon the gauze, and out of which eggs minute maggots were then seen to develop. This very simple experiment by which Redi proved his case, carries with it, as presently shown, a most practical and important bearing upon the question of spontaneous generation in the modern acceptation of the term. The weapon, however, that proved of the greatest service at about this same epoch in breaking down the ancient superstitions concerning the spontaneous generation of highly organized animals, was undoubtedly the microscope, now utilized for the first time in unravelling the mysteries of nature.

With this instrument in the hands of Leeuwenhoek, Robert Hooke, Hartsoeker, and other early labourers, it was soon discovered that the hitherto deemed doubtful or spontaneously multiplying species propagated their kind perpetually through the medium of impregnated seeds or eggs, after the manner of the larger and more familiar types, and the idea of spontaneous generation, so far as such organisms was concerned, was banished to oblivion. The agency, however, which thus achieved the overthrow of this theory in one direction, paved the way for its re-establishment in another, and as it at first seemed, on an apparently far more sure and substantial basis.

Among the most important revelations of the hitherto invisible and unknown world made known with the assistance of the microscope, was undoubtedly the discovery by Leeuwenhoek, in the year 1676, of the microscopic beings that form the subject-matter of this volume. The abundant confirmation of this discovery and the intense interest manifested on all sides in so newly indicated and fascinating a field of research, necessarily entailed a speedy recognition of the extraordinary rapidity with which these minute organisms multiplied, and also of their appearance suddenly in vast numbers under auspices totally at variance with the propagative phenomena of all previously known organic forms. None of the then familiar laws of organic reproduction sufficing to explain these several phenomena, the mind naturally reverted to that interpretation of the "incomprehensible" initiated by the philosophers of antiquity, and stamped such abnormal manifestations with the brand of the miraculous.

As indicated in a preceding chapter, the theory of abiogenesis or spontaneous generation, as applied to the minute animalcules produced so abundantly in infusions, took its origin as a possible hypothesis with their first discoverer, and was upheld with more or less force by Gleichen, Joblot, and O. F. Müller. The first, however, to mould this somewhat vague idea into shape and to formulate out of it that definitive doctrine concerning the spontaneous production of the lowest organisms that with varying fortune has commanded adherents thenceforward up to the present time, was undoubtedly our own countryman Tuberville Needham, who in his 'New Microscopical Discoveries,' printed in the year 1745, and various subsequent publications, declared that infusorial animalcules were directly and spontaneously engendered from more highly organized bodies in a state of putrefaction. This bold declaration was entirely approved by Buffon, who further maintained that with respect to these organisms such a mode of generation was not only the most frequent and universal, but also in all probability the most ancient.

Such being the definite position taken up by the advocates of spontaneous generation, it was not long before it was vigorously assailed, the controversy that ensued surpassing probably in acrimony and the extent of its duration that of any yet brought within the area of scientific polemics. The earliest authority to declare himself opposed to this doctrine and to submit an intelligible interpretation of the apparently anomalous conditions of growth and reproduction of infusorial organisms, is usually held to be the Abbé Lazzaro Spallanzani, of Pavia, who in the year 1765 enunciated the opinion that such animalcules were propagated through the medium of minute germs constantly present in the atmosphere, and which fructified or developed immediately they came in contact with the conditions suitable for their growth furnished by artificial or other infusions. The atmospheric "germ theory," attributed to Spallanzani, can boast, however, of a far more remote antiquity. Seventy years prior to the time of Spallanzani (1696), an Englishman, John Harris, whose name as one of the earliest observers of infusorial life has been previously quoted, contributed to the 'Philosophical Transactions' a suggestion concerning the generation of these minute beings that is now, almost two centuries later, found to represent the true position of the case more nearly than any of the manifold interpretations brought forward between that date and the present time. In the course of his observations upon the subject of infusorial animalcules, embodied in the foregoing communication, the following paragraph occurs:—

"How such vast numbers of animals can be as it were at pleasure, produced, without having recourse to equivocal generation, seems a very great difficulty to account for. But the solving of it that way makes short work of the matter (for 'tis easie enough to say they are bred there by putrefaction), yet the asserting equivocal generation seems to me to imply more absurdities and difficulties than perhaps may appear at first sight. I wish therefore that this matter would a while imploy the thought of some ingenious and inquisitive man. In the mean time I've conjectured that these *animalcula* may be produced by one or both of the following ways. I. I have thought that the eggs of some exceeding small insects, which are very numerous, may have been laid or lodged in the plicæ or rugæ of the coats of the grain by some kinds that inhabit the same as their proper places. For that insects of the larger kinds do frequently thus deposite their eggs on the flowers and leaves of plants, has been often experimented; and 'tis very probable that the smaller or microscopical insects do the same. Now these being washed out of the seeds, by their immersion in water, may rise to the surface and there be hatched into those animals which we see so plentifully to abound there. II. Or the surface of the water may arrest the straggling eggs of some microscopical insects that were perhaps about in the air, and being fitted and prepared for the purpose, by the infusion of proper grain, or a proportionable degree of heat, may compose so proper a nidus for them, that they may by the warmth of the sun be easily hatched into living creatures . . . . and perhaps sometimes both these circumstances, and others of the like nature, concur for their production."

Making due allowances for John Harris's conception of Infusoria as the product or offspring of microscopically minute insects, it is astonishing to find how closely his two suggestions of their being primarily attached in the form of eggs to the rugæ and plicæ of the surfaces of the vegetable substances experimented on, or of their falling from the atmosphere and germinating in such suitable liquid nidus as may present itself, coincide with the actual distribution of infusorial eggs or spores as demonstrated by the most recent research.

Proceeding to an enumeration of the results obtained by the many "ingenious and inquisitive men" who, following the recommendation of John Harris, did "imploy their thoughts" upon the subject of infusorial propagation, it has to be further recorded of Spallanzani that he initiated the experiment of filling flasks with organic infusions, and after hermetically sealing their apertures and boiling their contents, showed that no life was generated in them, however long they remained in their closed condition. The Genevan naturalist Bonnet, the intimate friend of Spallanzani, adopting the same line of argument, proceeded so much further as to declare that all substances both organic and inorganic were permeated with these infinitely minute germs, and that these germs were in some cases able to resist the highest temperatures. This latter property ascribed to the organic germs was the outcome of certain exceptional cases in which, in infusions boiled and confined in flasks in the manner above indicated, living organisms were found both by himself and Spallanzani to make their appearance.

This point of the controversy being arrived at, the subject attracted such general attention that the whole world of science may be said to have divided itself into two hostile camps, the one supporting Needham's and Buffon's, and the other Spallanzani's and Bonnet's hypotheses. As rallying titles or *noms de guerre* that should serve to distinguish the adherents of these two respective camps, that of "heterogenists" was generally associated with the supporters of abiogenesis, or who, as the word implies, advocated the heterogenetic or spontaneous generation of the organisms under dispute; that of "panspermists" being applied with corresponding significance to those followers of Spallanzani who attributed the rapid propagation and distribution of Infusoria to the universal presence of their germs in the surrounding air. Among the many doughty champions who, as successors to Needham, distinguished themselves for their ardent devotion to the cause of abiogenesis or heterogeny during the earlier portion of the nineteenth century, have more especially to be placed on record the names of Lamarck, Oken, Bory de St. Vincent, and Dujardin. On the side of the "panspermists," on the other hand, appear during the same epoch those of Paul Gervais, Schwann, Schultze, and

Ehrenberg. Lamarck, one of the most fervent advocates of heterogeny, in his celebrated 'Philosophie Zoologique' (Paris, 1809), freely declared that all bodies were constantly undergoing mutations of form, some passing continually from the state of the inorganic into the organic, and others reverting from the living to the inanimate condition. Nature was further represented as thus exhibiting one continuous evolutionary cycle, and with the aid of heat, light, moisture, and electricity, as producing new organisms by direct or spontaneous generation at the initial or root terms of both the animal and vegetable kingdoms.

Almost contemporaneously with this pronunciamento of Lamarck appeared also Lorenz Oken's celebrated 'Lehrbuch der Naturphilosophie,' in which, in addition to further expounding his views initiated in the year 1805 concerning the fundamental construction of all living bodies out of vesicular or cellular elements that found their equivalents in the independent and simple vesicular bodies of infusorial animalcules, he declared himself most strongly in favour of "spontaneous generation." Oken's remarkable enunciation of these two separate principles in their mutual or interdependent aspect is thus expressed in the treatise above quoted :—

"The first organic points are vesicles. The organic world has for its basis an infinity of vesicles.—The mucous primary vesicle may in a philosophical sense be aptly called an infusorium.—If the organic fundamental substance *consist* of infusoria, so must the whole organic world *originate* from infusoria. Plants and animals can only be metamorphoses of infusoria.—This being granted, so also must all organizations *consist* of infusoria, and during their destruction dissolve into the same. Every plant, every animal is converted by maceration into a mucous mass; this putrefies, and the moisture is stocked with infusoria.—Putrefaction is nothing else than a division of organisms into infusoria, and reduction of the higher to the primary life.—Organisms are a synthesis of infusoria. Their generation is none other than an accumulation of infinitely numerous mucous points or infusoria. In these the organisms have not been at once wholly and perfectly depicted as on the smallest scale, nor contained in a state of performation; but they are only infusorial vesicles, that by different combinations assume different forms, and grow up into higher organisms.

"As the whole of nature has been a successive fixation of æther, so is the organic world a successive fixation of infusorial mucous vesicles. The mucus is the æther, the chaos for the organic world. The semen of all animals consists also of infusoria; the same may be said of the vitellus.—Every generation commences *à priori* or from the beginning. The organic substance must again be dissolved into the original chaos or mucus if anything new should originate.—Out of an organic menstruum only can a new organism proceed, but not one organism out of the other. A finished or perfect organism cannot gradually transform itself into another.—The generative juices, or semen and vitellus, are none other than the total organism reduced to the primary menstruum.—Physically regarded also, every individual originates only from the absolute, but no one out of the other. The history of generation is a retrogression into the absolute of the organic, or the organic chaos-mucus, and a new evolution from the same.—This development from mucus is only applicable, however, to the generation of the perfect organisms, but not to the origin of the organic body, or the infusorial mass. The former originate only from an organic mass that has been already formed; but the infusorial mass, as constituting the organic primary bodies, cannot have originated in the same way. It was and must originate directly from the inorganic. From whence can the organic have otherwise proceeded?—The infusorial mucus-mass originated at the moment when the earth's metamorphosis was at an end, and at the moment when the planet succeeded in so bringing together and identifying all the elementary processes, that they were all together or at one and the same time in every point.—This origin of the organic primary bodies I designate *generatio originaria*, *creation.*—But infusorial vesicles can also originate by mere division of larger organic carcases, and these can again originate as well through the combination of these secondary as of the primitive vesicles, or as it were by coagulation only. I nominate this generation *generatio æquivoca.*—There are only two kinds of generation in the world, the creation proper and the propagation that is sequent thereupon, or the *generatio originaria* and *secondaria.*—No organism has been consequently created of larger size than an infusorial point. No organism is, nor has one ever been, created, which is not microscopic. Whatever is larger has not been created, but developed."

Wild, fanciful, and bordering on the very verge of "idiotic inspiration," as Oken's utterances in connection with the above and kindred physiological problems have been most generally pronounced, our wondering admiration must, so far as the present subject-matter is concerned, certainly be accorded to the creations of this most original and master mind. Notwithstanding the inability to reconcile his views of the constant recurrent or spontaneous generation of Infusoria out of inorganic matter with our present more perfected knowledge of the vital phenomena of the class, his conception of the morphologic value and significance of the infusorial body with relation to organic life in general, and compound or tissue-forming organisms in particular, has certainly anticipated in a most clear and striking manner the views expounded as original by many eminent physiologists who have succeeded him. Giving Oken his due, to him most certainly must be accredited the origination of the cellular theory subsequently introduced by Schleiden and Schwann; for what otherwise than the equivalents of cells, the ultimate factors of all organic bodies as recognized at the present date, are Oken's "first organic points," or "mucous primary vesicles"? By his comparison of the infusorian body with such a simple mucus-vesicle or cell, he anticipates again that conception of the same adopted by Von Siebold and Kölliker, and confirmed by the most recent investigation, while in his interpretation of all higher organisms as compound agglomerations of infusorial bodies, or their equivalents, and in his declaration that organic life must have originated with these simple infusorial types, out of which again by a process of development, and *not through independent creation*, the higher forms have been constructed, is most naturally foreshadowed that grand doctrine of evolution with which the names of Lamarck and Darwin are so honourably associated.

Returning to the more legitimate subject of discussion, that of "spontaneous generation," notice must now be taken of the arguments advanced by the leading and contemporary partisans of the opposite or panspermist persuasion. Ehrenberg, one of the most ardent espousers of this latter cause, based his objections to the spontaneous form of reproduction on the many new facts concerning the organography of the Infusoria elicited through his special investigations, and which included, in his own estimation, the discovery of reproductive organs and the production of ova corresponding with those of the higher animals, and which circumstance he declared rendered the addition of an independent or spontaneous mode of growth entirely superfluous. Evidence of a far more substantial nature, and which was held at the time to be utterly subversive of the cause of the heterogenists, was that produced by Schultze and Schwann in the years 1836 and 1837. The former of these demonstrated that organic infusions after boiling might be exposed to the action of the atmospheric air for many months without developing living animalcules, provided such air passed first through concentrated sulphuric acid, which was pronounced by Schultze to destroy or devitalize the air-suspended germs. The results obtained by Schwann and the means employed were precisely identical, excepting that calcined air was substituted by him in place of sulphuric acid. An important conclusion arrived at by this investigator, as a necessary corollary of the above results, was, that the putrefaction of organic bodies was entirely dependent on the associated growth and multiplication within their substance of minute organisms, such as Infusoria and their allies.

Helmholtz in the year 1843, and Schröder in various contributions published between the years 1854 and 1859, accumulated additional evidence in favour of the panspermists, and towards demonstrating that the animalcules developed in infusions originated mainly, if not entirely, from preexisting atmospheric germs. Among the more noteworthy experiments of Helmholtz, it was shown that a putrefying infusion, and one sterilized by boiling, might be divided from each other by means of a thin membrane only, so that the liquid masses of the two might freely intermingle through the processes of exosmosis and endosmosis without the latter one becoming tainted, as it indubitably did if the smallest portion of the putrescent fluid was added to it in its concrete form. The unavoidable conclusion derived from this experiment was that the germs existed in the putrescent infusion as actual very minute and solid particles that could not pass like the associated fluids through the intervening membrane. Following out this same line of demonstration, Schröder further showed that simple plugs of cotton-wool inserted in the necks of flasks containing organic infusions sterilized by boiling, sufficed as efficient filters for the exclusion of organic germs, and for the indefinite maintenance of the liquid in the sterilized condition. This last-named experiment is now commonly repeated; flasks of sterilized putrescible fluid being at the present moment on view at the South Kensington Biological Laboratory, which have remained for many years with a similar simple cotton plug guarding their contents from the invasion of organic germs and accompanying putrefaction.

Notwithstanding the almost overwhelming amount of evidence now adduced in contravention of the hitherto extensively upheld doctrine of spontaneous generation, a new champion of its cause was soon to the forefront, and one who has almost down to the present day laboured with all his force and much ingenuity to prove his case. This new leader of the heterogenists was no other than Dr. F. A. Pouchet, the accomplished

Director of the Rouen Natural History Museum. In the year 1847 Pouchet had already demonstrated that the multiplication of Infusoria by the process of fission was by no means so common as was ordinarily supposed, and that the astonishingly rapid increase of their numbers could not be accounted for by such simple means. It was not, however, until the year 1859 that he brought forward that new interpretation of their developmental phenomena with which his name is most eminently associated. In accordance with the representations of this author, the most important factor in the production of animalcules, independent of parental agency, or in other words by spontaneous generation, was the filmy or gelatinous skin or pellicle, that within a greater or less interval is commonly developed on the surface of putrefying infusions. According to Pouchet this superficial pellicle, designated by him the pseudo-membrane, or "proligerous membrane," was the matrix, produced through the decomposition or breaking down of pre-existing organisms, in which egg-like bodies were generated *de novo* and developed into various species of Infusoria. The idea of the germs existing in the atmosphere in sufficient quantities to produce their normal and remarkably rapid development, as held by the panspermists, was rejected by Pouchet as not only untenable, but ridiculous, he reasoning that if such abundance obtained, they would visibly interfere with the clearness of the atmosphere and produce masses comparable with the clouds themselves.

The arguments of Pouchet were not destined to remain long unchallenged. In the following year, 1860, M. Pasteur, the eminent chemist of the Parisian Conservatoire, entered the lists on behalf of the panspermists, and after several years of animated controversy with Pouchet and his partisans, accompanied by the most patient and ingenious experiments, achieved results that most completely turned the tables upon the heterogenists. Among the more prominent and positive of these must be mentioned Pasteur's actual collection of floating organic germs, mingled with inorganic particles from the atmosphere, and which sown by him in sterilized infusions, were found to develop the ordinary infusorial animalcules in abundance. It was further demonstrated by the same investigator that the atmospheric germs in question were by no means so evenly and abundantly distributed as the panspermists had previously maintained. Thus, while sterilized infusions became immediately affected, and crowded with animalcules, when exposed to the grosser and comparatively impure atmosphere of large towns, or other thickly peopled districts, he showed by direct experiment that the same infusions bore the ordeal of exposure to the clear and moteless atmosphere of the Alpine glaciers without exhibiting the slightest alteration or trace of organic life. Transporting his experimental flasks to the pure and tranquil air of those subterranean vaults or "catacombs" for which Paris is so famous, a similar exemption from organic change was observed. In a still more complete and precise manner, Pasteur also repeated and confirmed the experiments of Schwann and Schröder already mentioned, and in the long run produced so complete and logical a chain of evidence in support of the atmospheric dissemination of infusorial germs, and their derivation from similar antecedent parents, that his views were accepted by the Paris Academy as definitely solving the long contested problem in favour of the panspermists.

Banished from France, the doctrine of heterogeny or abiogenesis has yet once again, and probably for the last time, found a staunch advocate in England, the land of its birth, where, however, as presently demonstrated, such reappearance has been associated with an even more disastrous defeat than that administered at the hands of M. Pasteur. The English champion and recognized leader in these latter days of the forlorn hope of heterogeny, Dr. H. Charlton Bastian, entered the public arena in that capacity early in 1870. Already, in January of that year, Professor Tyndall approaching the subject from an entirely independent standpoint, had, as hereafter recorded, declared himself entirely in favour of Pasteur's panspermic interpretation, and it was with the view of refuting the arguments of both of these investigators that Dr. Bastian took up the gauntlet.

Divested of all irrelevant matter, the evidence elicited through his independent experiments was productive of two new arguments, which without doubt, had they remained uncontroverted, would have once more secured a substantial victory for the cause he advocated. In the first place, Dr. Bastian declared that he had succeeded in obtaining growths of bacteria, and other organic germs, from infusions remaining in hermetically closed flasks, from which almost the whole of the air had been expelled by boiling. As at this period of the controversy it was a mutually accepted axiom of heterogenists and panspermists alike that living matter in no shape or form could survive exposure to the temperature of boiling water, 212° Fahr., it necessarily followed that both this axiom and Dr. Bastian's results being substantiated, the organisms developed in the infusions after ebullition were the product of *de novo* or spontaneous generation. In the second place, he declared that all the evidence yet adduced since the date of its first announcement, concerning the existence of germs of invisible or ultra-microscopic minuteness in the atmosphere, springing from and developing to a *known* parental or specific type, was entirely negative, and as a necessary sequence totally unreliable and unworthy of credence. These two points of contention raised by the partisans of heterogeny through Dr. Bastian, viz. the unproduced proof of, firstly, the absolute existence of these prederived ultra-microscopic germs, and secondly, the capacity of such germs to withstand a temperature of 212° Fahr., represent the last tenable position held by the adherents of the doctrine of spontaneous generation, and with the carrying of that position, so far as its serious entertainment by the reasoning and scientific mind is concerned, this doctrine undoubtedly receives its final death-blow.

The two missing links in the otherwise strong chain of evidence adduced by the panspermists, and indicated in the preceding paragraph, have now to be supplied. Their production has necessarily, and as a guarantee of their reliability, to be the joint product of several independent workers, and those names which must ever remain memorably associated with their forging, are those of Professor Tyndall and Messrs. Dallinger and Drysdale. As a humble labourer at the eleventh hour only, seeking for and obtaining evidence of an independent character corroborative of the important results achieved by the foregoing authorities, the author of the present volume is, as presently shown, also in a position to subscribe his name as an additional witness for the panspermists.

Commencing with the achievements of Professor Tyndall in this special field of research, it has first to be related that his earliest association with the subject of spontaneous generation was the result of a happy accident. In the course of those physical investigations for which his name is so justly famous, he happened, while experimenting on the subject of radiant heat in relation to the gaseous form of matter, to require air that was completely free from all extraneous or floating matter, however fine. The passage of the same through alkalis, acids, alcohols, and ethers, was found insufficient to produce the purity desired ; but on the other hand, air filtered through cotton-wool, air kept free from agitation sufficiently long to allow the floating particles to subside, air in a calcined state, or obtained from the deeper cells of the human lungs, proved to be effectually cleansed from all such floating substances and to be in every way suited for the purposes required. A delicate and certain method of testing atmospheres to ensure their requisite purity was also devised by Professor Tyndall. This ready test was found to be presented by a concentrated beam of the oxyhydrogen or electric lamp. Surrounding objects being in darkness, such a beam thrown across the ordinary atmosphere revealed its track in a similar manner, but to a still more intense degree, as a sunbeam shining through a minute aperture of a closed window-shutter ; wherever it passed it either threw up vividly distinctly moving dust, or presented a turbid or foggy aspect, through the reflection or scattering of light of the myriads of invisibly minute particles with which the same air was laden. Passing a similar beam through air purified in either of the manners above recorded, no such interruption of its course occurred, and from one end to the other of the traversed space its route was dark, and entirely indistinguishable from the surrounding and unilluminated atmosphere.

It presently occurred to Professor Tyndall that the important results obtained by Schwann, Schröder, and Pasteur, and other notable panspermists, concerning the sterility of certain exposed infusions, were intimately associated with those pure and moteless optic conditions of the atmosphere last described. Put to the test, this inference was verified beyond his most sanguine expectations. The ordinary infusions of turnip, hay, and other organic substances were prepared in tubes, and after boiling left to their fate in carefully closed chambers of ingenious construction, whose air contents, after two or three days allowed for subsidence, were shown by the electric beam to be entirely pure and moteless. Other tubes containing a like infused material, prepared under precisely similar conditions, were placed in the ordinary air immediately adjacent to but outside the last-named chambers, and the result awaited. It was this: In the course of three or four days the tubes *outside* the chamber became turbid and swarming with Bacteria and other organisms, while those in the *inside* were as clear and sterile as on the day of preparation, and furthermore remained in the same sterile and pellucid state for several months. At the end of this period a door in the chamber wall was opened, so as to allow the ingress of the ordinary atmosphere, and within three days after such exposure they too became affected and swarming with bacterial life. One logical inference only was to be derived from these results. The Bacteria and other microscopic forms were abundantly present in their germinal state in that ordinary and dust-laden atmosphere on the outside of the closed chamber, and indicated their presence by falling into and freely developing in the suitable nidus provided for them in the exposed tubes. In the still, optically pure, and what may be correctly termed "empty," atmosphere of the closed chambers they were, on the other hand, entirely absent, though all the while, as the sequel demonstrated, beating against the outside of the door and ready to rush in by millions to carry out their work of infection and destruction immediately the portal was thrown open.

Varying his experiments in every conceivable form, a like ultimate result was arrived at. Thus, since leading heterogenists had declared that a high temperature was most suited for the production of *de novo* generation, and especially one approximating that of 115° Fahr., tubes, with infusions as before mentioned, were maintained at this temperature in one of the compartments of the Turkish Baths, Jermyn Street, for nine days without any trace of life appearing. To meet, again, the argument that certain organic infusions were more productive than others of spontaneously generated life, well-nigh the entire catalogue of animal and vegetable substances used in domestic economy, and including among the former beef, mutton, hare, rabbit, kidney, liver, fowl, pheasant, grouse, haddock, sole, salmon, cod, turbot, mullet, herring, whiting, eel, and oyster; and among the latter hay, turnips, potatoes, oatmeal, tea, coffee, hops, &c., were ransacked and severally experimented upon by Professor Tyndall, but with the same result. So long as the infusions were kept in pure and moteless air, so long did they remain pellucid and free from the slightest trace of bacterial or other life, but in all cases on exposure to the ordinary dusty and germ-laden atmosphere, they became, within three or four days at the outside, swarming with organic forms. A small pinch of dust from the laboratory floor, or a dip on a needle's-point from a previously infected infusion, was in either case found sufficient to inoculate the sterile tubes confined in the moteless chamber, though the time occupied in the development of the moving organisms in these two respective cases presented conspicuous points of divergence. Where the inoculation was produced through a needle-dip from an already affected tube the resulting contagion was almost immediate, while where dust was supplied in its dry form, two days mostly elapsed before any indication of such inoculation made its appearance. The sagacious explanation of these phenomena, given by Professor Tyndall, was that the dust supplied contained only germs in a desiccated state, which necessarily required a set time, or "period of latency," to expire before they displayed their vital properties; while in those taken from the fluid medium, these vital properties were already in their full force, permitting the organisms to increase and multiply from the first moment of their contact with the sterile liquid.

One interesting experiment bearing upon the phenomenon last described requires mention. A certain mineral solution, containing in proper proportions all the substances which enter into the composition of Bacteria, was found after inoculation with the least speck of liquid containing living Bacteria, to be always swarming and turbid with such organisms within a space of twenty-four hours; while a small pinch of laboratory dust added to the same fluid, and containing the germs in their desiccated condition, remained in contact with the fluid with impunity for many weeks. Bacteria in their living and moist condition, and those in their desiccated state, were thus shown to possess highly differentiated developmental properties. Another fact of importance, elicited by Professor Tyndall, bears reference to the want of uniformity in the distribution of bacterial and other germs in any given atmosphere. This was demonstrated through the preparation of large trays, contrived to hold as many as from sixty to one hundred tubes of infusions side by side, and on the same level. All of these exposed to dust-laden air were infallibly, after a greater or less duration of time, teeming with living organisms, but the order of their affection or inoculation was found to differ considerably, intervals of several days not unfrequently elapsing between the inoculation of closely contiguous tubes. A considerable difference was likewise found to obtain, under such conditions, in the character of the developed matter, Bacteria of different species, fungoid growths, and other organisms, variously and irregularly preponderating. Professor Tyndall happily explains these phenomena by comparing the aerial distribution of microscopic germs to the cloud-patches visible in a mottled sky; all parts of the landscape, as represented by the tray of tubes, being overshadowed in turn by these patches, but in no definite or regular sequence. It has been pointed out by Professor Huxley, that a closely corresponding simile was originally employed by Ehrenberg, who as an exponent of the atmospheric distribution of Infusoria, either as eggs or in their encysted state, likened the non-uniformity of their occurrence under such conditions to irregularly alternating days of sunshine and heavy downpour. As shown already, however, at page 120, the atmospheric germ theory originated with John Harris, more than a century prior even to the time of Ehrenberg.

That the atmosphere in its purest state may be entirely free from organic germs, had already been demonstrated by M. Pasteur through exposing infusions with perfect immunity from infection, to the open air of the Mer de Glace, which experiment, with precisely identical results, was repeated by Professor Tyndall in the vicinity of the Bel Alp at an elevation of 7000 feet above the sea, in July of the year 1877. Respecting the capacity of Bacteria and atmospheric germs to resist exposure to abnormal elevations of temperature, he found the widest divergence to obtain in materials derived from different sources or in different conditions of vitality. Where the fully developed and vitally active organisms were experimented on, contact with boiling water, or sometimes a temperature considerably below ebullition, was found sufficient to deprive them of life, but where the desiccated germinal matter was operated on, the results were as a rule entirely reversed. In some few instances these germs were so tender as to succumb to boiling for a term of five minutes, or even less, while in extreme cases they were found sufficiently obstinate to survive a similar ordeal of no less than eight hours' duration. As regards their respective "death-points," or limit of heat-resistance, Professor Tyndall suggests that the infusorial germs of the atmosphere might be conveniently classified under the following heads: "Killed in five minutes; not killed in five minutes, but killed in fifteen; not killed in fifteen minutes, but killed in thirty; not killed in thirty minutes, but killed in an hour; not killed in an hour, but killed in two hours; not killed in two, but killed in three hours; not killed in three, but killed in four hours." Several cases of survival after four, five, six, and even eight hours' boiling were met with, and as he further remarks, there is no valid warrant for fixing upon eight hours as the final limit.

The germinal dust obtained from long preserved, and thoroughly desiccated, hay was in all instances found to yield the most obstinately resisting material, and the presence of a truss of hay anywhere in the vicinity of the germinal matter experimented on, always constituted an important factor in its reduction by boiling to a condition of sterility. Notwithstanding, however, the great resistant property possessed by a large number of these germs, Professor Tyndall has shown that even the most obstinate can be sterilized or killed if certain precautions are taken in their treatment. These consist of setting aside the infusion containing them, after ebullition, in a warm room for a period of ten or twelve hours, then raising it again to, and maintaining it for a short interval at, the boiling point, repeating the process with similar intervals of rest several successive times. By these means the germs as they approach their point of final development are successively killed off in the order of their resistance, and the liquid is in the end completely sterilized.

The special chambers improvised by Professor Tyndall for the conduct of the experiments above recorded recommend themselves so strongly, on account of their simplicity of form and efficiency in action, both for further experiments in a similar direction, and for the cultivation of Infusoria generally, that an illustration of one constructed to hold six test-tubes, as given by its talented inventor, is embodied in the plate at the end of the Atlas devoted to mechanical appliances. This simply constructed apparatus consists of a square wooden chamber or box, having a glass front, side windows, and back-door. Through the bottom of the chamber test-tubes pass, packed air-tight, with their open ends protruding for about one-fifth of their length into the chamber. Provision is made through sinuous glass tubings for the free access of air from without, but through which, on account of their sinuous form, no germinal or other dust obtains admission to the central chamber. The top of the chamber is perforated by a circular hole two inches in diameter, and closed air-tight by a sheet of indiarubber. This is pierced in the middle by a pin, and through the pin-hole is pushed the shank of a long pipette, ending above in a small funnel. The shank also passes through a stuffing-box of cotton-wool, moistened with glycerine; so that, tightly clasped by the rubber and wool, the pipette is not likely in its motions up and down to carry any dust into the chamber. The four legs upon which the chamber is elevated are of sufficient height to permit of the application of a spirit-lamp, or other heat-generator, to the bases of the depending test-tubes.

Proceeding now to an examination of the more important data bearing upon the subject of spontaneous generation, obtained through the investigations of Messrs. Dallinger and Drysdale, it must be mentioned, in the first place, that the evidence elicited through their researches was arrived at from an entirely different standpoint, and, in the second place, that it fills up an important hiatus held by the heterogenists to be present in the chain of evidence adduced by Professor Tyndall. Notwithstanding that the only reasonable and inevitable inference to be drawn from the results of his experiments was that infusorial germs of exceeding minuteness were ever present in the ordinary atmosphere, and ready to germinate in the first suitable fluid medium with which they came in contact, it has been urged by his opponents that there is no direct proof of the actual presence of these countless ultra-microscopic germs, and that his evidence is therefore of an entirely negative character. But, to those who are well versed in the life-phenomena of this special class of organisms, the connection between the impalpable germinal dust gathered by Professor Tyndall from the laboratory floor or revealed by the electric beam, and the crops of animated beings produced out of it when sown in the sterilized fluid, is inductively as certain as that the celestial nebulæ, as yet unresolved into their ultimate elements by the telescope, consist of star-aggregations similar to those of the nearer and more familiar constellations.

Fortunately for the cause of the panspermists, this one weak joint in their armour, if such may be said to have been left open—this one little loophole for doubt, out of which the heterogenists have attempted at the eleventh hour to make good their untenable position—has now to be finally closed up. The propagation of infusorial organisms by germs or spores of ultra-microscopic minuteness, has been definitely and most conclusively demonstrated by Messrs. Dallinger and Drysdale, in their accounts of the life-history of various species of monads, contributed chiefly to the 'Monthly Microscopical Journal' during the years 1873 to 1875, and as described hereafter, systematically, under the specific headings of *Monas Dallingeri*, *Cercomonas typica*, and *Heteromita rostrata* and *uncinata*. As there recorded, the spores or germs of these animalcules, when first released by the rupture of their enclosing cyst, are of such extreme minuteness as to defy individual resolution with a $\frac{1}{50}$-inch objective and associated magnifying power of no less than 15,000 diameters, appearing in the aggregate under such conditions as a faintly granular fluid, having a refractive index scarcely distinguishable from the surrounding water. As germination and development progress, each individual spore, however, passes within the range of vision, and by degrees assumes the determinate size, form, and characteristics of the parent organism. The record of these reproductive phenomena of the monads in question was brought forward at the time simply as a newly discovered and interesting chapter in their life-history. Later on, however, Mr. Dallinger published in the 'Monthly Microscopical Journal' for December 1876, the results of his further investigations of these minute organisms, in which, through correlating his own discoveries with those of Professor Tyndall, he obtained some most important results.

Drying up the residual portion of a maceration or infusion containing a certain known form of monad, he had already shown that the light, porous, papier-maché-like substance resulting from such desiccation might be saved, like the seeds of a plant, and used for propagating the species at will in any suitable sterilized putrescible fluid. Working on this basis, an infusion of haddock's head, containing in abundance the so-called "Springing Monad" (*Heteromita rostrata*) and the Calycine Monad (*Tetramitus rostratus*) in the spore-producing stage, was gradually evaporated, then raised to a temperature of 150° Fahr., or 10° above that required to kill the adult form, and so reduced to a porous and highly friable condition. A small portion of this dried material, reduced to powder, was now diffused in an experimental chamber like those employed by Professor Tyndall, and the condensed beam of an oxyhydrogen lime-light being transmitted through the windows, its path within the chamber was more brilliantly marked than on the outside, indicating the preponderating existence therein of the spore-containing or germinal dust. This was now allowed to settle for a space of four hours and a half, when the lime-light still demonstrated, though in a less marked manner, the presence of the suspended dust. Ten small glass dishes, each partially filled with a sterilized fluid, were then introduced into the chamber, four of them being covered with projecting glass lids, mechanically movable, without opening the door of the chamber, and smeared with glycerine, to prevent the disturbance of any previously settled germs. At the end of twenty-four hours the lids were removed from the four covered vessels, and the whole now left undisturbed for four days. The six vessels left uncovered from the commencement being successively examined, were found in every instance to be abundantly peopled with both of the two monad forms present in the evaporized infusion, and developed from the germs diffused as dust through the air of the experimental chamber. Two days later a similar examination was made of the four remaining vessels which had remained covered, and with somewhat different results. In all these the Springing Monad was abundantly developed, but the Calycine form was found in only one of the receptacles, and then in very small numbers.

At first, this result appeared perplexing, but it occurred to Mr. Dallinger that the spores or germs of the last-named type, as in the case of the adult monad, were considerably larger than those of the former, and had, on account of their greater specific gravity, fallen to the bottom of the chamber before the removal of the covers from the four vessels last examined, and had thus been excluded from developing ; this inference was fully substantiated by a repetition of the experiment with certain modifications. On this occasion, the material used was the desiccated residuum of an infusion containing abundantly, in its sporiform condition, the simple uniflagellate type, *Monas Dallingeri*, the smallest species yet met with by him, and whose adult length did not exceed the 1-4000th or 1-4500th part of an English inch. The spores or germs produced by this animalcule were correspondingly minute, and it was consequently surmised that they would remain floating in the still air of the experimental chamber long after the subsidence of the germs of the larger types, and develop in vessels placed there for their reception at a later date. Finely pulverized and intimately mixed with material containing the larger Calycine Monad (*Tetramitus rostratus*) having an adult length of $\frac{1}{900}$ to $\frac{1}{1000}''$, these most minute germs were dispersed as before in a prepared chamber. At the end of four hours and a half, nine small glass basins were introduced, three of them remaining open and six being temporarily covered. At the end of twenty-four hours two of these covered vessels were exposed to the air of the chamber, and at the expiration of forty-two hours the remaining four were similarly exposed. After each set had been left undisturbed for five days they were examined with the following results. The first three (without covers) contained both descriptions of monads in every drop out of the sixty examined. The next two, uncovered at the end of twenty-four hours, were found in every instance to contain the smaller uniflagellate monad in abundance, but the larger one in a single drop only out of the total of sixty examined. In the remaining four vessels, uncovered after a lapse of forty-two hours, the result was that the smaller type was found abundantly in every drop, while the larger one was entirely absent. Finally, after the removal from the chamber of these last four, four more vessels of sterilized putrescible fluid were put in their places, to ascertain if any of the germs of the same type yet remained suspended in the air; but on examination five days later it was found that not a trace even of this most minute flagellate species was present in either one of the four vessels, their germs being thus demonstrated to have entirely subsided.

In addition to the highly suggestive evidence adduced through these several experiments, in demonstration of the persistency of form, and enormous capacity for atmospheric diffusion, possessed by these monads, their ultra-microscopic spores or germs are now shown to possess varying degrees of ponderosity, and it would seem by no means beyond the range of possibility, by further research, and having regard especially to the length of time occupied in the subsidence of a given type, to ascertain, by comparison with some larger and measurable variety, the exact or approximate dimensions of those germs, as yet lying beyond the defining powers of our most perfected microscopes, but instantly revealed by the searching electric beam, and which may be cultivated at will in an appropriate fluid medium.

In addition to the very important bearings upon the question of spontaneous generation embodied in the foregoing researches, Mr. Dallinger's name demands notice also with reference to some most important experiments conducted alone, and in combination with Dr. Drysdale, for the purpose of ascertaining the power of resisting high temperatures possessed by these lower forms of life in both their adult and sporular or germ condition. These experiments entirely confirmed Professor Tyndall's observations, and possessed, moreover, the additional advantage that a given and varying thermal death-point, or limit of heat-resistance, was now associated for the first time with fixed and specific monad types. Following out this line of investigation, it was thus shown that the spores of *Tetramitus rostrata* could successfully resist a temperature of 250° Fahr. (121° C.), those of *Dallingeria Drysdali* 220°, those of *Cercomonas typica* 260°, while in the case of *Heteromita rostrata* and *H. uncinata* they passed unscathed through a temperature of no less than 300° Fahr., or 148° C., which represents the highest limit that has as yet been obtained. It was further ascertained that a somewhat different result accrued according to whether the heat was applied in a wet or dry form, the spores in certain instances exhibiting a difference of as much as 10° Fahr. in this respect, and the highest being resisted when applied in the dry condition. The adult and active monads, having their constituent sarcode or protoplasm in a soft and semi-fluid state, in all cases succumbed to the comparatively low temperature, as an approximate limit, of 140° Fahr., and in many instances to one considerably lower even than this.

Some results of the author's personal investigations have now to be submitted, which tend, from an entirely independent point of view, towards the solution of the question now under discussion. Respecting Professor Tyndall's highly valuable testimony, it has been, and may yet be, objected by the partisans of heterogeny that his atmospheric germs are purely hypothetical and intangible, not having been actually seen by him, nor, what is more important, being so far connected with any recognized specific form of infusorial life. The evidence adduced by Messrs. Dallinger and Drysdale may also be cavilled at as deficient of the necessary proofs, inasmuch as the various species with which their researches are connected are peculiar to certain putrefying animal macerations only, and cannot therefore be said to fairly represent those types common to organic infusion generally, with which the phenomena of *de novo* generation have been held more especially to obtain.

Now, among these, infusion of hay has from the earliest date of the discovery of Infusoria, and the promulgation of the doctrine of spontaneous generation, been recognized as the most productive material for the artificial development of these minute beings, and as the one in which such presumed *de novo* or spontaneous generation is most prominently manifested. So far, this seeming special potentiality of macerated hay has not been made the subject of rigid and exhaustive inquiry, while the evidence recorded by Professor Tyndall concerning the extraordinary heat-resisting and infective properties of hay-derived germs in their concrete form, is no doubt accepted by the heterogenists as simply testifying to the possession by this material of such potentiality. If, however, the disciples of heterogeny flatter themselves that from this last uninvaded vantage-ground they may peradventure be able to withstand and bring discomfiture upon the advancing hosts of their opponents, the panspermists, they are destined to signal disappointment.

Within the last two years the animalcules produced so abundantly in hay-infusions have been the object of the author's special investigation, many of the new species described in the systematic portion of this volume being, indeed, the outcome of such research. Hitherto the infusorial types commonly observed in hay-infusions have been of comparatively large size, belonging to the higher order of the Ciliata, and pertaining to such genera as *Paramecium*, *Colpoda*, *Cyclidium*, *Oxytricha*, and *Vorticella*. These, however, represent numerically but an insignificant minority compared with the vast hosts of flagellate forms which abound in a hay-infusion during the earlier days of its maceration. In such infusions, watched from day to day, and produced from hay obtained from different localities, the number of types presenting themselves in tolerably regular sequence was found to be perfectly marvellous. Foremost among the generic groups putting in their appearance must be mentioned that of *Heteromita*, frequently represented simultaneously by three or four species, and including more especially the *Heteromita* (*Monas*) *lens* of O. F. Müller, *H. caudata*, and *H. gracilis*. Other genera, such as *Oikomonas*, *Dinomonas*, *Petalomonas*, *Rhabdomonas*, *Amphimonas*, *Monas* proper, *Cryptomonas*, *Hexamita*, and *Gymnodinium*, contribute likewise an almost equally considerable contingent; while Bacteria in their characteristic motile and quiescent states are invariably present, and furnish an abundant and ever ready pabulum for their more highly organized animal consociates.

The question presented to the author for solution was, from whence were derived all these myriad organisms, frequently produced in such abundance as to literally jostle each other for room in every drop of water extracted for examination? The heterogenists, including notably MM. Pouchet and Pennetier, have asserted that the highest Ciliate types present in hay-infusions, such as *Colpoda* and *Vorticella*, are generated *de novo* out of the filmy pellicle, or so-called "proligerous membrane," that in the course of a few days makes its appearance upon the surface of the liquid. This proligerous membrane, again, is further represented to be formed from the accumulated dead and floating bodies of Monads, Bacteria, and Vibrios, that first appeared in the infusion, and to constitute a kind of primordial stroma or pseud-ovary, out of the granular constituents of which, through coalescence at various points of the component particles, true eggs are developed, giving birth to such Ciliata as sooner or later appear upon the scene. The Monads themselves are treated as primary motile molecules, occupying a place midway between the organic and inorganic, and possessing motile properties most nearly corresponding with the molecular or Brownian motions of minute inorganic particles. The spontaneous derivation of these Monads from the dead and disintegrated particles of the macerated hay is regarded as too obvious to need discussion. It has been positively ascertained by the author, however, that these minute beings are derived from spores which literally encrust with their countless numbers the stalks and blades of the vegetable matter; these again being the product of pre-existing monad forms, whose active life was passed in close association with the green and growing hay under the circumstances hereafter narrated.

In order to arrive at a comprehensive insight into the life-phenomena and progressive developmental manifestations of the special group of infusorial animalcules now under consideration, hay from different localities was placed in maceration and examined continuously, from its first contact with the fluid medium, for periods varying in duration from a few days only to several weeks. The water added to the hay was of the purest possible description, and was frequently boiled for some time to prevent the introduction of extraneous germs. In all instances, the results obtained were broadly and fundamentally the same, and differed only with respect to the specific types found living together in the separate infusions. Even here, however, the general dominance of two or more special forms was notably apparent. Commencing with the first wetting and simultaneous examination of any given sample, spores of different sizes were found congregated in countless numbers, and in various orders of distribution, throughout the surfaces of the vegetable tissues. The majority of these spores were excessively minute, spherical, of the average diameter of the 1-20,000th part of an English inch, and required necessarily the employment of the highest powers of the compound microscope for the correct registration of their characteristic form and size. Sometimes these spores were to be observed collected in definite spherical heaps, but more often they were scattered in irregular-shaped patches, such patches being often again more or less confluent, and thus forming collections of considerable extent. A large number of these spores were likewise to be seen, detached from their original adhesions, freely floating in the water, or collected in masses, upon the peripheries of the small air-bubbles that had here and there become entangled between the slide and the covering glass. In this latter instance the spores exhibited a thicker and more opaque bounding wall, and manifested, as in the case of lycopodium powder, the power of resisting for some time the hydrostatic or wetting action of the water; this property had already been suspected by Professor Tyndall to be possessed by these minute bodies, but had not previously been practically demonstrated.

The hay within from four to six hours after maceration revealed, on examination of a small fragment, a considerable alteration in the character and comportment of the associated spores. Hitherto these had displayed no signs of motion, a uniform stillness reigning throughout the entire expanse of the microscopic field. Now, however, among the numbers that had become detached from their original adhesion to the vegetable matter, the majority exhibited an active vibratory motion that at first sight was scarcely to be distinguished from the characteristic "Brownian movements." The size of these motile spores corresponded with that of the quiescent ones, not exceeding the 1–20,000th of an inch in diameter, and without recourse to the highest magnifying power and the most careful adjustment of the illumination, it was not found possible to ascertain by what means their locomotion was accomplished. Examined successively with the $\frac{1}{16}$, $\frac{1}{25}$, and $\frac{1}{50}$ inch objectives of Messrs. Powell and Lealand, it was at length satisfactorily determined that each individual spore or body was furnished with a single, long, slender, whip-like organ or flagellum, whose active vibrations propelled the spherical body through the water. These minute motile corpuscles exhibited, in fact, at this early stage of their development a type of organization in all ways comparable with that of the simply uniflagellate genus *Monas*.

A highly characteristic feature of these moving spores remains to be mentioned. Although vast numbers of them were to be seen careering singly through the water, a very considerable proportion were united to each other in irregular clusters consisting of from two or three to as many as a dozen, or, as still more generally occurred, from two to as many as eight of them were joined laterally, so as to form floating moniliform or necklace-like aggregations corresponding in general aspect and mode of attachment with the normal moniliform colonies of the collared flagellate type *Desmarella moniliformis*, hereafter figured and described. If watched for a sufficient time, these clustered and serial aggregations were observed to become disintegrated, each separate corpuscle thenceforward maintaining an independent existence. In consequence of the characteristic aggregate forms primarily exhibited by this special species, it has been further found possible to definitely identify it with one of the types of animalcules described by O. F. Müller in the year 1786, and upon which he conferred the name of *Monas lens*. As figured and described by this author, the above-named species is distinguished in its more minute form by the two conditions of aggregation just enumerated, his illustrations of them being necessarily on a very small scale, and no trace being indicated or discernible with the instruments at his disposal of the characteristic locomotive flagella.

The further development of the separated monadiform corpuscles has yet to be traced. Following the assumption of the independent motile condition, an increment in the size of the constituent body, and with it a duplication of the locomotive appendage, was observed. Within twelve hours from the first submersion of the hay, many of these bodies had increased to twice their original size, measuring now the 1-10,000th part of an inch in diameter, and possessed in addition to a vibratile appendage a second flagellum which trailed posteriorly when the animalcule swam through the water, or held it anchored at will to the vegetable debris or other substances contained in the infusion. Retaining their spheroidal form and two associated flagella, they still continued to increase in bulk, until, at the end of twenty-four hours, the field was more or less crowded with biflagellate animalcules having an average diameter of from the 1-3000th to the 1-2500th part of an inch, and exhibiting in their adult state all the characteristics of an ordinary *Heteromita*. To make the history complete, these adult *Heteromitæ* were observed to increase abundantly by simple fission, as also more rarely to unite or coalesce, the product of such fusion being the assumption by the united zooids of a quiescent or encysted state, followed by the breaking up of the combined mass into a heap of minute sporular bodies corresponding with those just described, and which, like them, were subsequently released and recommenced their developmental cycle under the form of similar irregularly clustered or chain-like aggregations. *Heteromita lens*, however, represented but one, though perhaps the most constant and abundantly developed, out of a number of monad forms that were produced in the various macerations of hay examined, all of which existed, and were for the most part recognizable, in their sporular condition attached to the external surface of the vegetable tissues at the time of their immersion.

Such other spores of various descriptions were found abundantly scattered among those of the type just described, most of them, as in the case of *Heteromita caudata* and *Oikomonas mutabilis*, being of considerably larger dimensions than, and sometimes, as in the first of these two instances, presenting a contour altogether distinct from, the simply spheroidal spores of *H. lens*. In the last two instances the sporular bodies were produced by the subdivision of the parent animalcule into four, eight, or sixteen segments only, and thus conformed in character with the type designated "macrospores" in the account given of the reproductive phenomena of the Infusoria. In that of *Heteromita lens*, on the other hand, these corresponding bodies were so numerous and minute as to baffle computation, and laid claim in a corresponding manner to the appellation of "micro-spores." In yet other instances the encysted monads were observed to give exit to spores of such excessive minuteness, that, as in the case of several types described by Messrs. Dallinger and Drysdale, they were not individually recognizable as they escaped from the parent cyst, but presented in the aggregate, as viewed with the highest magnifying power, the aspect only of a viscid granular fluid, having a refractive index scarcely higher than that of the surrounding water. The recurrence of the various monad forms just enumerated by no means, however, exhausts the evidence of latent or pre-existing life found accompanying well-nigh every fragment of hay examined. The spores of fungi occurred in abundance, and also ciliate Infusoria, such as *Vorticella*, *Colpoda*, and *Trichoda*, in their resting or encysted state, while Bacteria were never absent. These latter, as time progressed, developed their several motile, glœa, and filamentous phases, and were repeatedly, with the assistance of the $\frac{1}{50}$-inch objective, demonstrated to increase by means of minute internally produced spores, after the manner of the co-associated monads. Some idea of the conditions under which the spores and encystments of the various animalcules present themselves in connection with hay-fibres, as viewed with a high magnifying power, may be arrived at on reference to the upper portion of Pl. XI., which, with its accompanying explanation, is devoted to the special illustration of this topic.

From the foregoing detailed account of the life-history of one special monad type, and of the circumstances under which the spores of this and other species are found primitively attached to the macerated hay, there would appear to be little left to prove the utter untenability of the arguments adduced by the heterogenists in favour of the *de novo* generative properties of this material. One important link in the chain, nevertheless, remains to be filled up. So far it has not been shown under what circumstances these countless multitudes of spores became originally deposited upon, and attached to, the dried hay fibre, and such an absence of definite demonstration might be interpreted by the heterogenists in favour of their having been developed there spontaneously. Of the larger Ciliate species it has been frequently suggested that they are derived from animalcules carried by river inundations on to the low-lying meadow lands, and which have remained attached in their encysted state to the grass on the retreat of the overflowing waters. Such an interpretation, however, necessarily implies a local and restricted distribution only, and in no way accounts for the unexceptional and cosmopolitan distribution of Infusoria and their germs upon hay derived from whatever source. Neither, again, does the vast quantity, and definite disposition of the spores with relation to their vegetable matrix, allow of the alternative that they have simply fallen from the surrounding atmosphere, and which, in point of fact, can be no more regarded as their native or parental element than it is that of the floating thistle-down.

The mode of distribution of these infusorial spores upon the hay-fibres indicated, in characters too clear to be mistaken, that all the essential conditions of their life-cycle had been passed in close connection with it. This interpretation was arrived at inductively, and its correctness was recently put to the test, with the following remarkable results. On Saturday, October the 10th, 1879, a day of intense fog, the author gathered grass, saturated with dew, from the Regent's Park Gardens, the Regent's Park, and the lawn of the Zoological Gardens, and submitted it to microscopical examination, without the addition of any supplementary liquid medium. In every drop of water examined, squeezed from the grass or obtained by its simple application to the glass slide, animalcules in their most active condition were found to be literally swarming, the material derived from each of the several named localities yielding, notwithstanding their close proximity, a conspicuous diversity of types. *Heteromita lens* and *H. caudata* were in all three instances abundantly present, as also minute actively motile Bacteria. Other types, such as *Vorticella infusionum*, *Dinomonas vorax*, *Hexamita inflata*, *Trepomonas agilis*, and *Phyllomitus undulans*, to say nothing of a host of unidentified spores and encystments, occurred variously distributed among the three examined samples of dew-laden grass, but even these by no means exhausted the list of living forms. Two species of Rotifera, *Rotifer vulgaris* and *Theorus vernalis*, numerous *Amœbæ*, *Anguillulæ*, and various diatoms, chiefly motile *Naviculæ*, contributed their quota towards the host of active living organisms that were found peopling more especially the lower and decaying regions of the dew-moistened vegetation, the collection as a whole being undistinguishable from the ordinary microscopic fauna of a roadside pond.

The data elicited through the observations just recorded carry with them an important and far-reaching significance. In addition to the conclusive proof herewith afforded of the primary origin of germs in hay, Infusoria and other minute forms of aquatic life were thereby demonstrated to possess an area of active vital distribution hitherto undreamt of. Water in its stable and concrete form is no longer, as hitherto presumed, a requisite concomitant of such vital energy. The smooth-shaven lawn, park-land, and meadow are each and all one vast teeming city, peopled by its myriads of tiny inhabitants, heedlessly crushed under foot in our daily walks abroad. Securely housed in their spore-membranes or encystments, these microscopic beings slumber undisturbed and unconsciously throughout the dry, dusty summer days, awaiting, however, only the fall of the evening dew, or passing shower, to cast off the frail cerements that enclose them, and to re-awake to active sentient life. The mode or conditions of existence of the animalcules thus found so plentifully on the dew-, or rain-moistened grass, are obvious. As already stated, they are encountered most abundantly on the lowermost blades, coloured brown or yellow, upon which the finger of decay has already set its stamp. Here, in fact, is a plentiful banquet ever set in order for them, closely identical in character with the artificially prepared infusions of hay, and other vegetable substances, which are so speedily attended by their myriad guests. Their purpose in life, as in the case of the animalcules inhabiting artificial infusions, is to break down and convert into new protoplasmic matter this otherwise waste product. To maintain the balance here, however, and to check the too rapid increase of the herbivorous monads, we find other types, such as *Dinomonas* and various Ciliata, answering to the Carnivora among the various higher animal sub-kingdoms, developed side by side with and feeding in turn upon the plant-eating species.

The general conclusions deducible from the long array of evidence now produced with respect to the question of "spontaneous generation," or "abiogenesis," may now be briefly summarized. From every line of inquiry investigated, one and the same answer is invariably returned. Life in its most humble and obscure form, be it existent as impalpable germinal dust floating in the atmosphere, or shaken from a truss of hay, or manifested in its more active state as the minute monads, bacteria, and other organisms developed in infusions, tells everywhere the same unvarying tale. Traced backwards to its origin, or forwards to its ultimate development, each type is found by patient search to be derived, not *de novo* out of dead or inorganic elements, but from a specific parental form identical in all respects with itself, and whose life-cycle is as true and complete as that, even, of man himself.

To the scientific mind the conception that organic matter was primarily eliminated, or in other words created, out of the inorganic, is forced home as a natural and logical conclusion, and also that this transition may be a process of every day occurrence. So far, however, as such recurring or *de novo* generation is exhibited by the types of organic life dealt with in this volume, or at present known, there is no longer left a loophole for doubt. The evidence from all sides, revealed by the exhaustive light of recent research, proves conclusively that in all these cases, down to the lowest monad and bacterium, the reproduction of their kind, formerly supposed to be altogether fortuitous and irregular, conforms in every essential particular with that of the highest members of the organic series.

Accepting, in point of fact, the infusorial or protozoic spore as the physiological, though not morphological, equivalent of the ovum of all higher animals, or Metazoa, Harvey's once famous, but since discarded, aphorism "*Omne vivum ex ovo*," is found, so far as human knowledge has as yet penetrated, to dominate with equal force from one extremity to the other of nature's chain. To assert, however, that we have penetrated to and laid bare the ultimate and finite confines of the organic realm, would be an arrogant and altogether illogical assumption: a vast *terra incognita* of organic forms may still remain to be explored. As yet, the latest investigations of physiologists have pushed so far forward as to acquire an approximate, though by no means exhaustive, knowledge of the "*cellular*" as manifested by unicellular and multicellular products. Unicellular products, however, there are ample grounds for maintaining, are susceptible of differentiation to an almost unlimited extent, such differentiation being essentially "*molecular*." In the same manner that unicellular organisms are now shown to correspond with the essential or primary elements out of which all multicellular organisms are built up, so is it within the region of possibility that entities yet exist which in a parallel manner find their morphological equivalent in the constituent elements of unicellular beings, and whose composition may be therefore correctly described as simply molecular. Practically, such molecular organic entities exist in the individually invisible or ultra-microscopic germs, discharged in a semifluid state from the encystments of many monads. The embryonic condition of one form typifying the adult state of one lower in the organic scale, is of almost undeviating recurrence in the scheme of nature, and the conception, therefore, of beings possessing in their highest state of development a corresponding germinal, and yet ultra-microscopic or molecular condition, follows as a natural and almost unavoidable deduction. It is, logically, within the realms of the *molecular* alone, if anywhere, that the transition from the inorganic to the organic is to be sought. Elsewhere, throughout the entire range of *cellular* structures, the phenomena of reproduction are distinct and uniform, rendering entirely untenable and nugatory their correlation with the doctrine of abiogenesis.

One final, though indirect, result of the rigid scrutiny to which the monads, and other low unicellular organisms, have been submitted in order to solve the mystery of their generation, remains to be recorded. As conclusively proved by Professor Tyndall, Dallinger and Drysdale, Cohn, Kühne, and other investigators, such organisms in their germinal or sporular state can successfully resist exposure to temperatures that prove fatal to any other more highly organized structures, even up to and beyond the boiling-point of water. So far, therefore, as they are brought in contact with the ordinary conditions of the earth's surface they are practically *indestructible*. Nay more! as suggested by Professor Tyndall, there is no reasonable pretext for assuming that there are not germs capable of resisting far higher temperatures than those which have been hitherto subjected to experiment. Hence, among all known organic forms, the Infusoria and their allies alone would appear to possess the power of weathering the cataclysmic changes of the universe, and, secure from all influences of heat and cold, of migrating in safety through interplanetary space.

CHAPTER V.

NATURE AND AFFINITIES OF THE SPONGES.

It is proposed to devote the present chapter to an extensive discussion of that near relationship of the sponges to certain of the Infusoria Flagellata, briefly referred to on several occasions in the course of the preceding pages. This affinity is found, indeed, upon an impartial examination of the data here collected, to be so comprehensive and thoroughgoing as to render absolutely unavoidable the correlation of this group with the typical representatives of the flagellate Protozoa. Those differences which do exist between the two groups are, in point of fact, far less essential than those which obtain between many of the subordinate sections of the ordinary Ciliate and Flagellate Infusoria; such being the case, the present work could not be considered complete if it did not embrace a more or less extensive account of the fundamental plan of organization, at least, of the Spongida. Strictly speaking, the sponges, throughout all their wealth of form and organization, are here accepted as Mastigophorous Protozoa, and it is on account only of the limited space at disposal, that their full specific enumeration and description, on a scale corresponding with that allotted to the more typical representatives of the Flagellate Infusoria, is here omitted. Under existing circumstances, it is found possible to submit a brief sketch only of those broad fundamental characters which either unite with, or distinguish the members of the sponge-tribe from their nearest allies, supplementing them with the author's personal interpretation of those somewhat obscure structural and developmental points which have been held by other authorities to indicate an affinity in a different direction. For, although it is confidently anticipated that the evidence now brought forward must materially assist in securing to the sponges, eventually, a general recognition of their intimate relationship to the Choanophorous section of the Flagellate Infusoria, it can by no means be said that such an affinity is at the present date universally recognized. On the contrary, the balance of contemporaneous scientific opinion favours the relegation of this organic group to the division of the Metazoa, though upon grounds which, plausible as they seem to be upon the surface, are fundamentally purely artificial and untrustworthy.

In order to arrive at a position permitting a thoroughgoing and impartial appreciation of the very voluminous and conflicting evidence that has been amassed with reference to the much debated affinities of the sponges, it is, before all things, desirable to commence with an examination of the earlier periods of their intelligibly recorded history, and thence to trace forwards, link by link, those consecutively recorded data which have led up to the present controversial position of the question.

As an initial step in this direction, it is worthy of remark that the conclusive demonstration of the very animal nature of the Spongida has only been accomplished within the present generation ; for while originally premised by Marsigli at the commencement of the eighteenth century, and subsequently advocated by Ellis and Solander, Montagu, and Lamarck, it was left to Grant, Bowerbank, Carter, Lieberkuhn, and Dujardin within these later limits to produce the actual proofs of their animal organization. Among the investigators just enumerated, the name of our fellow-countryman Dr. Grant may be specially singled out, as the authority who first discovered the characteristic ciliary action in sponges, as also the existence of the remarkable free-swimming ciliated reproductive bodies described at length later on. That of Felix Dujardin, however, has to be still more prominently mentioned, he having been the first to indicate that relationship between these organisms and the more ordinary Flagellate Protozoa, which with some modification is here supported. In the course of his 'Histoire des Infusoires,' published in the year 1854, this author devotes two brief pages to the nature and organization of the group now under consideration. Tearing to pieces a living fresh-water sponge (*Spongilla lacustris*), he there records that the constituent living particles will be found, on submission to microscopical examination, singly or united in groups, either floating in the water or adherent to the glass slide, and that for the most part these constituents are furnished with long vibratile filaments or flagella, similar in character to those possessed by the simplest Flagellate Infusoria or monads. These same constituent particles, he, moreover, observed to throw out lobe-like expansions or pseudopodia, and to creep about after the manner of amœbæ. This phenomenon, while possessed by the floating ones, is more especially marked in those which adhere to the surface of the glass, and in which the vibratile flagella had become withdrawn or obliterated. He also briefly alluded to the ciliated reproductive bodies of *Spongilla* and various marine sponges, and the group as a whole he declared to exhibit a type of organization comparable to associated colonies of Infusoria, possessing the united characteristics of both monads and amœbæ. Respecting the horny fibres and siliceous or calcareous spicules secreted by the various tribes of sponges, Dujardin suggested that they are analogous respectively to the branching and somewhat horn-like supporting stalk of such monads as *Anthophysa*, and to the siliceous and calcareous tests presented by the ordinary Rhizopoda.

By Mr. Carter, in November of the same year 1854,* the announcement was made of the discovery, in *Spongilla*, of so-called zoosperm-like bodies, these, however, as he afterwards admitted, representing the ordinary

* 'Ann. and Mag. Nat. Hist.,' vol. xiv. ser. ii.

polymorphic and flagellate cells first noticed by Dujardin. To a like category must undoubtedly also be relegated the so-called "spermatic elements," described by Professor Huxley in the 'Annals of Natural History' for the year 1851. Lieberkuhn * corroborated and added considerably to the details of the structure and life-history of *Spongilla* made known by Dujardin, and elicited much new evidence concerning the occurrence in this type of the motile ciliated germs, in addition to the more ordinarily occurring non-motile and so-called "seed-like bodies," first discovered by Dr. Grant, in association with various marine species, and merely recorded by Dujardin, on the authority of M. Laurent, as existing in *Spongilla*. Following upon Lieberkuhn's discoveries, must be recorded the very important contributions respecting the ultimate structure of the closely allied Indian species of *Spongilla*, contributed by Mr. Carter to the 'Annals and Magazine of Natural History,' during the years 1857 and 1859. In the first of these contributions, the entire life-history, from the indurated "seed-like body" up to the adult state, was successfully traced out, and many entirely new facts respecting the more minute histology of the sponge organism elicited. Among these it was demonstrated that the essential living constituents of the sponge-body were represented by the ciliated monad-like elements first described by Dujardin, and that they exhibited a very definite mode of arrangement. Under normal conditions, Mr. Carter found that the monad cells were congregated together so as to form a single and even layer within the interior of small spherical chambers excavated within the sarcode or mucilaginous basal substance of the sponge, and to which chambers he applied the term of "ampullaceous sacs." The additional name of ovi-cells was also given to these chambers in their earlier condition, from his having observed their development out of a pre-existing ovule-like or granular mass, this latter first passing into the normal, small, monociliated and unciliated sponge-cells which then spread over the interior surface of the so-called ovi-cell, each with its cilium directed inwards, and so leaving a cavity in the centre which finally became connected with the nearest adjacent afferent canal.

The origin of these "ampullaceous sacs," by a process of development corresponding to the growth and segmentation of an ordinary ovum, is, as hereafter shown, entirely confirmed by the investigations of the present author. Mr. Carter further demonstrated the capacity of both the ciliated and unciliated sponge-cells of the ampullaceous sacs to take in solid food in the form of minute granules of carmine distributed in the surrounding water, as also the possession by these individual bodies of contractile vacuoles and nucleus-like granules. Taken as a whole, the animal nature of *Spongilla* was now proved beyond further question, and its composition maintained to consist essentially of polymorphic monadiform or amœba-like elements, closely corresponding with ordinary monads and amœbæ, the former being aggregated together in definite order within the structureless

* Müller's 'Archiv,' Bd. i., 1856.

jelly-like sarcode, that formed the groundwork or substratum of the sponge-body. Within the central substance of this sponge-body, and also in the superficial part, called by Mr. Carter the investing membrane, were found scattered the innumerable amœba-like non-flagellate cells, as also the characteristic spicules of the species, which were reported to be secreted by the amœboid elements. Finally, the entire sponge-body was shown to be brought into intimate relationship with the external water, firstly, by a series of pore-like apertures opening or closing at will in the investing membrane, and communicating through the afferent canals with the ampullaceous sacs; and secondly, by another series of tubular channels, the efferent canals, which originating in the deeper substance of the sponge, united with each other, and finally debouched upon the large excurrent apertures or "oscula."

As a result chiefly of the very exhaustive evidence concerning the ultimate structure of *Spongilla* elicited through Mr. Carter's investigations as here briefly epitomized, the position of the sponges among the ranks of the Protozoa, and as specialized and colonial aggregations of amœboid and monadiform Protozoic beings, became almost universally accepted. It is at the same time worthy of notice, that Mr. Carter hinted at the possible correspondence of the ciliated sponge-chambers or ampullaceous sacs with the stomach-cavities of the simplest polyps, certain Planariæ, and other organisms in which the cavities receiving the injected food are also lined with cilia. In January 1859, Mr. Carter contributed a further communication to the journal already named, recording new data of interest relative to the form and structure of the essential monadiform sponge-cells, though at the same time he temporarily modified his previous views concerning the character of the ampullaceous sacs. The most important point that requires notice relates to the circumstance that he here described and figured in association with certain of the larger ciliate or monadiform sponge-cells, the existence of two "spines" or "ear-like points," which he figured and described as projecting to an even distance on either side of the base of the single whip-like cilium. A possible spermatozoic character of these so-called "spiniferous cells" was at first suggested by Mr. Carter, but subsequently abandoned through his demonstration of their capacity to take in solid nutriment. The special interest attached to the discovery by Mr. Carter of these spiniferous elements will shortly become apparent.

The earliest complete treatise of importance demanding notice bearing upon the structure and organization of sponges, is the first volume of Dr. Bowerbank's 'Monograph of the British Spongiadæ,' published by the Royal Society in the year 1864. Vast, however, as is the mass of material embodied in this and the two subsequent volumes of this work (1866 and 1874), it relates almost entirely to the structure and organization of sponges in their dried or preserved condition, and is of practical value only for the purposes of specific identification. In such preserved specimens, as there described, the essential vital elements now under discussion had become completely metamorphosed or obliterated. Excepting, in fact, his notice of the several observations of Grant, Dujardin, Carter, and Lieberkuhn, concerning the presence and disposition of the monociliated sponge-cells, Dr. Bowerbank's only personal record of their definite recognition is associated with the calcareous type *Grantia compressa*, of which species he figures and describes their characteristic tesselated plan of arrangement. In their isolated condition the separate flagellate elements are so delineated as to resemble the spermatic cells of ordinary vertebrate animals, having a small ovate body and a long and comparatively thick terminal flagellum.

With the year 1866, an important epoch in the elucidation of the structure and affinities of the Spongida was inaugurated. In June of that year was published in a condensed form in the 'Proceedings of the Boston Society of Natural History,' the results of a prolonged and painstaking investigation instituted by Professor H. James-Clark, of the Agricultural College of Pennsylvania, U.S.A., with reference to the ultimate form and composition of the monociliated cells of a calcareous sponge most nearly allied to the *Leucosolenia botryoides* of Bowerbank, and having respect to their close correspondence with the individual zooids or units of certain new forms of Flagellate Infusoria which he had recently discovered and then described for the first time. This important communication, with accompanying plates, appeared *in extenso* in the 'Memoirs' of the above-named society, vol. i. plate iii., for the year 1868. The essential feature of the new and special forms of Flagellata here introduced, numbering in all four species, and referred to the then two newly instituted genera *Codosiga* and *Salpingœca*, consisted of the fact that all of their representatives were provided at the free anterior extremity with a delicate funnel-shaped expansion of the sarcode, possessing an extraordinary amount of plasticity, which in its normal condition of expansion surrounded the base of the flagellum.

Upon this newly discovered and remarkable structural element Professor Clark bestowed the appropriate title of the "collar," and as "collared" or "collar-bearing" monads, the animalcules then and since discovered sharing a corresponding structure, are now generally known. Turning his attention to the ultimate ciliated elements of the calcareous sponge just mentioned, Professor Clark at once recognized that when viewed with a sufficiently high magnifying power they exhibited a type of organization precisely identical with that which obtained in the independent collar-bearing monads, possessing like these a similar film-like, extensile and contractile, collar-like membrane, enclosed terminal flagellum, posteriorly located contractile vesicles, and all other details characteristic of an isolated monad of his newly established genus *Codosiga* or *Salpingœca*. As indicated by Professor Clark, any one previously acquainted with the structure of *Codosiga*, but not with the sponge, would without doubt, in describing merely the congregated monads of the latter, pronounce them to be colonial and massive growths of the previously named simple Flagellata. The other elements recognized by Professor Clark as entering into the composition of the complete sponge-body, manifesting its differentiation from such a simple monad colony as *Codosiga*, were, in the first place, an externally placed and excessively hyaline, glairy, gelatinous matrix, upon the internal surface of which the characteristic flagellate cells were embedded, and secondly, the spicular bodies found immersed within the substance of this glairy matrix, and by which latter element he considered them to be secreted. Upon this common matrix he conferred the title of the cyto-blastematous layer, or "cytoblastema," in contradistinction to the internal pavement-like one composed of collar-bearing units, and which he designated the monadigerous layer. The spiculæ themselves he represented as directly comparable with the horn-like loricæ secreted, or rather excreted, as protective coverings by such genera as *Cothurnia*, *Salpingœca*, and other ordinary Infusoria.

It was at once recognized by Professor Clark that the so-called spiniferous elements of *Spongilla*, figured and described by Mr. Carter in the year 1859, were closely identical with what had been observed by himself in *Leucosolenia*, and that the two "spines" or "ear-like" points recorded by the former authority, represented actually the right and left profiles of a similar subcylindrical membranous collar. Mr. Carter's observation of these "spine-bearing" cells in a limited number of instances only is satisfactorily accounted for by Professor Clark's record of the facility and rapidity with which when disturbed this membranous collar is completely withdrawn into the general substance of the body-sarcode. With reference to the food-incepting phenomena of the sponge-monads, Professor Clark was not able to arrive at a definite conclusion. Presuming, nevertheless, from his assumed discovery of a distinct oral aperture in *Codosiga* and other Flagellata, close to the base of the flagellum, he was led to predicate the existence of a similarly located one in the case of the sponge-monads. As hereafter shown, however, Professor Clark's inferences concerning the nature and position of the oral aperture in both the independent and associated collared monads, have not been confirmed. Summing up the results of his discoveries, the views maintained by Professor H. James-Clark with reference to the position and affinities of the sponges were, that these organisms must be regarded as compound colonial forms of Flagellata, whose units, in the case of *Leucosolenia*, exhibited a type of structure essentially similar to that of *Codosiga* and *Salpingœca*, but might possibly in other instances more closely approximate to that of *Monas* (*Spumella*) *Bicosœca* or *Anthophysa*.

The entirely new light brought to bear upon the much vexed question of the affinities of the sponges, and the influence upon the scientific mind it was calculated to exert, through the important discoveries of Professor Clark, were doomed, for a time at least, to be thrown into the background, if not altogether set aside, in consequence of the almost contemporaneous introduction upon the scene of a yet more novel, and for the disciples of the doctrine of evolution, a far more fascinating interpretation of the structure and relationship of these organisms.

The following year, that of 1869, was signalized in the annals of the scientific world by the publication of Professor Ernst Haeckel's brilliant disquisition in the 'Jenaische Zeitschrift,' Bd. v. 1869 (reprinted in the 'Annals' for January and February, 1870), in which this talented author announced, in the most emphatic terms, that the sponges were more nearly related to the corals, or Anthozoarian Cœlenterata, than to any other organized beings, and that the position hitherto assigned to them among the Protozoa was fallacious, and could no longer be maintained. Practically, in the advancement of this theory, Haeckel may be said to have merely resuscitated and clothed in a new and attractive garb the moribund one that, first originating with Ellis and Pallas, was still more extensively developed by Leuckart, but rejected by the verdict of subsequent investigators. This supposed affinity, as advocated by Leuckart and his predecessors, was, however, one only of broad external isomorphic or homoplastic resemblances. In accordance with their views, each efferent or oscular area in a compound sponge-body was regarded as the equivalent of an individual polyp of a coral stock, minus in each instance the characteristic tentacles, stomachal sac, and internal mesenteries and septa that distinguish the representatives of the corals. Summing it up, such a likeness as evoked by Leuckart on the part of the sponges with respect to the corals may, borrowing a dramatic simile, be aptly compared to the play of 'Hamlet,' minus the king of Denmark. Professor Haeckel, however, disinterring and infusing new breath into Leuckart's abandoned conception, claimed for it a far wider and more deeply reaching significance. It was insisted upon by the illustrious biologist of Jena that not only a general external or homoplastic resemblance existed between the organic groups in question, but that the internal structure and histological organization of the two also coincided. Following out this line of argument, it was represented that the nutritive canal system of the sponges was both homologous and analogous with the gastrovascular system of the corals; that both the corals and the sponges were characterized by the possession of similar distinct external and internal cellular layers, or ectoderm and entoderm; and that the adult organisms were derived in either case from similar primitive diploplastic ciliated larvæ, *planulæ* and *gastrulæ*, these again being developed from ordinary segmented ova.

As may have been anticipated, this bold conception of Professor Haeckel's inaugurated for the sponges an era of most close and rigid investigation not yet ended, which has already resulted in a mass of evidence that has added vastly to our previous knowledge of the ultimate composition of these structures. None of this testimony, however, can be said to confirm precisely that interpretation of the structural or developmental phenomena insisted upon by Haeckel. In the majority of instances, indeed, it is entirely subversive of his theory. Among the earliest of the several protests against the views submitted by Professor Haeckel, reference may be made to the communications contributed by the present author to the 'Annals of Natural History' for March and August 1870. The subject on these occasions was approached more entirely from the Cœlenterate point of view, the writer being at that time officially occupied in the study, identification, and arrangement of the series of corals, recent and fossil, contained in the Natural History Department of the British Museum. Arguing from such a standpoint, it was sought to demonstrate that between the alimentary systems of the two groups in question there was nothing whatever in common; that the single, well-defined gastrovascular aperture in a coral, subservient both for the processes of ingestion and excretion, was in no ways comparable to the multifarious canal-system through which, upon every side of its periphery, the sponge-body received its nutriment, and that the assumption by Professor Haeckel of a distinct ectoderm and endoderm in the structural elements of a sponge was by no means clearly demonstrated. His claim of a distinct personality for each oscular area of a sponge-body was likewise contested, and an adhesion given generally to that Protozoic interpretation of the sponge question, then supported in the text-books of Huxley, Carpenter, and other English authorities, and manifested by the investigations of Lieberkuhn, Bowerbank, and Carter, and especially through the more recent investigations of Professor H. James-Clark already quoted. Evidence of a still more substantial nature, tending in the same direction, and emanating from one of the earliest and first authorities in this country upon sponge organization, has next to be noticed.

In October 1871, Mr. H. J. Carter contributed to the 'Annals of Natural History' the announcement of his identification, in all of the numerous marine siliceous and calcareous sponge types recently examined by him, of a structure essentially corresponding with that which he previously described as obtaining in *Spongilla*, and generally indicated their nonconformity with the Cœlenterate plan of organization insisted on by Professor Haeckel. As interpreted by Mr. Carter, the "ampullaceous sacs," or other ciliated systems, represented the only essential portion of the sponge structure, the remaining elements compared with these being entirely subsidiary. One especially weak point in Professor Haeckel's argument was further pointed out in his remarks concerning the sexuality of the sponges. In none out of the hundreds of Calcispongiæ examined by him with the microscope, Haeckel says, could he detect a trace of fecundatory male elements or zoospermia, and that therefore the bodies subserving the purposes of reproduction constantly present cannot be designated true sexual eggs or ova, but asexual germ-cells or "spores." These spores, or so-called ova, in all the sponges he investigated, Professor Haeckel, moreover, declared to be perfectly naked and destitute of membrane, like the flagellate cells from which they proceed; furthermore, he reported that in all the sponges examined by him he had never found any trace of a membrane or true cell-membrane on the cells, and that therefore all sponge structures were composed of naked cells or "gymnocytodes." As indicated by Mr. Carter, this sporidular interpretation of the reproductive phenomena advocated by Professor Haeckel was in itself completely subversive of the theory he attempted to substantiate, and, as the very essence and starting-point of which, the existence of true and normally fecundated ova, represents an indispensable condition for the evolution of the two primitive germinal layers having the significance of an ectoderm and endoderm in the ordinary and restricted acceptation of the terms. Finally, Mr. Carter directed attention to the recent discoveries of Professor H. James-Clark as indicative probably of the true direction in which the affinities of the sponges are to be sought.

Practically following up this clue, Mr. Carter, in the 'Annals' for July of the year 1871, produced a still more important contribution towards the elucidation of the structure and affinities of the sponges. On this occasion he announced that by renewed investigations, with increased magnifying power, he was enabled to entirely confirm Professor Clark's discoveries concerning the peculiar collar-like structures possessed by the monoflagellate sponge-cells, and stated that it is out of such collared monoflagellate elements that sponge organisms are more essentially constructed. While the material supplying Mr. Carter with this important confirmatory evidence was chiefly derived from the calcareous type *Grantia compressa*, other species, such as *Grantia* (*Sycon*) *ciliata*, *Leuconia nivea*, and *Clathrina sulphurea*, were found to yield substantially parallel testimony. Those elements of *Spongilla* described by himself, in the year 1859, as flagellate cells with ear-like or spine-like points, were also now recognized as indicating the same fundamental structural form in the fresh-water species. On one point only did Mr. Carter dissent essentially from the views of Professor Clark, namely, with reference to the mode of food-inception. While the last-named author attributed to the collar-bearing sponge-cells, and also to the independent collared flagellate types *Codosiga* and *Salpingœca*, the possession of a distinct mouth—not actually discerned, but supposed to be situated within the collar, close to the base of the flagellum—Mr. Carter was inclined, in consequence of the exceedingly variable or polymorphic properties of these sponge-cells, to infer that they engulfed food at any point of their periphery after the manner of amœbæ. With respect to the highly conspicuous polymorphic features of these essential sponge-cells, he further considered that they were to be regarded rather as forms intermediate between Rhizopoda and Infusoria-Flagellata than as typical Infusoria as interpreted by Professor Clark; preferentially, perhaps, they were to be accepted as a distinct and independent Protozoic group, whose component units or individuals might be appropriately designated sponge-animals or Spongozoa.

Before the close of the same year, 1871, additional but unfortunately for science, the latest evidence in this direction, a few months prior only to his much-to-be-lamented decease, was produced by Professor Clark himself. Already, in 'Silliman's American Journal' for February 1871, he had drawn attention to Cienkowski's new social monad genus *Phalansterium*, and indicated its apparent close affinity to the collared types *Codosiga* and *Salpingœca* discovered by himself, but from which they differed most essentially in the less conspicuous development of the characteristic collar, and in their social or colonial occupation of a common gelatinous matrix. This latter point more especially was cited as indicative of a still more intimate relationship with the sponges than that presented by the two last-named genera. Professor Clark further placed on record in the same serial the results of his recent investigations into the ultimate structure of the American Fresh-water Sponge, *Spongilla arachnoides* J.-Clk., the results confirming substantially, and adding considerably to, the data elicited through his previous examination of the marine calcareous type *Leucosolenia botryoides*. In this fresh-water form, however, the characteristic collared flagellate cells were found occupying definite spherical excavated chambers, corresponding with those described by Mr. Carter of *Spongilla alba* under the name of ampullaceous-sacs, which received from Professor Clark the equivalent title of the "monad chambers." Taken in its entirety, the sponge-body of this species was declared to be composed of the three following distinct and well-marked elements: Firstly, of a common, glairy, gelatinous basis, within which all the remaining constituents were embedded, and which he designated the *cytoblastema*. Although presenting the same characteristic consistence throughout, this glairy cytoblastema exhibited a separation into two distinct regions, the one consisting of a thin superficial stratum, stretched out on the points of the larger externally projecting spicula, after the manner of a tent-canvas extended upon the ends of its supporting poles. Within this peripheral cytoblastematous layer, designated by Professor Clark in its separate form the "investing membrane," there was no trace to be found of the monad-chambers. These latter, which constituted the second and most important structural element, were confined entirely to the deeper and comparatively solid substratum of the cytoblastema, and which he therefore distinguished, with relation to its contents, as the "monadigerous layer." The third and remaining essential element recognized by Professor Clark consisted of the innumerable amœbiform cells or bodies scattered more or less abundantly throughout the substance of the cytoblastema, and most conspicuously visible, in consequence of the absence of the monad-chambers, in the thin superficial stratum or so-called investing membrane. These amœbiform cells were distinguished by Professor Clark merely by the name of the "cell-elements" of the cytoblastema, but, for convenience, may be appropriately designated the "cytoblasts" or "cytodes." Like simple cytodes, they were shown, as also pointed out by Professor Haeckel, to possess no distinct cell-wall, and, unless specially focussed for, were scarcely to be distinguished from the cytoblastema in which they were embedded. Seen under the most favourable auspices, their substance was demonstrated to be slightly granular, and that they contained a subcentral, spherical, and more highly refractive nucleus or endoplast. The contours presented by these cytoblastic bodies varied greatly, ranging from simply ovate to every variety of irregular and jagged outline, and their periphery often taking the form of more or less prolonged caudiform projections, directly comparable with the pseudopodic appendages of a typical *Amœba*. In addition to these three essential elements, e.g. the transparent structureless "cytoblastema," the "collared monads," and the polymorphic amœbiform "cytoblasts," one conspicuous but non-essential structural element, as represented by the supporting or strengthening siliceous spicula, remains to be mentioned. The spicula in the sponge in question were of two sorts, large and small, and were found in either case to be confined exclusively to the cytoblastematous layer, and not to intrude into the monad-chambers; while the larger ones penetrated into the deeper substratum of this element, the smaller ones occurred only in the more attenuate peripheral region, and were evidently built up or secreted by the cytoblastema or its enclosed amœbiform cytoblasts. The exclusion here made of the secreted spicula from the category of essential elements, while a departure from the course taken by Professor Clark, is justified by the fact that sponges exist—e. g. the Myxospongiæ, including *Halisarca* and its allies—in which, while all the other three elements are fully represented, spicula or skeletal structures of any kind are entirely absent.

Among the data of importance recorded by Professor Clark concerning the organization of the separate collar-bearing elements of the monad-chambers or ampullaceous sacs, has to be particularly mentioned that he demonstrated in this type most definitely the possession by each monad of two or more conspicuously developed and evenly pulsating contractile vesicles. The location of these vesicles was found to be more towards the posterior extremity of the body, their systole and diastole being further described as on the whole extremely slow, but very distinct, if sufficient patience was used to watch them fixedly and without interruption. The last third portion of the act of systole differed in being considerably more abrupt, the vesicle appearing only at such time to contract suddenly. This latter circumstance, taken together with the constant position of the vesicles, is cited by Professor Clark as sufficing to rebut the inference that might otherwise be arrived at, and as actually insisted on by Professor Haeckel, that these vesicles were simply irregular protoplasmic vacuoles, such as occur among undoubted protophytes and various ordinary tissue-cells. Comparing the arguments adduced by Professor Haeckel, in favour of the Cœlenterate affinities of the sponges, with the actual structural composition of *Spongilla* and *Leucosolenia*, elicited by his own special investigations, Professor Clark finally arrived at the decision that the attempted parallelism between the two groups must utterly fail, the relationship of the sponges to certain Flagellate Protozoa being, on the other hand, so distinct and decisive as to forbid their logical inclusion among the representatives of any other organic class.

The year 1872 is, perhaps, more notable that any in the entire annals of sponge biography through the publication of Professor Haeckel's truly magnificent work of labour and art, if nothing more, entitled 'A Monograph of the Calcispongiæ.' This treatise, as its name denotes, embraced an exhaustive account of every known form and variety of sponge characterized by the possession of a skeleton composed of spicules of carbonate of lime, and of which the little white *Grantia compressa* of our own coast affords a familiar example. The chief interest of this monograph, however, depends upon the fact that it is made the vehicle of Professor Haeckel's more matured views concerning the near relationship affirmed by him to subsist between the sponges and the corals, and which he now sought, by means of the sponge-group monographed, to establish on a more firm and solid basis. This remarkable work has in other words to be regarded as embodying the veritable consummation of his then newly conceived and now world-familiar "Gastræa" theory, having as its aim the demonstration that all animal forms, from the sponges up to the Vertebrata, emanate in their developmental history from one single stock-form or phylum, upon which the common title of a "gastrula" is conferred. This gastrula, as formulated by Haeckel, is constructed fundamentally upon the same type as the advanced condition of the embryonic planula, having an ovate body composed of two even, separate cellular layers, the ectoderm and endoderm, and a central primitive stomach-cavity or archenteron, which communicates at one extremity with the outer world by a primitive oral orifice. From this identity of the bilaminate gastrula in representatives of the most various animal stocks, from the sponges to the Vertebrata, Haeckel, to quote his own words, deduced the common descent of these various animal phyla from a single unknown stock-form, his hypothetical gastræa, which was constructed on a plan essentially corresponding with the above-described typical gastrula. As a first step towards the successful correlation of his gastræa theory with the group of organisms now under consideration, it necessarily devolved upon Professor Haeckel to refute the more recent interpretations, still adhered to by many authorities, which relegated the sponges to the lowermost or Protozoic section of the organic series. At the least, it was to be expected that this eminent author would devote some little space to the serious discussion of the new and very important facts concerning the ultimate structure of sponges and suggestive affinities elicited through the investigations of Professor H. James-Clark and Mr. Carter. In place of this, no consideration whatever is given to their discoveries, which are brusquely dismissed with the comment that neither one nor the other of these authorities have any conception of the essence of the cell-theory. The present author is visited, for his temerity in having dared to call in question the soundness of the suggested Cœlenterate affinities of the sponges, with a far more substantial share of the learned professor's attention. "Mr. Saville Kent's attacks" upon his theory are finally summed up as incapable of refutation, since he "neither understands the arguments brought forward, nor is in general sufficiently acquainted with the structure and development of zoophytes and sponges."—The endeavour is here made to show that Mr. Saville Kent has since that time devoted his best energies to rectifying the omission in his education pointed out by Professor Haeckel, the outcome of his humble efforts in this direction being, however, scarcely conducive perhaps to the firmer establishment of that authority's hypothesis.—The most crushing shafts of Haeckel's sarcasm are undoubtedly directed against an accidental misrendering or misinterpretation, on the author's part, of some of the more abstruse questions of homology and analogy propounded as subsisting between the representatives of the two groups in question. Whatever may have been the error in this direction, the very important and significant fact remains that Professor Haeckel's exposition of the Cœlenterate affinities of the sponges, embodied in his 'Monograph of the Calcispongiæ,' is characterized by a complete abandonment of that position which he had formerly maintained with so much vehemence, and by a repudiation of that very homology he had formerly insisted on, and which was especially disputed by the present author. In order to make this significant contradiction clear, it is necessary merely to quote and compare Haeckel's oracular utterances of the two respective years 1869 and 1872. In his first notable essay, 'On the Organization of the Sponges and their Relationship to the Corals,' he says:—

"Certain sponges differ from certain corals only by a less degree of histological differentiation, and especially by the want of urticating organs. The *most essential* peculiarity of the organization of sponges is their nutritive canal system, which is both *homologous* with, and *analogous* to, the so-called cœlenteric vascular system, or gastrovascular apparatus of the Cœlenterata."

In his 'Monograph of the Calcispongiæ,' Bd. i. p. 461, his recantation, modestly interred in an unobtrusive footnote, runs as follows:—

"Whereas the near relation of the sponges to the corals, to which I formerly gave particular prominence, is to be understood *only as an analogy*, *not as an homology*, I thought at that time that I found in the radiate structure of the Sycones (*Grantia* (*Sycon*) *ciliata*) an essential morphological point of comparison with the corals; but the developmental history of the radial tubes of the Sycones, with which I only became acquainted subsequently, has convinced me that these *are not homologous* with the perigastric radial chambers of the corals."

Having abandoned his former line of defence, Professor Haeckel depends mainly, in the monograph now under discussion, upon making good his position with relation to the suggested affinities through the evidence he adduces with respect to the developmental phenomena of the Calcispongiæ. The radial aquiferous system of the adult sponge, originally paraded with so much *éclat*, when put to the test was, to use a familiar expression, found incapable of "holding water"; it now remains to be seen whether Professor Haeckel's new arguments were based upon a more firm foundation. The one essential point brought forward on this occasion relates to the composition and significance of those ciliated and motile reproductive bodies common to all sponges, first discovered by Dr. Grant, and noticed by various subsequent observers, but whose true structure and import have not yet been exhaustively investigated. In accordance with Professor Haeckel's interpretations, these bodies, or "ciliated larvæ," as they have since been more commonly designated, abundantly developed throughout the representatives of the Calcispongiæ, were all referable to one common plan, with regard both to external configuration and internal histologic composition. This common plan, as now enunciated, manifested itself externally in the possession of an evenly ovate or subpyriform contour, the broader end representing the anterior pole, as exhibited by the body in its condition of natation. Except at one point, the entire peripheral surface of these bodies was clothed with long vibratile cilia, each cilium originating from the centre of a minutely circumscribed polygonal area, to each of which was assigned the morphologic value of a single cell. The exceptional region referred to, over which the cilia did not extend, was limited to the anterior pole, from which point an axial canal was described as leading from the external surface to a central body-cavity. Round the outer edge of this apical opening were stationed a circular border of larger subspheroidal non-ciliated cells, which represented the externally protruding units of a layer of similar cells that lined in a single and continuous series the entire surface of the hollow internal cavity with which the apical aperture was continuous. Taken thus in optical longitudinal section, these bodies, as interpreted by Professor Haeckel, or borrowing from his own illustrations, as represented at Fig. 2 in the adjoining woodcut, presented the aspect of an ovate sac composed of two separate, and histologically distinct, external and internal cellular layers, the outer one being composed of more minute subcylindrical and radially disposed monociliate cells, and the inner one of a correspondingly simple layer of much larger subspheroidal and non-ciliated cells. This sac-shaped bilaminated structure Professor Haeckel denominated a "gastrula," and represented it to be the ground or stock-form from which all sponges were primarily developed. It was further insisted that the outer or so-called "dermal lamina" of this bilaminated structure represented a true external dermal layer or ectoderm, and the inner or so-called "gastral lamina" a true entoderm, as obtains in all ordinary Metazoic organisms. Launching out into the regions of hypothesis, Professor Haeckel claimed for his so-called "gastrula" a far-reaching and most important significance.

"I regard the gastrula," Haeckel says, "as the most important and significant embryonic form in the whole animal kingdom. It occurs among the sponges, the Acalephæ, the Annelida, Echinodermata, Arthropoda, Mollusca, and the Vertebrata as represented by *Amphioxus.* In all these representatives of the most various animal stocks, the gastrula preserves exactly the same structure. From this identity of the gastrula in representatives of the most various animal stocks, from the sponges to the Vertebrata, I deduce, in accordance with the biogenetic fundamental law, a common descent of the animal phyla from a single unknown stock-form, gastræa or archegastrula, which was constructed essentially like the gastrula."

Speculating still further with reference to this newly-detected keystone, Haeckel maintained that the primary stock-form of all the sponges must have been an attached, bilaminate, gastrula-like organism, in all ways com-

FIG. 1.

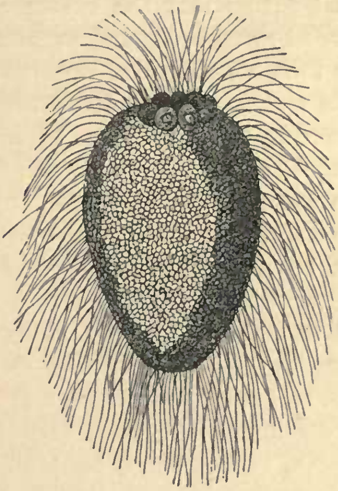
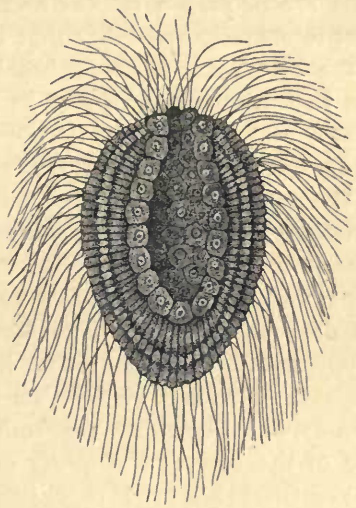


FIG. 2.



Hypothetical Ciliated Larva or so-called "*Gastrula*" of a Calcareous Sponge, *Leuculmis echinus* Hkl., as viewed, Fig. 1, superficially, and Fig. 2 in longitudinal section. In Fig. 2 an imaginary central gastric cavity, having a terminal but non-existing oral aperture and imaginary lining of subspheroidal endodermal cells, is represented. In Fig. 1 the most anteriorly developed cells of this imaginary endodermic layer are projecting around the hypothetic oral aperture.—After Haeckel, *Monograph of the Calcispongiæ*, pl. xxx. figs. 8 and 9, 1872.

parable with this typical "archegastrula," possessing a simple, double-walled, sac-shaped body, with a central stomachal cavity, terminal oral aperture, and no porous system. Should the walls be strengthened with spicula, such a type might be designated *Prosycum*, or, in its still more simplified form without any spicula, *Archespongia.* Such a typical hypothetic *Archespongia*, though not actually known to exist, Haeckel anticipated to probably possess a close ally in the singular form first described by Dr. Bowerbank under the title of *Haliphysema Tumanowiczii.* Haeckel's later and most ingenious exploits with this self-selected type will receive due notice presently.

Summing up the deductions and speculations concerning the affinities and significance of the so-called sponge-larva or gastrula, just enumerated, it is almost impossible to overrate the important and far-reaching issues involved in Professor Haeckel's interpretation of this developmental structure. Presuming his interpretation to have been substantiated, and to have received the confirmation of the many investigators who have subsequently devoted themselves to the study of this special zoologic group, the Metazoic organization and affinities of the sponges, as insisted upon by Haeckel, would undoubtedly have been established upon a firm basis. If, on the other hand, such investigation proved the existence of important errors in the interpretation rendered, neither the intimated affinity of the sponges, nor any of the many side-inferences and deductions connected with and interdependent upon such interpretation, possess further value. As a matter of fact, the crucial test applied has been productive of the most unlooked-for results, for, not only has it been shown that errors do exist, but that these are of such a radical and fundamental nature that the inference is most reluctantly arrived at that Haeckel, carried away in his ardent pursuit of the Metazoic archetype, has lost for the time his power of discrimination between matters of fact and hypothesis, and so evolved from his own inner consciousness those details that are wanting to complete and perfect his theory. This at any rate is the most charitable construction to place on the extraordinary discrepancies found to exist between even the broad structural characteristics of his so-called sponge-gastrula as reported by himself, and as since found to exist in fact by a number of independent witnesses. Without entering now into a precise and extensive account of the data elicited, it will suffice at present to state that on all sides, as demonstrated by the independent investigations of Metschnikoff, Oscar Schmidt, Barrois, F. E. Schulze, H. J. Carter, and the present author, it has been made evident that a reproductive body having the form and organization of the so-called *gastrula* or ciliated larva, as attributed by Haeckel to the Spongida, and reproduced in the foregoing woodcut, has no real existence, and that his representation of such a structure is entirely at fault in the following cardinal points. In the first place, this ciliated body never does possess two distinctly marked cellular layers comparable to a true ectoderm and endoderm; in the second place, there is neither a distinct gastric cavity nor an intercommunicating apical, oral, or other aperture as required for the confirmation of Haeckel's dictum; while, finally, the anterior and posterior poles have, as compared with what exists in nature, been exactly reversed in order to make them conform with his particular requirements. This latter circumstance is made obvious from the fact that in all instances, in both his figures and descriptions, the larger cells, which do frequently, but not invariably, occur in connection with these bodies, are stationed by him at the anterior, or his so-called "oral extremity," while in reality they are located at the posterior one. Taken altogether, it is clearly evident that the so-called "sponge-gastrulæ," described and figured over and over again in Professor Haeckel's 'Monograph,' are an entire myth, and that the superstructure of the gastræa theory, so far as it rests upon this basis, is entirely worthless. From this it is also clear that a very considerable portion of Professor Haeckel's artistically executed plates in the monograph in question are utterly untrustworthy and worse than use-less, since, accepting as infallible the representations of so high an authority, these entirely imaginary figures with their accompanying definitions have been already extensively reproduced as proven facts in many recent text-books of biology.* The glaring unreliability of Professor Haeckel's representations, in this special connection, necessarily justifies more than customary precaution in accepting as Gospel fact his evidence in other directions, wherever room is left for entertaining the slightest reasonable doubt. A case altogether to the point is afforded by his representations of the spermatozooids of various sponge species, in Plates 1, 7, 9, 11, 25, and 48 of his monograph. Scarcely three years previously, Haeckel, as already stated, declared that sponges were asexual and sporiparous, and that the careful examination by himself of hundreds of specimens had satisfied him that spermatic elements were entirely wanting throughout the class. As pointed out by Mr. Carter, the admission was in itself fatal to his Metazoic or gastræa theory as applied to the sponges, spore production being an essential property of Protozoic organisms only, and the union of true sexual elements, ova and spermatozoa, being of unvarying occurrence throughout all the higher or Metazoic groups. Tacitly, Professor Haeckel evidently acknowledged the trenchant force of Mr. Carter's argument. At any rate it is an interesting and significant fact that so-called true spermatozoa were found ready to hand and produced in abundance in Haeckel's succeeding essay on the affinities of the sponges. The celerity with which these missing elements were discovered in profusion, directly their presence was shown to be essential for the sustenance of his Metazoic theory, and in face of his previously declared incapacity to recognize them after a most exhaustive investigation, when not specially wanted, a few months earlier, is in itself a suspicious circumstance. It is just possible that these supposed spermatozoa may represent in some instances a misinterpretation of certain earlier conditions of the ordinary flagellate cells; but in one special case,† in which the actual fructification of a sponge ovum by spermatic bodies is delineated, it is difficult to resist the conclusion that the learned professor's fertile imagination—as in the case of the gastric cavity, oral aperture, and endodermic cell-layer of his sponge-gastrula—has risen to the occasion and kindled into being forms and features possessing no tangible existence.

Before proceeding to an examination of the evidence towards an elucidation of the precise structure and affinities of the sponges, accumulated through other independent sources, one later contribution of Professor Haeckel's demands brief notice. Reference is here made to his separate brochure 'Studien zur Gastræa-theorie,' published in the year 1877. While devoted generally to the exposition of his latest and most matured views upon the gastræa theory, it is specially worthy of notice as the

* E. g. "Development of Sponge, *Ascetta primordialis,*" in Prof. Huxley's 'Manual of the Invertebrata,' p. 112, fig. vi.

† 'Monograph of the Calcispongiæ,' pl. 48, fig. 6.

channel selected by him for the introduction to the scientific world of what appeared to be an entirely new and remarkable little group of organisms. Professor Haeckel had previously declared, in his 'Monograph of the Calcispongiæ,' his belief that the so-called "gastrula" or "ciliated larva" of a sponge typified the permanent and adult condition of some pre-existing type which might be appropriately designated an *archegastrula*, and that probably a very close approach to this hypothetic archetype was furnished by the supposed little sponge-form first described by Dr. Bowerbank under the title of *Haliphysema Tumanowiczii.* In the 'Biologische Studien' Haeckel announces, as the results of his most recent personal investigation, the discovery of a series of forms generically identical for the most part with this type; that his former anticipations were fully verified; and that in *Haliphysema*, and its allies, the true archetype of all sponges and the entire Metazoic series was at length forthcoming. As interpreted by Haeckel, *Haliphysema* was declared to be simply an attached sac-like "gastrula," having a simple central gastric cavity, terminal orifice, and imperforate body-wall composed of two closely apposed inner and outer cellular layers, the former one or entoderm being made up of flagellate cells, corresponding with those of the ciliated chambers of the ordinary Spongida, and the outer or ectoderm being constructed out of coalescent non-ciliate cells, and in all ways corresponding with his so-called syncytial element of the more complex sponges. No spicula or other endoskeletal structures were secreted by these *Haliphysemata*, but the external layer or "syncytium" possessed the faculty of appropriating and building up a variously modified and protective test, or exoskeletal covering, out of sand-grains, sponge-spicules, or any other suitable adventitious particles found in its vicinity. For the reception of the various types described the new group-title of the Physemaria was created, its members being announced by Haeckel to belong properly neither to the sponges nor to the zoophytes, but to represent in themselves an independent order which more nearly approached the hypothetic root-form of all Metazoa, his so-called "gastræa," than any yet discovered organic type.

The various species, five in all, referred to the genus *Haliphysema* were severally distinguished by the form and composition of their respective tests or exoskeletal elements, one among these, *H. globigerina*, being specially remarkable in having its test built up entirely of the shells of Rhizopods, such as *Globigerina*, *Rotalia*, *Orbulina*, *Textularia*, and various Radiolarians, collectively indicative of a deep-sea habitat. A second generic group was referred by Haeckel to the Physemarian order, under the new name of *Gastrophysema*. Of the two species referred to this genus the one received the title of *Gastrophysema dithalamium*, while the other, *G. scopula*, was identified with an organism described by Mr. Carter in the year 1870 under the name of *Squamulina scopula*, and referred by that investigator to the group of the Foraminifera. The only essential external difference presented by *Gastrophysema*, as compared with *Haliphysema*, was afforded by the character of the test, which in the former instance consisted of two or more intercommunicating chambers in place of the single one only possessed by the last-named type. Concerning the internal structure and significance of the interconnecting cavities in *Gastrophysema*, however, a far different and most remarkable interpretation was arrived at. The different chambers were in fact declared by Haeckel to be set apart for the performance of special and independent functions. Affirming that ciliated bodies or gastrulæ, similar to those of the sponges, were found only in the proximal or basal of the two chambers of *G. dithalamium*, he relegated to this cavity the function of reproduction, and bestowed upon it the special title of the "brood-chamber" or "uterus." The succeeding or anterior of the two cavities he declared to be a true stomach, communicating with the external world through the medium of the terminal aperture designated by him the mouth. The list of structural complexity, however, by no means ended here. Among the ordinary flagellate cells of the so-called stomach-cavity, Haeckel observed, or affirms to have observed, certain ovate cells of a special nature, pronounced by him to be of a glandular character; these he accordingly figured and described as gland-cells, "Drüsenzellen."

Had Professor Haeckel's observations and interpretations concerning this newly introduced group of the Physemaria been confirmed, *Haliphysema* would undoubtedly have to be accepted as a sponge structure in its simplest known form, while in *Gastrophysema* a complexity of organization would be superadded forbidding its correlation with either the sponges or the ordinary Cœlenterata. As a matter of fact, however, the evidence more recently adduced has tended to raise the gravest doubts concerning the very existence even of such an organic group as the so-called Physemaria of Professor Haeckel.

Haliphysema Tumanowiczii and *Gastrophysema* (*Squamulina*) *scopula* have both been proved to be varieties of one form, and instead of a simple sponge, as first described by Dr. Bowerbank, to be an arenaceous or test-bearing foraminiferal type. This interpretation, first suggested by Mr. Carter, has been fully established by the present author in a paper, with accompanying illustrations, published in the 'Annals and Magazine of Natural History' for July 1878. The account and illustrations there given were derived from the examination of living specimens collected in the Channel Islands, and which in their healthy condition exhibited their true nature by the emission, from the terminal aperture of their tests, of extensive reticulate pseudopodia exhibiting circulatory currents, comparable in all ways to those of the ordinary Foraminifera. By a careful investigation of that portion of the organism contained within the test, it was likewise shown that there was no trace whatever of a lining layer of flagellate cells, as asserted by Professor Haeckel, all, throughout, being simple homogeneous or more or less granular sarcode. A similar Foraminiferal interpretation has been arrived at by Professor Mobius, with respect to a new species, *Haliphysema capitulatum*, examined by him in the living state at the Mauritius, and in which pseudopodia were seen issuing in a corresponding manner from the single terminal aperture of the spiculiferous test. This confirmation, to which the author's attention was directed, after the publication of his communication to the 'Annals,' appeared in the 'Versammlung d. deutschen Naturforscher in Hamburg,' p. 115, for the year 1876. Evidence corroborating still more strongly the results above recorded, was published, however, in the 'Quarterly Journal of Microscopical Science' for October 1879, in which Professor E. Ray Lankester, after a most exhaustive examination of duplicate specimens of *Haliphysema Tumanowiczii* remitted him by the author from Jersey, in both the living and preserved condition, entirely supports the foraminiferal interpretation, and indicates the necessity of Professor Haeckel producing some satisfactory explanation of the very antagonistic statements now on record, for which he is responsible, with reference to *Haliphysema* and its allies.

Possibly, as suggested by the present author, isomorphic forms may exist having the external contour of a *Haliphysema* and the histologic internal structure of a simple sponge; but the evidence in this direction is up to the present time altogether opposed to such a supposition. Analyzing, in fact, the by no means extensive list of Professor Haeckel's Physemarian genera, *Haliphysema* and *Gastrophysema,* scarcely a single type is left him wherewith to demonstrate the existence of such isomorphism. Thus out of his five species of *Haliphysema, H. echinoides* is undoubtedly, as already pointed out by Mr. Norman, the young condition of the Tethyadan sponge first described in its young and stalked condition by Professor G. Percival Wright, under the name of *Wyville-Thomsonia Wallichii,** next described by the present author in the adult state as *Dorvillia agariciformis,*† and finally by Sir Wyville Thomson, as one of the trophies of the 'Lightning' and 'Porcupine' expedition, under the name of *Tisiphonia agariciformis. Haliphysema Tumanowiczii* and *H. ramulosa* are identified as undoubted Foraminifera. *H. globigerina* has been examined by Haeckel as dead, spirit-preserved examples only, and consequently under conditions in which the characters attributed by him to the typical forms would not be recognizable.

Of the genus *Gastrophysema, G. scopula* is demonstrated to be a Foraminifer identical with *Haliphysema Tumanowiczii,* and it so happens that *H. primordiale* and *G. dithalamium* are now alone left to vindicate the claims of the Physemaria for further scientific recognition. Even here the resemblance in every particular—setting aside the hypothetic and the utterly untenable "uterine" and "glandular" differentiations—coincides so closely with all the broad external features of some one or other of the numerous polymorphic forms of the one-, two-, three-, four-, or many-chambered spiculiferous tests of *Haliphysema Tumanowiczii,* that, unless Professor Haeckel can produce substantial testimony of their independent,

* 'Quarterly Journal of Microscopical Science,' vol. x., January 1870.
† 'Monthly Microscopical Journal,' December 1870.

and in that case amazingly remarkable isomorphism, the erasure of their names from scientific nomenclature, and also that of the entire Physemarian order, will be rendered unavoidable. Most unfortunately for Professor Haeckel, the context of his essay under discussion upon the gastræa theory in general, and upon the group of the Physemaria in particular, so abounds with direct negations and manipulations of known facts in order to adapt them to the requirements of his own hypotheses, that the verdict arrived at by the most impartial students of this question must inevitably tend to cast discredit upon his representations even where the same are possibly correct. It is thus not a little surprising to find reproduced as the larval type of *Haliphysema* in this essay, the self-same erroneous accounts and diagrammatic illustrations of his so-called "gastrula-larva" of the sponges, first formulated in his 'Monograph of the Calcispongiæ,' and submitted at page 157 of this volume.

The same inversion of the anterior and posterior apices and accompanying fallacious allocation of a gastric cavity, oral aperture, and evenly developed external and internal cellular layers, is once more repeated, the larval forms of the Physemaria being made to correspond with a like altogether hypothetic formula. The histologic characters of the essential collar-bearing flagellate cells of the sponge-body, assumed to be shared by *Haliphysema* and its allies, are again materially reduced in order to make them conform more nearly to the plan of ordinary tissue-cells, and with the morphologic and functional value of which they are alone accredited. Professor H. James-Clark and Mr. Carter had already shown that these peculiar flagellate sponge-cells exhibited a very significant Protozoic feature in the possession of two or more posteriorly located, rhythmically pulsating, contractile vesicles. In his 'Monograph of the Calcispongiæ,' Professor Haeckel grudgingly conceded and figured a single posterior vacuole, but denied to it the property of rhythmical contraction, affirming that it was a mere non-persistent and unessential lacuna developed in the protoplasmic substance of the cell. In that advanced exposition of the gastræa theory, however, embodied in his 'Biologische Studien' for the year 1877, the contractile vesicle, or protoplasmic lacuna, is improved altogether off the morphologic landscape, and the essential flagellate sponge-cell now appears with a simply nucleated but otherwise undifferentiated protoplasmic body. In two instances only does Haeckel make any concession to the antagonistic results arrived at by contemporary explorers in the same field of research, while even here these results are with a little tension made subservient to his special views. In the first place, the evidence since adduced not being confirmatory of his diploblastic interpretation of the sponge embryo, as produced by the delamination of the interior from the outer cellular layer, he now declared that essentially the same results were obtained, and the same form constructed, by the process of invagination. In the second place, the researches, more especially, of Oscar Schmidt, having elicited the fact that in many instances these ciliated bodies, as produced by the Calcispongiæ, exhibited an external conformation entirely different from his so-called "gastrulæ," Haeckel accounted for the inconsistency by declaring that in these special instances the embryonic form was represented by a distinct biogenetic type, which might be conveniently denominated an "amphiblastula."

Passing on from the foregoing brief record of the peculiar interpretations maintained by Professor Haeckel, with reference to the structure and affinities of the sponges, attention may now be directed to the facts elicited in this connection by the light of most recent research, including those adduced through the investigations of the present author. As an inevitable consequence of the very authoritative declarations of Professor Haeckel in favour of the Cœlenterate affinities of the sponges, and seeming coincidence of the evidence brought forward with these emphatic statements, the bias of late years has been altogether in the direction of substantiating their Metazoic nature, and of reconciling, with this end in view, the very conflicting structural and developmental data exhibited by the different members of this highly important group. Most noteworthy in this direction is that line of interpretation followed by Metschnikoff, Barrois, and F. E. Schulze, by whom, in both the adult and embryo sponge, the existence of three cellular layers, ectoderm, endoderm, and mesoderm, are distinctly recognized. In conformity with such interpretations, the ectoderm in the adult organism consists of a superficial layer of flattened, simply nucleated cells, closely approximated to each other, and agreeing to a considerable extent with the so-called "syncytium" of Professor Haeckel, this external element being also produced inwards, and lining the cavities of the aquiferous system. The special collared flagellate cells that line the so-called ciliate chambers are accepted as entodermic elements, while to the mesoderm is relegated the remaining interstitial portion, upon which chiefly devolves the secretion of the spicula or other skeletal structures.

In opposition to the widely supported Metazoic view founded by Professor Haeckel, adhesion is given in this treatise to that interpretation of the structure and affinities of the sponges that first originated with Professor H. James-Clark, and indicated their close relationship to the then small and insignificant little group of Flagellate Protozoa, first introduced to scientific notice by himself, and here described in a greatly extended form under the title of the Choano-Flagellata or Discostomata-Gymnozoida. The immense wealth of material that has been accumulated, both in the direction of the more minute structure of the sponges, and in the extension of our acquaintance with the above special group of Flagellate Protozoa and their allies, since the death of Professor Clark, is found on examination to support the views here adopted to the fullest possible extent. Already, in the 'Annals and Magazine of Natural History' for January and August 1878, and in the 'Popular Science Review' for April of the same year, the leading features of this advocated affinity have been submitted at considerable length. With this evidence, however, has now to be amalgamated the results of more recent research, as educed both by the author's personal researches and those of contemporaneous investigators.

Commencing with the general structural features of an adult sponge, as met with throughout the several more important groups into which the class Spongida is most naturally divided, it will be found that in any one of them, the three elements, demonstrated through the investigations of Professor Clark, constitute the actual and essential components of the sponge-body. These three, the collar-bearing flagellate monads, the hyaline and mucous-like cytoblastema, and the included amœba-like cytoblasts, will be invariably found in every sponge, more generally with superadded skeletal structures, and often with a greater or less proportional preponderance or reduction of the first, second, or third of the essential elements enumerated, but in no instance presenting an entire absence of any one of them. Out of these three elements, again, it is beyond question that the first-named, or collar-bearing flagellate monads, lay claim to the foremost position in the sponge economy, and that the two remaining ones are, as compared with them, entirely subsidiary. Separating the collar-bearing units from those two subordinate elements, as shown more especially at Pl. VIII., and comparing them with the independent collar-bearing flagellate monads, figured in Pls. II. to VI., the close identity of the two cannot possibly fail to be recognized. This likeness, furthermore, is found to be not merely general and superficial, but to extend to every point that may be enumerated. Neither is such likeness common and unimportant, or comparable to such as is usually found between ordinary tissue-cells, or to more practically illustrate the case, to such as exists between an amœba and a leucocyte or white blood-corpuscle. Amœbiform cells, indistinguishable in their isolated condition from ordinary amœbæ, recur again and again as the constituent or associated elements of the organic tissues of both vertebrate and invertebrate animals. That special modification of a simple cell, however, exemplified by the independent collared monads or Choano-Flagellata, and precisely reflected in the essential elements of the sponge-body, finds its counterpart nowhere else throughout the entire range of organic nature. While these two can be correlated and shown to harmonize with each other in every detail, it becomes self-evident that all attempts to co-ordinate either of them with any other structures are rendered nugatory, and are, in point of fact, attempts to compare that which is altogether uncomparable. In what manner the collar-bearing monads differ essentially from all other known unicellular structures, is explained at length in the section devoted to the systematic description of their order. Briefly, however, it may now be stated that the all-important distinction here insisted on is connected with that peculiar structure the "collar" and its accompanying functions. As demonstrated by the author, this "collar" is not a mere funnel-shaped expansion of inert sarcode, as might be inferred from the earliest accounts given of it, but it practically represents the most actively motile and important element in the animalcule's economy. During life, in its typical fully-extended state, a continuous stream of fine granular protoplasm is ever flowing up the exterior and down the interior surface of the collar, in all ways identical with the protoplasmic circulation or cyclosis exhibited in the extended pseudopodia of the Foraminifera and other Rhizopoda. In other words, this structure with its circulatory currents might be described as a peculiarly modified funnel-shaped pseudopodium. By direct observation the author has further demonstrated that the collar, with its characteristic currents, is an exquisitely contrived trap for the arrest and capture of its customary food, which, driven by the action of the centrally enclosed flagellum against the outer margin of the collar, adheres to it, and passes with the onflowing protoplasmic stream into the animalcule's body. The whole nutrient process, with its associated circulatory currents, as exhibited by an animalcule of the solitary genus *Monosiga*, will be at once comprehended on reference to the coloured illustration given in the frontispiece. Now, what has been described and delineated of the independent collar-bearing type *Monosiga* and its allies, is found to obtain with full force, and in the very minutest detail, in the essential collar-bearing flagellate units of a sponge-body. The collar there exhibits the same circulatory motions and is subservient, in the self-same way, as a trap for the capture of food-particles; the body, as already intimated, exhibits the same posteriorly located rhythmically pulsating contractile vesicles, the same central spheroidal nucleus or endoplast, and presents, furthermore, the most closely identical reproductive phenomena. The essential collar-bearing sponge-monads, or Spongozoa, as they have been appropriately designated by Mr. Carter, are, in fact, to all intents and purposes, collar-bearing Flagellate Protozoa, differing only from *Codosiga*, *Salpingœca*, *Desmarella*, and the various other genera included in this volume under the denomination of the Choano-Flagellata, in their special colonial mode of aggregation, and in the accessory and non-essential elements more usually, but not invariably, added in the form of skeletal structures.

An additional character, indicative of the close identity in all functional manifestations that exists between the sponge-monads and the independent collared types, remains to be mentioned. In the descriptions given of these latter, attention is frequently directed to the extreme plasticity of the individual animalcules, and the facility with which the funnel-shaped collar and flagellum is retracted at will, pseudopodium-like extensions of the body-sarcode projected, and the most polymorphic aspects exhibited. Examples of such metamorphoses, as presented by the loricate type *Salpingœca amphoridium*, may be seen at Pl. V. Figs. 5–8, and also in many other figures illustrative of this genus, and the illoricate *Codosiga* and *Monosiga*, in the several plates devoted to this interesting group. Among the collared monads of the more complex sponge-stock, not only an equal, but a far higher degree of plasticity is presented. The component sarcode of the monad's body in this latter case is apparently of thinner or more fluid consistence, permitting of rapid and protean changes of form on the slightest irritation or other stimulus. Thus, when a dissection is made of any living sponge, such as *Grantia compressa*, it is found requisite to examine rapidly with the microscope in order to witness the constituent monads with their collars and flagella in the normal condition of extension; otherwise, within the space of a few minutes, these organs are, one or both, more or less completely retracted, and their former possessors creeping about the field, or remaining congregated in clusters under conditions that render them indistinguishable from ordinary Flagellate monads, or simple amœbæ. In this latter instance, they are, indeed, identical in all respects with the amœbiform zooids or cytoblasts scattered throughout the common gelatinous central matrix or cytoblastema of the sponge-body. The more conspicuous modifications of form assumed at will by the collared sponge-monads, either with the collar and flagellum extended with the former organ alone, or with both of these two retracted, will be found abundantly illustrated in Figs. 2–38 of Pl. VIII., devoted especially to the histology of the Spongida. Among them two or three examples occur which deserve particular notice. Thus, at Fig. 17 of the plate quoted, is represented an individual monad which, after the retraction of the collar and flagellum, has thrown out innumerable long slender pseudopodia, which convey to it an appearance highly suggestive of that of the Radiolarian type *Actinophrys*. Other examples, exhibiting in a less degree the same plan of metamorphosis, are also delineated in connection with the groups or isolated examples numbered respectively 12, 14, 15, 16, 20, and 24. In Figs. 29, 30, 31, a modification in an entirely different direction is shown. Here, with the collars and flagella entirely withdrawn, as before, slender pseudopodia are emitted from the periphery, terminating in distinctly capitate extremities which recall to mind the specialized suctorial tentacles of the Acinetidæ. Recovering from the disturbing influence which has brought about any of the various metamorphoses above enumerated, the emitted pseudopodia or lobate sarcode extensions are, after a while, drawn in, and the normal form with the extended collar and flagellum again assumed. At Fig. 18 of Pl. VIII. will be found examples of such sponge-monads, which after a short tenure of a vagrant amœboid condition, have reattached themselves to a minute spiculum of the parent sponge, and resumed the customary aspect of the typical Spongozoa.

Were it not explained that these readherent collared monads belonged to a sponge-stock, it would be impossible to distinguish them from the representatives of such independent collared animalcules as *Monosiga Steinii*, represented at Pl. IV. Fig. 12. The collared sponge-monads, thus reattached, soon throw out around them a thin investing film of hyaline cytoblastema, as shown at Figs. 19, 21, and 22, and are thus capable, without any other extraneous assistance, of either repairing a mutilated sponge-stock, or of building up an entirely new one. With reference to the feeding capacities of the sponge-monads, it may be here noted, that the phenomena of nutrition are precisely identical with those exhibited by the independent collared species, the selected pabulum being arrested by the hyaline collar and carried with its circulating current into the body of the animalcule. Examples are given at Pl. VIII. Figs. 9 and 19, in which the bodies of the neighbouring sponge-monads are filled with ingested and artificially administered carmine particles. Such functions of nutrition are, however, not confined to the collared zooids; the amœbiform units or cytoblasts being equally capable, as shown at Fig. 41 of the same plate, of ingesting solid pabulum.

Examining the matter more closely, it has now to be shown that even the special differences already cited as indicating a distinction between the Spongida, independent collared monads, and ordinary Infusoria, are scarcely more substantial than those found to exist between the more conspicuously divergent representatives of the same groups or orders of the last-named section. Taking, in illustration of this analogy, the very familiar group of the Vorticellidæ, we find in *Vorticella*, or more correctly, in the stiff-stalked form *Rhabdostyla* and in the compound type *Epistylis*, the precise analogues of the solitary collared type *Monosiga* and the social genus *Codosiga*. Proceeding yet a step further, the slime-immersed colonial type *Ophrydium* is beyond doubt comparable in a like manner to the colonial slime-immersed genus *Phalansterium*. Beyond this it is not possible, as yet, to institute a direct comparison, but, supposing that a genus of colonial slime-immersed Vorticellidæ should be discovered in which the animalcules, instead of projecting directly into the surrounding water through the peripheral surface of their common matrix, as obtains in *Ophrydium*, were enclosed within chambers which communicated with each other, and with the outer water, by a system of interconnecting canals; supposing also that all the spores, germs, encystments, or other reproductive products remained embedded and developed to maturity within the common matrix, a type of the Vorticellidæ would be produced presenting a parallel to *Ophrydium* precisely identical with what actually exists between the most simple known sponge and *Phalansterium*.*

With the assistance of Plates VII. to X. it is now proposed to draw

* At the eleventh hour, while going to press, the author has had the good fortune to light upon a new and highly interesting representative of the independent collared series, that illustrates in a yet more decisive manner the close relationship of this group to the Spongida. The type in question, represented at Pl. X. Figs. 20–30, and hereafter described under the title of *Protospongia Haeckeli*, agrees with *Phalansterium*, so far as the zooids are immersed within a common gelatinous matrix or zoocytium. The characteristic collars are, however, fully developed in place of being rudimentary as in the last-named genus, while the inhabited gelatinous matrix is perfectly transparent and homogeneous instead of densely granular. Within their matrix the zooids were observed to assume various metamorphic amœboid conditions, to multiply both by the process of binary subdivision and by the partition of their entire mass into sporular elements. The resultants of the last reproductive process commence their active existence as simple, minute, uniflagellate monads, which project, as shown at Fig. 22 *b b*, from the periphery of the zoocytium side by side with the adult collared units. This interesting species which, in its mature condition, corresponds in a most remarkable and significant manner with a fragment of cytoblastema, with its enclosed collared zooids, amœbiform cytoblasts, and sporular elements, of any typical sponge-form, was obtained by the author in July 1880, in water brought from the lake in Kew Gardens.

attention to the more important structural features exhibited by the leading subdivisions of the Spongida, and especially to those points in which their close relationship to the independent collar-bearing monads figured in the five preceding plates is most prominently shown. As already stated, the collared cells or essential Spongozoa of any given sponge-body are invariably found lining special chambers excavated within the common, structureless, mucilaginous basis or cytoblastema which enters more or less considerably into its composition. These special chambers, again, are found in different sponges to exhibit a considerable diversity of contour, but, on the whole, to conform to two distinct and widely differentiated plans. In one of them it is found that the collared cells more or less completely line the entire internal cavities of the sponge, including both the afferent and efferent canal-systems. Such a type of structure, as is most prominently developed among the section of the Calcispongiæ, is illustrated in the sectional views given at Pl. VII. Figs. 3 and 4, of the interstitial canal-system and disposition of the characteristic collared monads or Spongozoa in the familiar British species *Grantia compressa.* At Fig. 3 a general view is given of the segment of a complete transverse section of this sponge, showing the characteristic disposition of the interstitial loculi with their monad linings around the common cloaca, while at Fig. 4 one complete and another incomplete loculus is considerably enlarged, proving the essential correspondence of the contained monads with the independent forms figured in the preceding plates. In the series belonging to the second structural plan, the collared cells, instead of being distributed more or less generally throughout the entire internal canal-system, are confined to certain spheroidal chambers excavated within the substance of the sponge body, these chambers being brought freely into relation with the external water through the agency of both the afferent and efferent canals. It was upon these spheroidal chambers, as first discovered in *Spongilla*, that Mr. Carter conferred the title of "ampullaceous sacs," by which name, together with that of "ciliated chambers," they have since been most familiarly known. A similar ampullaceous disposition of the collar-bearing cells is found to obtain among a very extensive series, if not throughout the majority of the Spongida, including, in fact, all the known members of the Myxospongia, the greater part of the Siliceospongia, and in accordance with the representations given by Professor Haeckel, the family of the Leuconidæ among the Calcispongiæ. The highly characteristic aspect presented by the collared monads or Spongozoa, as grouped upon this principle, will be found delineated at Pl. VII. Figs. 1 and 2, and Pl. IX. Figs. 1, 3, and 12, and is remarkable for the elegant clustered or grape-like appearance presented by the monad aggregations with their interconnecting canal-systems. In Fig. 1 of Pl. VII. is reproduced the portion of a section of the non-spiculiferous sponge *Halisarca lobularis* as delineated by F. E. Schulze, while at Fig. 2 is represented a somewhat similar section of the siliceous type *Esperia* sp., as observed by the author.

Deferring for a while the more minute account of the structure and significance of these monad-lined chambers, brief attention may be directed to certain other broad external features superficially recognizable in the various more highly differentiated sponge groups. As previously stated, in every known variety of sponge three essential elements are invariably present, namely, the collar-bearing flagelliferous cells, the mucilaginous cytoblastema, and the amœbiform cytoblasts, to which other accessory or non-essential elements may, or may not, be added. The relative proportions in which these three essential elements exist among the several sections of the Spongida, present some important differences. Among the simplest known sponge forms, as represented by the genus *Halisarca*, in which these elements occur in their pure and simple condition without any addition of spicula, horny fibres, or other skeletal structures, and where, as just stated, the collar-bearing monads exhibit the ampullaceous plan of arrangement, it will be observed, on further reference to the illustration quoted (Pl. VII. Fig. 1.) that this special system by no means occupies a largely predominating portion of the entire sponge body, a very considerable part consisting of the common gelatinous matrix or cytoblastema and its enclosed amœbiform cytoblasts. With the majority of the Siliceospongiæ, including those forms which have, either with or without siliceous spicules, a horny or keratose skeleton, an almost identical predominance of these elements is met with. Among the more characteristic representatives of the Siliceospongiæ, however, including the species of *Esperia* delineated at Pl. VII. Fig. 2, a highly characteristic modification is presented. In such as these the cytoblastema is especially remarkable for its extremely thin and pellucid consistence, this being particularly noticeable in the superficial or peripheral region, where it is supported canopywise, or after the manner of a tent-covering, from the light and efficient scaffold-work furnished by the projecting spicula. A similar type of structure is, as first pointed out by Professor Clark, highly characteristic of the fresh-water genus *Spongilla*. That combination remaining to be described, in which the proportions of the three primary structural elements exhibit a marked divergence from those just noticed, is most conspicuously developed in the section of the Calcispongiæ, and, with the exception of the Leuconidæ, would appear to be essentially characteristic of that group. As already stated, the collared cells in this section are characterized by their diffuse plan of distribution, the entire surface of the internal chambers and passages being more or less completely lined with them. In correlation with this distribution of the collared cells, it is found that the cytoblastema is, as compared with those elements, reduced to its minimum, being indeed superficially, as exhibited in the sections of *Grantia compressa* in Figs. 3 and 4 of Pl. VII., altogether inconspicuous.

A closer examination of those special points by which, in accordance with the author's views, the close affinity of the Spongida with the independent collar-bearing Discostomata is held to be substantiated, may now be proceeded with. As previously maintained, between the separate collar-bearing monads of any of the independent Choano-Flagellata and the special collar-bearing cells that constitute the one essential element of all sponge structures, there is absolutely no recognizable distinction in form, structure, and function. The body with its nucleus or endoplast, multiple contractile vesicles, and appendages as represented by the characteristic collar and enclosed flagellum, so precisely accord with each other as to defy individual identification, a circumstance which will be at once recognized on comparing these collared elements in their isolated or aggregated form, as abundantly illustrated in the Plates VII. to X. and II. to VI., devoted respectively to the morphology of the Spongida and that of the independent collared monads. The likeness, however, does not end, but practically only commences here, for, as it has now to be shown, all the phenomena of reproduction and development are likewise reducible to a corresponding type.

In order to fully comprehend and appreciate the full force of this relationship, it is requisite only to place still more intimately *en rapport*, the life-phenomena of the collar-bearing sponge-monads and those of the independent Choanophorous and ordinary Flagellate Protozoa. That the thin, structureless cytoblastema forming the common gelatinous matrix which encloses and more or less completely conceals the collar-bearing monads of the sponge-body, is the equivalent of the common gelatinous matrix of such genera as *Phalansterium* and *Spongomonas*, or, reverting to a still more familiar ciliate infusorial type, that of *Ophrydium*, is immediately apparent, and is similarly, as hereafter shown, the direct product by exudation of the included zooids. By Professor Haeckel this common gelatinous element in sponge structures is denominated the "syncytium," and treated of as an independent tissue-layer formed by so intimate a coalescence of independent constituent cells that their nuclei only are to be discerned. That a syncytium, however, in the sense assumed by Haeckel, does not exist, is abundantly proved by the testimony accumulated from a variety of sources; what he embodies under this title represents in point of fact both of those fundamental elements which receive in this volume the titles of the "cytoblastema" and "cytoblasts." It is to the existence and significance of the last-named elements that attention has now to be directed. The characteristic aspect of the cytoblasts — which occur as amœbiform bodies of variable size and contour, variously distributed and more or less completely immersed within the substance of the cytoblastema—is delineated at Pl. VII. Fig. 2 *c* and Pl. VIII. Figs. 41 to 43. Like *Amœbæ*, they are constantly undergoing a change of outline, and may also be observed to shift their position from one part to another of the inhabited matrix or cytoblastema. Oftentimes their long, slender pseudopodia, radiating towards those of their neighbours, unite together, forming under such conditions a complex network which presents, as a whole, as shown at Fig. 43, a remarkable resemblance to ganglionic corpuscles; these highly differentiated metazoic tissue-elements they may be said, in fact, to typify in both form and function.

It is undoubtedly through the stimulus received and transmitted by the cytoblasts that the characteristic contractions and expansions of the oscula, and other portions of the sponge-body, are accomplished. Strictly, however, these elements perform a more general function than that of simple nerve-ganglia, they being in addition the direct motor agents in the contraction and expansion of the general cytoblastema, and thus fulfilling the part of both nerve- and muscle-fibres. The independent existence and characteristic aspect and functions of the cytoblasts were first pointed out by Lieberkuhn,* his observations being since abundantly confirmed by the independent researches of Carter, H. James-Clark, F. E. Schulze, and many other investigators, including the author.

At first sight, the connection between these amœbiform cytoblasts and the more essential collar-bearing zooids is scarcely obvious and has not as yet, apparently, been even so much as suspected by any other authority. To arrive at a comprehension of their true significance it is only necessary, however, to refer to the life and developmental phenomena presented by the independent collared monads and Flagellate Infusoria generally. Here, both the primary and terminal conditions of the typical flagellate zooids are frequently characterized by the exhibition of a similar amœboid aspect, as is abundantly shown in the accounts and illustrations given of the life and developmental phases of the genera *Codosiga*, *Salpingœca*, *Monas*, *Oikomonas*, *Euglena*, *Eutreptia*, *Heteromita*, and a host of other forms described in this volume. The capability of the adult collared and flagelliferous spongozoa to take upon themselves a similar amœbiform character has been observed repeatedly by the author, as illustrated in a large number of figures contained in Pl. VIII., which is confirmed by the observations of Carter, F. E. Schulze, and other recent investigators, including even Professor Haeckel himself.† The amœbiform elements of a sponge-stock cannot therefore be consistently regarded even as independent structures. To all intents and purposes they are the mere larval or metamorphosed phases of the typical and essential collar-bearing zooids; the distinctive title of cytoblasts, as here adopted, being conferred upon them only as a matter of convenience. Where, as frequently occurs, the amœbiform bodies are of comparatively colossal size, the coalescence of a greater or less number of the ordinary cytoblasts has undoubtedly taken place, the phenomena in this instance being directly comparable with the building up of the huge amœbiform "plasmodia" of the Mycetozoa, or with the coalescence of a number of metamorphosed amœbiform elements as exhibited by the simple Flagellate types *Heteromita uncinata* and *H. amyli*. The import of the amœba-like masses thus constructed is likewise in all instances identical; each such aggregate mass ultimately producing, by

* "Ueber das contractile Gewebe der Spongien." Müller's 'Archives,' pp. 74–86, 1867.

† See 'Monograph of the Calcispongiæ,' Taf. 25, fig. 6: "Vier Geisselzellen welche sich in amœboide Zellen verwandelt haben." Also, Pl. VIII. Figs. 32 to 35 of this work.

segmentation, a swarm of unicellular flagellate zooids resembling those from whence they derived their origin.

The very important phenomenon of spore-production by sponges, comparable in every way with that exhibited so abundantly among the ordinary Infusoria, and which places in a still more prominent light their close connection with the typical Flagellata and Protozoa generally, has now to be described. While the occurrence of spores in various sponge-types had been noted so long since as the year 1874, its first record was contained in a communication made by the author to the Linnean Society in June 1877; further reference to this phenomenon, with accompanying illustrations, being likewise published in the author's "Notes on the Embryology of Sponges," contributed to the 'Annals and Magazine of Natural History' for August 1878. Since that time, however, much additional material has been amassed in demonstration of this special mode of reproduction, and more especially in connection with various sponge forms collected and examined by the author at Teignmouth, Devonshire, in the summer of 1879.

The types thus recently examined in the living state included more especially *Grantia compressa*, *Grantia* (*Sycon*) *ciliatum*, *Leucosolenia botryoides*, and *Leucosolenia* (*Ascetta*) *coriacea*, among the calcareous forms, and *Halichondria punicea*, *H. incrustans*, and a species of *Esperia* belonging to the siliceous series. All of these were found to yield sporular bodies in abundance, their most profuse development being, however, afforded by the calcareous type *Leucosolenia coriacea*. Here symmetrically rounded masses, irregular patches, or more or less isolated spores, of a yellow or light brown hue, were found scattered literally in thousands throughout the substance of the cytoblastema and in various stages of development. In their earliest observed condition, in which the spore-aggregations form compact spheroidal masses, these masses measured in diameter the 1–1300th, and the individual spores that only of the 1–7500th, part of an English inch. Bringing to bear upon them the high magnifying power of 2500 diameters, as obtained with a $\frac{1}{50}$-inch objective by Powell and Lealand, it was discovered that at a very early period of their development, that is in all that had arrived at twice their first noted bulk, each spore possessed a single long vibratile flagellum, and corresponded precisely in aspect with the initial phases of many of the simple monad types hereafter figured and described. Moreover, as liberated by dissection from their natural position in the cytoblastema of the parent sponge, these sporular bodies, with their vibrating flagella, were set free in the surrounding water singly, in twos or threes, or in larger social aggregations that singularly resembled the early phases of development of *Monas* (*Heteromita*) *lens*, described at page 137, and delineated at Pl. XI. Figs. 8–13. Not unfrequently, again, these motile spore-aggregations were of considerably larger size, and retained their primitive spheroidal form. Illustrations of all of these various conditions of spore-production, as observed in *Leucosolenia coriacea*, are given at Pl. X. Figs. 1–7, while, for the purposes of future reference and comparison, sections of this sponge and the other species named, exhibiting similar reproductive features, were preserved with osmic acid and other suitable media.

As a substantial proof of the derivation of these variously formed spore-masses from the typical collar-bearing units, examples were observed, as represented at Pl. X. Figs. 1*a* and 2*b*, in which these zooids had withdrawn their characteristic collars and flagella and assumed a quiescent or encysted state, while in closely adjacent examples they had become resolved into the spore-masses under discussion. Near these again, the spore-masses in their disintegrated state, or higher developmental phases, were found, as shown at Fig. 2, *d d*, scattered through the substance of the thin, transparent cytoblastema. In one point only was the character of the spore-masses, as now examined with the highest available magnifying power, found to differ from that assigned to them in their earlier record already quoted. At that time, in the case of *Leucosolenia botryoides*, a delicate capsular investment or sporocyst was presumed to exist. No trace of such an investing element could, however, be detected in *L. coriacea.* The entire body of the collared sponge-monad, after assuming a quiescent state, divides by segmentation into a mass of characteristic microspores, and these falling asunder, become distributed throughout the hyaline cytoblastema. It might have been suggested, and was indeed at first anticipated by the author, that the spore-masses, as here figured and described, might have been derived from some protozoon or protophyte which had established itself as a parasite or commensal within the canal-system of the sponge-body. The unmistakable import of these structures as integral constituents of the latter, is, however, abundantly demonstrated by their undeviating recurrence and mode of distribution in the sponge-body, even when obtained from the most remote localities.

In this connection it has to be recorded that spore-masses, presenting the same form, size, and character, have been encountered by the author without any exception in examples of *Leucosolenia coriacea*, personally collected and examined in the living state, derived from Teignmouth, Ansty's Cove, Falmouth, and other points on the Devonshire and Cornish coasts, and also from various stations in the Channel Islands. Corroborative evidence relating to this species has likewise been recently obtained from an independent and altogether unexpected source. In vol. iii. page 8, of Dr. Bowerbank's 'Monograph of the British Spongiadæ,' 1874, bodies of a precisely similar character, though connected with a different title, are described as occurring in specimens of this sponge collected in Shetland and remitted, preserved in spirit, to the author by the Rev. A. M. Norman. Dr. Bowerbank's account of these spores is as follows :—

"On examining the sponge microscopically I found it contained an abundance of gemmules. They were exceedingly numerous on the inner surface of the dermal membrane. Their form was either spherical or slightly oval; they were of a nut-brown colour, and filled with numerous spherical molecules, which were distinctly visible with a power of 700 linear. One of the largest of the gemmules measured 1–1119 inch in diameter, and the molecules within did not exceed 1–15000 inch in diameter. This gemmule had all the appearance of being in a fully developed condition. The greater portion of the other gemmules were much smaller; one, of about the average size, measured 1–1705 inch in diameter."

Unfortunately no figures are given of these bodies, but there is scarcely room for doubt that the spore-masses figured and described in this volume, and the so-called "gemmules" with their "molecular contents," as observed by Dr. Bowerbank, represent the same structures. Apparently the last-named authority attributed to these molecular or sporular aggregations the possession of a distinct investing cellular membrane, his interpretation thus according with the impression first conveyed to the author when examining them with inadequate magnifying power. In yet another calcareous type Dr. Bowerbank has placed on record his observation of somewhat similar spore-like bodies. In his account of *Leucosolenia* (*Ascortis*) *lacunosa*,* he writes:—

"The whole surface of the interior of the fistulæ and central cloacal cavity is abundantly furnished with circular nucleated cells varying in diameter from 1–5454 inch to 1–3000 inch; they are regularly disposed, and are seldom more than about the length of their diameter distant from each other. The nuclei occupy from one-third to about two-thirds of the diameter of the interior of the cell, and neither in it, nor in the cell surrounding it, is there any appearance of granules. I could not detect any of these cells in the dried specimen of the same species, nor have I ever seen similar cells in any other calcareous sponge. It is difficult, in the present limited state of our knowledge of this tribe of sponges, to determine the import of these bodies in the economy of the sponge, but it is most probable they are reproductive organs."

Correlated with the evidence just submitted in connection with the allied type *L. coriacea*, there is every reason to believe that here also spores of a closely identical type exist. Much evidence substantiating the very general occurrence of spores among the Spongida may be further adduced from the more recent publications of various Continental spongologists, though no such interpretation of the structures observed would so far appear to have presented itself to the minds of these investigators. Thus in his "Untersuchungen über Hexactinelliden,"† W. Marshall figures and describes spore-like granules as occurring separately or in spherical masses within the substance of the undifferentiated sarcode or cytoblastema of a species of *Holtenia*. C. Barrois, "Embryologie de quelques Éponges de la Manche,"‡ figures as peculiar granular cells, perhaps spermatozoa, of a species of *Isodictya*, subspheroidal and more or less elongate aggregations of spore-like bodies held together by thread-like transparent chords. This identical type has been encountered abundantly by the author on the Jersey coast, and was independently observed to exhibit a similar peculiarity. The

* 'Mon. Brit. Spong.,' vol. ii., 1866. † 'Zeit. Wiss. Zool.,' Bd. xxv., 1875.
‡ 'Ann. de Sc. Nat. Zool.,' 1876.

whole cytoblastemic element in this species is remarkably tenacious or glutinous, and is drawn out in long strings, like bird-lime, when the sponge is broken apart; the granular cells observed by Barrois are evidently the spore-masses held together in the withdrawn glutinous threads of the investing cytoblastema. The so-called "sperm-balls," figured by F. E. Schulze, in relation with the genus *Halisarca*,* would appear also to belong to the same category. The abundantly distributed subspheroidal groups of so-called coloured corpuscles figured and described by this last-named authority as imparting the characteristic yellow tint to the keratose type *Aplysina aerophoba*, † correspond remarkably with the yellow or light brown spores of *Leucosolenia coriacea*. Lastly, Metschnikoff's valuable "Spongologische Studien" ‡ embraces abundant testimony in a corresponding direction, and as is made evident at Pl. X. Figs. 8 and 9 of the present treatise, reproducing his illustrations of the so-called "mesoderm" elements of the genus *Siphonochatina*.

In anticipation of the argument that may be advanced by the adherents of the Metazoic interpretation of sponge structures, to the effect that the sporular bodies here figured and described, represent spermatic or male reproductive elements, it is only requisite to point still more emphatically to the fact that these spores distributed broadcast throughout the substance of the cytoblastema may, as ascertained by the author, be met with and traced onwards through every intermediate size and stage, from the single spheroidal spore up to the adult collared monads or amœbiform cytoblasts; the derivation of these spores through the splitting up into a granular or sporular mass of the entire substance of the matured collar-bearing zooids being correspondingly substantiated. Their phenomena of production and cycle of development are, in fact, in all ways identical with those that obtain among the typical Choano-Flagellata and ordinary Flagellata, and in all of which the spores derived by a similar segmentation of the parent body develop first a simple monadiform or amœboid phase, and after arriving at the adult state revert once more to the amœbiform condition, become quiescent, and are again resolved into minute spores. In the sponge, all these transformations and developmental processes take place within the substance of the cytoblastema, which constitutes a suitable nidus for them essentially corresponding with the gelatinous matrix or zoocytium of *Ophrydium*, *Phalansterium*, and *Protospongia*.

While the evidence so far submitted suffices to indicate the close connection of the Spongida with the typical Infusoria-Flagellata, and also explains, in connection with the phenomena last described, the manner in which the general sponge-body is, by ever progressing internal spore-production, rapidly increased in size, certain other important features connected with their reproduction remain to be recorded. Although the scattering of the spores through, and their development within, the

* 'Zeit. Wiss. Zool.,' Bd. xxviii., 1877. † Ibid., Bd. xxx., 1878.
‡ Ibid., Bd. xxxii., 1879.

substance of the cytoblastema contributes largely towards the augmentation of the common colony, it evidently does not provide for the more remote dispersion of the species. This is effected in an entirely distinct manner. In many cases, such as that of the common fresh-water *Spongilla*, such a desired result is partly brought about by the production of encapsuled gemmules, or so-called "seed-like bodies" at the time of the decadence and disintegration of the parent stock. Practically, the development of these reproductive bodies may be said to represent on a large scale a modified process of encystment closely corresponding with the production of sporangia among the Mycetozoa described on a preceding page. As winter approaches, the zooids forming the parent colony assume an amœboid state and coalescing in spheroïdal groups, secrete around them a common spiculiferous capsule, within which they remain in a torpid or quiescent state, until revivified by the return of spring and its accompanying congenial temperature. A singular inversion of this phenomenon obtains among the *Spongillæ* of tropic countries, and in which, as recorded by Mr. Carter of certain types occurring in the neighbourhood of Calcutta, the production of gemmules, or entrance upon a hibernating or quiescent state is resorted to (identically with that of many tropic fishes, such as *Lepidosiren*) as a protective provision against the summer droughts, when the tanks and reservoirs that they customarily inhabit are dried up.

The quiescent or hibernating gemmules, however, play but a minor part in the local distribution of the species compared with the actively motile reproductive bodies produced as offgrowths by sponges of apparently every denomination during their period of luxuriant growth. With these motile bodies, indeed, the quiescent or hibernating gemmules are in no ways comparable, they representing more correctly composite modifications of the temporary "protective encystments" of the ordinary Infusoria. As true reproductive gemmules only are here recognized those free-swimming bodies, the so-called "ciliated-larvæ," or "ciliated sponge-embryos," first discovered by Grant and Lieberkuhn, upon the correct interpretation of which the minds of biologists within these latter days have been so diligently exercised. It is upon these seemingly anomalous reproductive structures, moreover, that Professor Haeckel has, as already stated, conferred the distinctive title of *gastrulæ*, and sought to demonstrate the conformance of the Spongida to the Metazoic type. Without recapitulating the altogether erroneous interpretations first published, and quite recently maintained, by Haeckel concerning the form and structure of these bodies, reproduced, rather as an admonition and warning than for the purposes of edification, in the woodcut illustration with its accompanying description at page 157, a brief examination of the more reliable data accumulated through the independent investigations of Metschnikoff, Oscar Schmidt, F. E. Schulze, Barrois, and other recent authorities may be proceeded with. While one and all of them are unanimous in condemning, as entirely fallacious and untrustworthy, that special bilaminate and sac-shaped structural type attributed by Haeckel to the so-called ciliated embryos, the Haeckelian interpretation of the Metazoic affinities of the sponges has exerted so widespread an influence, and obtained such favour, that every point has been strained on all sides to reduce these reproductive structures, one way or another, to the Metazoic formula.

Unfortunately for these authorities, however, the one dissentient party to this seemingly plausible and, so far as the sponges are concerned, most honourable correlation is encountered in the very object of their solicitous attention. The ciliated sponge-embryo—or, as shown later on, it may be more appropriately denominated the "ciliated sponge-gemmule"—stubbornly resists interpretation as the exact analogue of any one of the various embryonic types prevalent among the Metazoa, and seems indeed to derive a pleasurable satisfaction from the exhibition of a varying type of structure, possessing by turns some shadowy semblance of all, but actually conforming in no single instance to any one of them. Sometimes, in fact, not only in the same order, or in the same family, but in the same genus, in the same species, and even in the same individual sponge-colony, an entire series of diversely constructed reproductive bodies may be met with.

Abundant illustration is afforded of the more important variations of form and structure found to obtain among the free-swimming sponge-gemmules, by the figures numbered 22 to 36 of Pl. IX., derived partly from the author's personal investigation, and partly from the published contributions of the various authorities previously quoted. Examined attentively, it will become apparent that this entire series exhibits, with various intermediate gradations, what may be denominated three fundamental plans of structural differentiation. Thus, in the first of these, as shown in Figs. 22, 23, and 36, such plan presents the simplest possible expression, the so-called body-wall of the more or less ovate body consisting of a simple and even layer of columnar cells, each giving origin peripherally to a single elongate cilium or flagellum. In the second series, Figs. 27 and 29, an entirely distinct and more complex plan is exhibited. Here, the cellular components of the anterior and posterior regions of the gemmule differ in both size and structure; those of the former being columnar, and bearing flagella as in those of the first series, while in the latter they are very much larger, usually more or less spheroidal, and entirely devoid of flagellate appendages. The third and highest state of complexity is arrived at in Fig. 30, where a new element is superadded in the form of a central zone of smaller rounded cells, interposed between the anterior columnar and posterior spheroidal series. It is scarcely to be wondered that the energies of talented biologists have been taxed to their uttermost to reconcile such entirely diverse structures with the typical developmental formulæ of the Metazoic embryo. By none of these, as yet, can such identification be claimed to have been successfully established; nor, on examining more closely the very discordant interpretations that have been suggested by different authorities with relation even to gemmules found in the same specific type, would there seem to be much prospect of arrival at a more definite result.

The Metazoic nature of the sponges, in deference to the authoritative dictum of Professor Haeckel, being accepted *à priori* as an article of creed, it has been rendered necessary to indicate, in one and all of those diverse so-called ciliated sponge-embryos, the existence of the two primary and absolutely essential constituents of the Metazoic embryo, the ectoderm and endoderm, as produced by the segmentation and subsequent metamorphosis of a primitive unicellular impregnated ovum. Deferring for a while the consideration of the presumed identity of this earliest or initial phase, it may be first observed that the structural type, out of the three respective series just enumerated, which has been accepted as conforming itself most conveniently to the Metazoic formula, is exhibited by that one in which the apical pole or segment of the reproductive body is composed of more minute columnar flagellate cells, and the opposite one of larger but simply subspheroidal elements. Here, as typically represented in the calcareous sponge, *Grantia compressa* (Pl. IX. Fig. 27), there certainly, at first sight, appears to be a remarkable structural correspondence with the segmented holoblastic ovum of the Mammalia, Amphibia, and various fishes, including *Amphioxus*, and numerous higher Invertebrata in which one-half of the primitive ovum, dividing more rapidly and abundantly, becomes converted into numerous minute columnar blastomeres, and the opposite half, dividing more slowly and less extensively, into fewer larger and subspheroidal blastomeres. Out of these two elemental series, distinguished respectively as the epiblast and hypoblast, the future ectoderm and endoderm are subsequently developed, the former from the minute columnar blastomeres or epiblast, and the latter from the larger blastomeres or hypoblast. The identity of the segmentation process in the Metazoic embryo and in the so-called sponge-larva being so far regarded as complete, the apparent corresponding factors in either case have also been accepted as homologous ectodermic and endodermic elements. Supposing, for the time, that these two structural elements could be consistently correlated, what should be the next step?

In the Metazoic embryo it invariably happens that either by the invagination or falling inwards, as in *Amphioxus*, upon the primitive central segmentation cavity or archenteron of the hypoblast or endodermic element, or by the encroachment upon or growing over the latter, as in the Amphibia, of the epiblast or ectodermal element, it comes to pass that the endoderm is enclosed within the ectoderm, and a bilaminate structure is produced roughly resembling the double-walled sac-like body or so-called "gastrula" of Professor Haeckel. The outer lamina or wall of this sac-like body is now the ectoderm, the inner one, closely applied to it, the endoderm. The central cavity most usually enclosed within these layers represents the primitive alimentary tract or archenteron, and the aperture placing the latter in communication with the outer world the primitive anal

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aperture or blastopore. The question at issue is whether similar or equivalent developmental steps are traceable in the ciliated sponge-gemmule? F. E. Schulze, writing of *Sycandra raphanus* in the year 1875, deposes that there are, giving in demonstration the figures reproduced at Pl. IX. Fig. 33. The same authority reports, however, as the result of a more recent investigation of this species, an entirely opposite plan of structure. According to his later interpretation,* it is not the larger and apparent endodermic blastomeres that become invaginated or enclosed within the more minute ectodermal elements, but, as indicated at Fig. 34 of the same plate, the latter that sink down into, and are enclosed by, the former. By Metschnikoff, a second chronicler of the developmental phases of this identical species, the so-called ciliated larvæ are described as presenting, in addition to the ordinary form having dissimilar hemispheres of large, subspheroidal, non-flagelliferous, and more minute columnar flagellate cells, examples that are made up entirely of flagellate columnar elements, which, however, towards the basal region, are of somewhat larger size. This slight modification of the first of the three structural types enumerated in a preceding page, as observed by Metschnikoff, of *Sycandra raphanus*, represents the dominant form found in other closely allied calcareous species, as also in the Myxospongiæ and the majority of the Siliceospongiæ, where the characteristic amphiblastuloid type previously considered is not known to occur. This so to say homoblastic embryonic form, produced by the entire and even segmentation of the primitive so-called ovum, and exhibiting in its characteristic state the structure and condition only of a monoblastic or simple single-cell-walled morula, with a more or less extensive segmentation cavity, does not subsequently, by direct or indirect invagination, as occurs with the monoblastic morulæ of the Metazoa, attain to the higher diploblastic formula; it cannot therefore be consistently compared with the typical and characteristic diploblastic embryo of any Metazoic organism. Nevertheless, various more or less arduous attempts have been made to demonstrate that even in this simpler monoblastic reproductive body, the essential Metazoic elements, "ectoderm," "endoderm," and in some cases even "mesoderm," are substantially represented.

By some, including Professor Haeckel, it has been suggested that the endoderm is indirectly produced through the process of delamination, instead of that of invagination, as most usually obtains. Such an interpretation, however, is entirely upset by some highly remarkable results of recent investigation. It has been shown, in fact, by Oscar Schmidt,† with relation to the calcareous type *Ascetta primordialis*, that the elements usually accepted as representing the endoderm are produced neither by delamination nor by invagination, but creep into the central segmentation cavity as separate and independent amœbiform units from the circumjacent so-called ectodermal layer, of which latter they are the metamorphosed

* 'Zeitschrift für Wissenschaftliche Zoologie,' Bd. xxxi., 1878.

† 'Archiv für Mikroskopische Anatomie,' Bd. xiv., 1877.

constituents. Sooner or later, the segmentation cavity becomes filled up with these metamorphosed, or, as Oscar Schmidt has denominated them, "wandering cells," which breaking their way through the posterior pole, ultimately appear as a projecting heap in this region, and thus convey to the entire organism an aspect closely corresponding with the normal amphiblastuloid type. It is through the medium of these projecting metamorphosed cells that the young sponge becomes fixed to its selected fulcrum of support, and that the further development onward to the characteristic adult sponge-stock is initiated. Some of the most characteristic representations of the phenomena last described, as given by Oscar Schmidt, will be found reproduced at Pl. IX. Figs. 36–38. The remarkable and important data, first elicited by the last-named authority, have been entirely confirmed by the later researches of Metschnikoff,* in connection with both *Ascetta primordialis* and various other widely separated sponge-forms. Proceeding still further, however, this investigator maintains that in these types not only the so-called endodermic, but special mesodermic (spiculiferous) elements are likewise produced by a similar developmental process.

The task of reconciling all of the various developmental formulæ now enumerated as exhibited by diverse, or, it may be, by even a single sponge type, with one or any of those that typically characterize the Metazoic embryo, is obviously almost hopeless: it now remains to be seen whether or not more substantial progress in the interpretation of the affinities of the sponges by means of the so-called ciliated larvæ can be accomplished in a totally distinct direction. Presuming that the account given by F. E. Schulze of *Sycandra raphanus* represented the typical and constant form and process of development—though practically such is very far from the case—Mr. T. M. Balfour, one of our leading authorities in this country on embryologic matters, has quite recently, January 1879, contributed to the 'Quarterly Journal of Microscopical Science' the results of his own analysis of the evidence so far adduced. The verdict he arrives at, while not proceeding to the full length advocated by the author of this volume, is noteworthy for its marked bias in a similar direction, and for its deviation in an essential manner from that Metazoic interpretation hitherto most generally acquiesced in by Continental biologists.

Mr. Balfour's expressed views in this connection are so important as to demand quotation *in extenso*. After enumerating the chief features of the developmental history of *Sycandra raphanus* as last reported by F. E. Schulze, he thus proceeds:—

"The first point in the development of *Sycandra* which deserves notice is the character of the free-swimming larva. The peculiar larval form, with one half of the body composed of amœboid granular cells, and the other of clear ciliated cells, is nearly constant among the Calcispongiæ, and widely distributed in a modified form amongst the Fibrospongiæ and Myxospongiæ. Does this larva retain the characters of an ancestral type of the Spongida, and if so, what does its form mean?

* 'Zeitschrift Wissenschaftliche Zoologie,' Bd. xxxii., 1879.

It is, of course, possible that it has no ancestral meaning, but has been secondarily acquired. I prefer myself to think that this is not the case, more especially as it appears to me that the characters of the larva may be plausibly explained by regarding it as a transitional form between the Protozoa and Metazoa.

"According to this view, the larva is to be considered as a colony of Protozoa—one half of the individuals of which have become differentiated into nutritive forms, and the other half into locomotor and respiratory forms. The granular amœboid cells represent the nutritive forms, and the ciliated cells represent the locomotor and respiratory forms. That the passage from the Protozoa to the Metazoa may have been effected by such a differentiation is not improbable on *à priori* grounds, and fits in very well with the condition of the free-swimming larva of the Spongida.

"While the above view seems fairly satisfactory for the free-swimming stage of the larval sponge, there arises in the subsequent development a difficulty which at first sight seems fatal to it. This difficulty is the invagination of the ciliated cells instead of the granular ones. If the granular ones represent the nutritive individuals of the colony, they, and not the ciliated cells, ought most certainly to give rise to the lining of the gastrula cavity, according to the generally accepted views of the morphology of the Spongida.

"The suggestion which I would venture to put forward in explanation of this paradox involves a completely new view of the nature and functions of the germinal layers of the adult sponges. It is as follows:—When the free-swimming ancestor of the Spongida became fixed, the ciliated cells by which its movements used to be effected must have to a great extent become functionless; at the same time the amœboid nutritive cells would need to expose as large a surface as possible. In these two considerations there may, perhaps, be found a sufficient explanation of the invagination of the ciliated cells and the growth of the amœboid cells over them. Though respiration was, no doubt, mainly effected by the ciliated cells, it is improbable that it was completely localized in them; but the continuation of their function was provided for by the formation of an osculum and pores. The ciliated collared cells which line the ciliated chambers, or in some cases the radial tubes, are undoubtedly derived from the invaginated cells; and if there is any truth in the above suggestion, the collared cells in the adult sponge must be mainly respiratory, and not digestive, in function, while the normal epithelial cells which cover the surface of the sponge, and in most cases line the greater part of the passages through its substance, must carry on the digestion. If the reverse is the case, the whole theory falls to the ground. It has not, so far as I know, been definitely made out where the digestion is carried on. Lieberkuhn would appear to hold the view that the amœboid lining cells of the passages are mainly concerned with digestion, while Carter holds that digestion is carried on by the collared cells of the ciliated chambers. If it is eventually proved by actual experiments in the nutrition of sponges that digestion is carried on by the general cells lining the passages, and not by the ciliated cells, it is clear that neither the ectoderm nor entoderm of sponges will correspond with the similarly named layers in the Cœlenterata and the Metazoa. The invaginated entoderm will be the respiratory layer, and the ectoderm the digestive and sensory layer; the sensory function being probably mainly localized in the epithelium on the surface, and the digestive one in the epithelium lining the passages. Such a fundamental difference in the germinal layers between the Spongida and the other Metazoa would necessarily involve the creation of a special division of the Metazoa for the reception of the former group."

It is very clear, after a perusal of Mr. Balfour's views as above enunciated, that the claims of the Spongida for admission into the ranks of the typical Metazoa, and more especially for correlation with the Cœlenterata, as advocated by Professor Haeckel, rests upon the most shallow and insecure foundation. It is likewise evident that in Mr. Balfour's estimation the sponges retain a close kinship with the Protozoa, and are at the outside an intermediate group between the Protozoic and Metazoic sections. Proceeding yet further, it is maintained by the present author that the structure and relationship of the Spongida is altogether Protozoic, and that the phenomena exhibited by the life and developmental history of the ciliated reproductive bodies now under discussion are, equally with the structural composition of the adult sponge, reducible to and capable of correct interpretation only in association with a Protozoic standard.

Before proceeding to an examination of the evidence that can be adduced in support of this declaration, a passing note may be made of one or two of the points involved in Mr. Balfour's argument. In the first instance, the so-called larval sponge form distinguished by Haeckel by the title of an "amphiblastula," and consisting of one hemisphere of amœboid, and the other of flagellate cells, cannot, as Mr. Balfour suggests, be accepted as the typical and ancestral form of these bodies, it occurring only, and then not persistently, in the group of the Calcispongiæ; a still simpler type having all the cellular constituents alike in form and character, and thus presenting a closer structural conformance to a simple vesicular morula, is mostly dominant. The important issue at stake, recognized by Mr. Balfour, relating to the digestive functions of the amœboid and flagellate elements of both the adult and embryo sponge, can fortunately be completely disposed of, and in such a manner as, on Mr. Balfour's own admission, demonstrates that neither the so-called ectoderm nor endoderm of Spongida will correspond with the similarly named layers in the Cœlenterata and other Metazoa. Nutrition and digestion are, in fact, accomplished by *both* the collared flagellate and the amœboid cells, a circumstance which would require for their strict correlation with the equivalent Metazoic elements, the possession of nutritive functions by both the ectodermal and endodermal layers.

Passing now to a consideration of the interpretation of these special reproductive sponge structures maintained in this volume, it may be affirmed to be substantially identical with that submitted by the author in the 'Annals and Magazine of Natural History' for August 1878, previously embodied in the communication made to the Linnean Society in June 1877, and as extensively confirmed by subsequent investigation. The fact of the case is, that in almost every one of the accounts and illustrations given by contemporaneous authorities, that which may unhesitatingly be pronounced to represent the most important and significant structural element in these reproductive bodies, has been persistently ignored. The omission referred to is the fundamental composition of the free-swimming sponge-embryos of collared flagellate zooids, in all ways identical with those that line the interstitial cavities, and constitute the essential factors of the adult sponge. The so-called ciliated sponge-larva is, it is here maintained, in its typical phase of development, not an individual germ or larva, but a motile swarm-gemmule, consisting of a more or less ovate colonial aggregation of typical collared zooids, as shown at Pl. IX.

Figs. 24 and 25, which represent phases of these reproductive structures, as observed by the author in the common calcareous sponge *Grantia compressa.* The collars left out—and it is admitted that without much care and patience in examination they are, like the collars of the independent collared monads and Spongozoa, most difficult to recognize—the structure accords completely with that vesicular, moruloid embryonic type so abundantly figured and described by Oscar Schmidt, F. E. Schulze, and Metschnikoff. Neither of these biologists appear to have detected the existence of that important element, the collar. That such a structure, however, positively exists, does not rest only upon testimony submitted by the present author, it being substantially confirmed by the independent investigation of Barrois, and even Haeckel. The former of these two authorities indicates, though feebly, the possession of collars by the motile reproductive gemmules of *Halisarca lobularis*, while Professor Haeckel still more clearly denotes their existence in his representations of his so-called ciliated larvæ or gastrulæ of the calcareous sponges *Leuculmis echinus* and *Sycyssa Huxleyi.* With both Haeckel and Barrois, however, the collared cells have apparently no significance beyond that of ordinary ciliated epithelium, the special function of the funnel-shaped collar, and its import with relation to both the sponge-monads and the entire order of independent organisms described in this volume under the title of the Choano-Flagellata, being as yet unrecognized.

It is not only in connection with the simpler moruloid type of the ciliated sponge-gemmule that its fundamental composition out of typical collar-bearing zooids is made manifest. A like interpretation applies with equal force to that seemingly more complex amphiblastuloid type upon which an agreement with the Metazoic embryologic formula has been most powerfully upheld. This may be demonstrated in connection with the identical sponge-form, *Grantia compressa*, cited in the previous instance. As shown at Pl. IX. Figs. 26–29, this amphiblastuloid reproductive body may, furthermore, present three very distinct developmental phases. It may, as in the first instance, Fig. 26, exhibit typical collared cells in the posterior or basal hemisphere, and simply flagellate ones in the anterior one; in a second case, Fig. 27, the basal elements may be simply amœboid and the anterior flagellate, this representing indeed the characteristic condition under which the amphiblastuloid type has been most extensively figured and described. A modification of this type, in which the basal amœbiform units project irregularly from the periphery, is shown at Fig. 29. In the third and remaining form, Fig. 28, the basal elements are also amœboid, but the anterior ones, in place of being simply flagellate, bear also characteristic hyaline collars. These three are, in fact, progressional phases only of one and the same fundamental amphiblastuloid type, the latter again being an unevenly developed variation only of the simpler and homogeneously constructed moruloid form. In the moruloid type, Figs. 22 to 25, the development of the collared units has progressed evenly throughout the entire series, while in the three amphiblastuloid ones above enumerated, it exhibits various phases of unevenness which may be thus explained. In all three, the posterior half has developed considerably in advance of the anterior one, but exhibits in the first figure its typical composition of collar-bearing monads; in the other two, on the other hand, the posterior basal elements have passed from the collar-bearing to the amœboid state, and coalesced more or less extensively with each other. In a like manner, the elements of the anterior half in both of the Figs. 26 and 27 represent the immature and simply flagellate phases of the collared zooids, but which in Fig. 28 have acquired their characteristic adult form. The life-history and various developmental phases of the free-swimming ciliated sponge-gemmules are, in fact, epitomizations only of the phenomena already described of the collared zooids of the adult sponge-stock. Here, as there, the essential constituents, or collared zooids, of the colonial aggregation, commence life as simple flagellate units, which, after attaining their typical adult form, assume successively an amœboid and quiescent state, and give rise by minute sporular subdivision to a further progeny of collared zooids. As a clear indication of the common origin and significance of both the moruloid and amphiblastuloid sponge-gemmules, with their various modifications, it needs only to be recorded that every one of these seemingly distinct structures has been met with by the author in a single sponge-stock of *Grantia compressa*, and also in *Leucosolenia botryoides* and *Grantia* (*Sycon*) *ciliatum*, as obtained both in the Channel Islands in the years 1877–8, and on the South Devon and Cornish coast in 1879. From the last examined examples, furthermore, sections containing these gemmules in abundance, treated with osmic acid, have been successfully preserved for permanent reference and comparison. It is, moreover, in connection with the first-named sponge-form (*Grantia compressa*) that Barrois has reported the occurrence of that variety of the amphiblastuloid gemmule, in which a ring of intermediate non-flagellate cells are developed equatorially between the typical flagellate and amœboid series. The latter elements, as shown at Pl. IX. Fig. 30, are of somewhat abnormal size, and, as in many other of the examples figured, are far too large to have represented individually a primarily single collared zooid. This phenomenon, as also that of the presence of the equatorial girdle of smaller cells in the example cited, admits of simultaneous explanation. The equatorial girdle, in fact, may be interpreted as representing an anterior ring of amœboid cells metamorphosed from the typical collared units at a slightly later date than those of the posterior area, and which latter have become still more obscurely transformed and increased in size, though lessened in number, by coalescence. It is by a similar process of retrogression to an amœboid type, and the more or less extensive union or coalescence of amœboid zooids that the ciliated gemmules themselves originate.

In addition to the various symmetrically constructed moruloid and amphiblastuloid modifications of the ciliated sponge-gemmule already enumerated, it has yet to be recorded that it very commonly happens that these structures present an altogether irregular and asymmetrical contour. Illustrations of such irregular formations, as figured by Oscar Schmidt, of *Grantia* (*Sycandra*) *compressa*, and as observed by the author, will be found reproduced at Pl. IX. Figs. 32 and 35. Such asymmetrically developed gemmules may retain fundamentally the moruloid or amphiblastuloid structural type, being in the one case composed entirely of similar and in the other case of dissimilar constituents. The fact that these various irregularly formed gemmules are by no means of rare occurrence, may be accepted as furnishing supplementary evidence in demonstration of the non-correspondence of these sponge-gemmules, or so-called ciliated larvæ, with the embryos of the typical Metazoa, and in which latter organic series the production of asymmetrical germs is quite exceptional. One of the strongest arguments furnished in support of the essentially Protozoic significance of these reproductive bodies is, undoubtedly, afforded by the independently contributed testimony of Oscar Schmidt and Metschnikoff, by both of whom it is shown that in the case of *Ascetta primordialis*, the component flagellate elements of the moruloid gemmule assume quite independently an amœboid condition, and retiring separately into the central segmentation cavity, undergo their further metamorphoses. Ultimately, these separately retreating amœbiform units completely fill up the central cavity, and burst through the posterior region of the ciliated body, project at this extremity, and so produce in a roundabout manner a pseudo-amphiblastula. It will be at once recognized that while this peculiar developmental phenomenon of the sponge-gemmule exhibited by *Ascetta primordialis*, is altogether opposed to anything that obtains among the Metazoic series, it is at once reconcilable with a Protozoic interpretation. With their near allies the simple flagellate or collared monads, e.g. *Phalansterium*, *Spongomonas*, and *Protospongia*, parallel phenomena, including the assumption by the adult zooids of an amœboid state, and their retreat within the common gelatinous cytoblastema-like matrix, or zoocytium, represents the normal reproductive process.

The highly important evidence that demonstrates the thoroughgoing Protozoic affinities of the sponge with relation to the primary origin and development within the parent sponge-stock of the free-swimming ciliated gemmules, has yet to be submitted. The initial condition of these reproductive structures, as conceded unanimously by the independent testimony of every investigator, takes the form of an amœbiform body, varying in size from the 1–3000th to the 1–200th of an English inch, and presents a considerable likeness to the primary condition of an ordinary ovum. With, however, the interpretation of the significance and subsequent evolution of this amœbiform structure that is most generally advocated, the author has to declare himself entirely at issue. In accordance with this more widely accepted view, the amœbiform body is a true ovum, developed separately and independently in the interstitial substance of the sponge, and afterwards fecundated by spermatozoa independently generated within the same sponge-body.

Had such a process of production and development been actually substantiated, the Metazoic affinities of the Spongida would undoubtedly be capable of considerable development, but, as a matter of fact, no substantial proof of the existence of any such process has been as yet adduced. The evidence available for the gauging of this important question favours, on the other hand, an entirely opposite conclusion. It is here maintained, indeed, as first suggested in the author's communication to the 'Annals of Natural History' for July 1878, that the amœboid oviform bodies are not independent products of the adult sponge-stock, but simply retromorphosed collar-bearing zooids that have retreated within the cytoblastema, and assumed, as is common to them after passing their matured collar-bearing stage, an amœboid condition. It is these amœboid units that through coalescence with their fellows attain by degrees the comparatively colossal proportions they present in their most advanced phase of development, and then by the process of segmentation produce the characteristic moruloid or amphiblastuloid ciliated gemmule. There is in this process of evolution no concourse of male and female or true ova and spermatozoa as occurs among the Metazoa, but the phenomena exhibited are in all ways identical with those that obtain among the most simple Flagellate Infusoria, such as *Monas* and *Heteromita*, in which the typical flagellate zooids, passing the zenith of their adult condition, enter into an amœboid state, and coalescing in pairs, or even socially, give rise by segmentation to a new generation of flagellate units. On a yet larger scale, and in a manner more closely corresponding with what obtains among the Spongida, identical phenomena, as described at page 42, are encountered in the group of the Myxomycetes or Mycetozoa. The only fundamental point that distinguishes the segmentation process in the two groups of the Spongida and ordinary Flagellata is that, whereas in the more simple Flagellata the products of such segmentation are scattered apart throughout the inhabited fluid medium, and maintain an independent existence, in that of the sponge-gemmule these flagellate units are intimately bound to one another at the time of their exodus from the parent colony-stock, and remain associated within their subsequently developed common gelatinous matrix or cytoblastema for the whole term of their existence. Substantial corroboration of the opinion here maintained that the reproductive sponge-gemmules, or so-called ciliated larvæ, are the product of the coalescence or fusing with one another of a large number of metamorphosed collared zooids, and that they are not independently generated after the manner of true ova, is afforded by the circumstances under which they are naturally met with in the tissues of the parent sponge-stock. In this connection, both in accordance with the author's experiences, and as distinctly shown in the figures given by all the more notable investigators of this organic group, it is invariably found that these bodies are, as shown at Pl. VII. Fig. 1, produced first in the deeper and consequently older portion of the sponge-stock, and that where abundantly developed they monopolize its interstitial substance to the exclusion of the ampullaceous sacs or other combinations under which the collared zooids may be characteristically distributed. These latter have, in fact, after attaining maturity, assumed the amœboid state, and, abandoning their normal position, coalesced extensively with one another after the manner of various ordinary Flagellata, the outcome of this process being the more or less regular segmentation of the united mass and production of the characteristic ciliated gemmule. Regarded from such a point of view, this ciliated reproductive structure is in no sense an egg, or its derivative, but represents a coherent aggregate of monadiform swarm-spores, or, as it may be most appropriately denominated, a "swarm-gemmule."

In addition to the characteristic ciliated reproductive bodies or swarm-gemmules just described, there remain to be discussed certain other complex bodies, generated within the interstitial sponge-substance, that, as first suggested by Mr. Carter, take their origin by an essentially identical developmental process. The structures here referred to are the so-called "ampullaceous sacs" or spheroidal ciliated chambers characteristic of *Halisarca*, the greater portion of the keratose and siliceous sponge-forms, and some few calcareous species. It has been ascertained by the author in the case of *Halisarca Dujardinii*, a species of *Isodictya*, and various other types, that these structures are also, as shown at Pl. IX. Figs. 4-9, originally developed from the segmentation of a primitive amœboid body produced, as in the former instance, by the coalescence of more or fewer metamorphosed collared zooids. Such segmentation is in this instance, however, entirely even, and results in the production of a perfectly spheroidal moruloid body having a somewhat extensive central segmentation cavity. The only difference that characterizes the more advanced condition of the ampullaceous sacs is manifested by the fact, that while in the case of the free-swimming ciliated gemmules the constituent collared zooids are so developed that their collars and flagella are directed peripherally or away from the central segmentation cavity, in the case of the ampullaceous sacs they take an opposite direction, their flagella and collars being projected into this cavity. As with the ciliated gemmules, the component zooids, before acquiring their characteristic collars, present a simply flagellate condition, their aspect at such stage being represented at Pl. IX. Fig. 11. Immediately prior to this simply ciliate condition the individual units are amœbiform and non-flagelliferous, and held together circumferentially by a thin film of structureless cytoblastema ; often, as shown at Pl. IX. Fig. 10, they are considerably isolated. In their more matured state the collared zooids cohere laterally to one another, and, excepting at the afferent and efferent apertures, present no break or interruption. Taken in optical section, so as to avoid these openings, a matured and typical ampullaceous sac presents, in fact, the exceedingly elegant and symmetrical structural form illustrated by Fig. 1 of the plate just quoted. Isolating some half-dozen cell-units from this complete section, as shown at Pl. IX. Fig. 2, a monad aggregation is produced that corresponds in a most remarkable manner with the characteristic moniliform colony-stocks of the free-swimming marine collared type *Desmarella moniliformis*, S. K., represented at Pl. II. Fig. 30, a fresh-water variety of which genus has been since figured by Professor Stein under the title of *Codonodesmus phalanx.* The symmetrical pattern of the ampullaceous sacs just described is, however, by no means persistent. In many sponges a greater or less number of these primitively spheroidal chambers, abutting upon one another, coalesce together, and so form altogether irregularly shaped cavities that may ultimately be of very considerable extent.

In his 'Spongiologische Studien' * Metschnikoff has quite recently drawn attention to certain structural elements in *Halisarca Dujardinii* that have hitherto escaped notice. These structures, upon which he bestows the name of "rosette-cells," consist of small subspheroidal groups of cells, usually eight or sixteen, that are developed independently within the interstitial substance of the adult sponge, and also within the central cavity of the free-swimming ciliated gemmules, in this latter case being the product, by segmentation, of the metamorphosed and increeping zooids from the peripheral region. Some of the more characteristic representatives given by Metschnikoff of these rosette-cells are reproduced at Pl. IX. Figs. 15–17, the two last of these exhibiting the existence of flagellate appendages. It so happens that these newly-reported rosette-cells supply, most opportunely, an important link in the organization of certain Spongida, recognized by the author some years since, but which, pending the production of corroborative evidence, has not hitherto been brought forward. Closely identical cell-aggregations have been thus observed in a variety of sponge-forms, being found more especially abundant, however, in blood-red examples of the same type, *Halisarca Dujardinii*, collected on the Jersey coast and examined in the living state in the month of February 1878. At this time of the year none of the characteristic ciliated swarm-gemmules were present; but in cutting sections, numbers of spheroidal uvella-like groups of typical collared monads were liberated, and were likewise observed united to the cytoblastema, entering largely, in combination with the ampullaceous sacs, under such conditions into the formation of the general substance of the sponge-stock. While in their most typical and matured condition the constituent zooids of these independent rosette-shaped groups were provided with collars and flagella, and in all respects resembled those lining the ampullaceous sacs, in less matured examples they were simply flagellate, and in still earlier conditions possessed no appendages whatever, the larger examples being then indistinguishable from the morula-like cell-aggregates out of which the ampullaceous sacs are themselves developed. There can be but little doubt that these structures observed in the Channel

* 'Zeitschrift für Wissenschaftliche Zoologie,' Bd. xxxii., 1879.

Islands examples, and as exhibited in their various developmental phases at Pl. IX. Figs. 18-21, are identical with the so-called rosette-cells lately described by Metschnikoff; the descriptions and delineations of them as given by him being, however, deficient in one important point—that of the possession by each constituent unit, in its matured condition, of the characteristic collar. This oversight is, however, altogether what might have been expected when it is found on examining his text and plates illustrating the histology of various calcareous and siliceous sponge-forms, that that important structure is not, except in one doubtful instance, either figured or alluded to.

The true significance of the special rosette-like aggregations remains to be discussed. Their derivation through the coalescence and segmentation of a greater or less number of amœbiform units, as in the case of the larger ciliated gemmules, and that of the ampullaceous sacs, was ascertained by the author, their close correspondence with the former of these two structures being thus made especially apparent. Their only distinction from the ciliated gemmules subsists, in fact, in their much smaller size, through being derived from the fusion of a small number of zooids only, and their retention of a spheroidal uvella-like contour, without any development, by separation from each other, of an extensive cleavage cavity. It would seem to be by no means improbable that the rosette-shaped aggregations, thus derived from the fusion and segmentation of a smaller number of the typical collared cells, represent in the one direction a more primitive form of the ciliated reproductive gemmule, and in another the more primitive mode of grouping of the typical collared zooids in the colonial sponge-stock. As already stated, and as shown at Pl. IX. Fig. 21, these spheroidal groups were found attached to and projecting from the cytoblastema into the adjacent canal-systems in the case of *Halisarca*, and contributed largely, in combination with the ampullaceous sacs, to the composition of the general substance of the compound body. It is quite probable that sponge-forms exist, or have existed, in which such a disposition alone of the collar-bearing zooids represents the normal and characteristic type of structure. A close approach to this has in fact already been observed by the writer in connection with a siliceous-spiculed sponge, further investigation, however, being desirable for its complete exposition. Should anticipations in this direction be confirmed, it will certainly admit of a yet closer approximation of the sponges to the independent Flagellate Infusoria than is now attempted. For in such a case, a sponge-stock having its essential collared zooids so disposed that they project simply in the form of uvella-like clusters into the interstitial canal-system, and whose motile reproductive bodies consist simply of similar, but detached, uvelloid clusters, would in all ways be comparable to a colony of *Codosiga botrytis* or *Anthophysa vegetans*, in which, instead of developing a branching stem, the spheroidal clusters or "cœnobia" of associated zooids extended around them, and remained immersed within, a common gelatinous matrix, or "zoocytium," such as actually exists in the several genera *Spongomonas*, *Phalansterium*, and *Ophrydium*, taking there the place of a dendritic pedicle. In *Anthophysa vegetans*, furthermore, as shown at Pl. XVIII. Figs. 2, 4, 5, the propagation of the species by the detachment of entire uvelloid masses corresponding essentially with the rosette-like clusters of *Halisarca*, is well substantiated. A still more pertinent comparison in this direction may, however, be instituted between the rosette-gemmules of *Halisarca Dujardinii* delineated at Pl. IX. Figs. 19 and 20, and the monad aggregate of *Codosiga botrytis* reproduced from Stein's drawings at Pl. IV. Fig. 6.

Summing up the entire evidence now submitted with reference to the structural and developmental phenomena of the Spongida, and correlating it with that embodied in this volume relative to those of the independent Choano-Flagellata and other Flagellate Protozoa, scarcely a shadow of doubt even is admissible concerning the intimate and thoroughgoing relationship that subsists between one and the other. The primary and essential element of the apparently complex sponge-stock is the assemblage of collared flagellate zooids that inhabit its interstitial cavities under various plans of distribution. Individually, these collared zooids correspond, structurally and functionally, in every detail with the separate collared units of such genera as *Codosiga*, *Salpingœca*, and *Protospongia*. The collar in either case presents the same structure and functions, exhibits the same circulatory currents or cyclosis, and acts in a precisely similar manner as a trap for the capture of food. The body contains an identical centrally located spheroidal nucleus or endoplast, and a corresponding, posteriorly located, series of rhythmically pulsating contractile vesicles. The developmental and reproductive phenomena are also strictly parallel. Both originate as simple amœbæ or simple flagellate monads exhibiting no trace, in their earliest developmental phase, of the subsequently acquired characteristic collar. Both again, after passing matured age, withdraw their collar and flagellum, and assume an amœboid state. Then, coalescing or not with their fellows, they enter upon a quiescent or encysted condition, and breaking up into a greater or fewer number of sporular bodies, provide for the further existence and distribution of the species. Among the independent collared types this sporular progeny, except in *Protospongia* and *Phalansterium*, is scattered through the surrounding water, while in the sponge they are retained within the common gelatinous matrix, or cytoblastema, and assist in the extension of the common colony. More exceptionally, for the purpose of securing the local distribution of the species, the coalescing amœbiform zooids of the sponge-stock, derived from the metamorphosed collared zooids, form by repeated segmentation a pseud-embryo, or so-called ciliated larva, of considerable size, whose cell-constituents when analyzed are found to consist of typical collared zooids, resembling those from whence they previously originated, and presenting similarly in their earliest phase of existence a simply flagellate structural type. In their most characteristic form, these reproductive bodies or cell-aggregates consist of a uniform series of collared zooids, but by irregular growth one half may arrive at or pass maturity in advance of the other, the product then being a compound structure presenting a close correspondence with that phase of development of the Metazoic ovum known as the amphiblastula. Since, however, these bodies are in no way comparable with the Metazoic ovum—not being the product of the concourse of true sexual elements—the above likeness is simply homoplastic, and the body as a whole, consisting as it does of an aggregation of numerous independent zooids, may be most appropriately denominated a "swarm-gemmule." While no direct approach to the production of a similar compound gemmule occurs among the typical Infusoria-Flagellata, as at present known, something much akin to it obtains in the protophytic type *Volvox globator*, which liberates from its interior, free-swimming gemmules that take the form of spherical aggregations of biflagellate daughter-cells. In their isolated state, on the other hand, the swarm-gemmules of the sponge-stock are directly comparable with the free-swimming subspheroidal colony-stock of the flagellate Infusoria *Synura*, *Syncrypta*, and *Uroglena*, or with the attached subspheroidal clusters of *Codosiga* and *Anthophysa*.

In certain respects, as already pointed out at page 41 *et seq.*, a very remarkable and suggestive analogy in the direction of the Spongida is furnished by the Protozoic group of the Myxomycetes or Mycetozoa. Here we find the essential elements consisting primarily of independent flagellate zooids possessing a spheroidal endoplast, contractile vesicles, taking in solid nutriment, and presenting other characters in common with the ordinary Flagellata. Passing their matured flagellate condition these now assume an amœbiform condition and coalescing in large numbers, as in the case of the Spongozoa, form a colossal amœbiform mass, the plasmodium, not unlike the cytoblastema of a sponge with its amœbiform contents, out of which by a species of encystment the characteristic fungus-like sporangia are developed. These sporangia are to a considerable extent comparable with the hibernating encystments or so-called "gemmules" of *Spongilla* and other sponges, and subsequently, through the process of segmentation, become resolved into innumerable minute spores, which again give birth to a host of flagellate monadiform zooids resembling those from whence they originally sprang. It is further remarkable and suggestive of some distant affinity with the Spongida, that the network of fine interlacing threads, or "capillitium," that frequently binds the enclosed spores together, closely corresponds with the fine horny fibre of the keratose sponge-series ; while in the substance of the outer wall or "peridium" of the sporangia of some Mycetozoa, such as *Didymium nigripes* and *D. serpula* (see Pl. X. Figs. 30 and 31), calcareous deposits resembling sponge spicula are developed.

It is clearly manifest that in a very singular manner, and to a marked extent, the developmental phenomena of the Spongida are productive of composite structures, the swarm-gemmules or so-called ciliated larvæ, which bear the closest superficial resemblance to the segmented ovum and primary form and disposition of the component blastomeres of the Metazoic embryo. Penetrating beneath this superficial likeness, however, the points of analogy are found to diverge and vanish altogether. No Metazoic embryo, and no Metazoic structure, whatever, is distinguished by the possession of collared flagellate cells, with their attendant properties and functions, as found to exist respectively in these ciliated reproductive bodies, in the essential monadiform constituents of the adult sponge, and among the independent Discostomatous Flagellata. It is this one important histologic element, the collared cell with its attendant physiologic functions, that so closely unites together the two sections of the Spongida and independent Discostomata or Choano-Flagellata, while it isolates them at the same time from the members of every other organic group. Were the interstitial canals and chambers of the sponge-stock lined with cells possessing no contractile vesicles, bearing simply flagella, or corresponding with ordinary ciliated epithelium, and yet capable of ingesting solid food-matter, the grounds for removing this organic section into the Metazoic series would apparently be based on a surer foundation and some analogy would be presented with the simpler Hydrozoa and many Turbellaria, where, as shown by Kölliker and Kleinenberg, the endoderm cells lining the alimentary canal develop long flagella or pseudopodic processes, and it would appear, engulf food-substances after the manner of Amœba. Even here, however, the hypothetical analogy would be entirely delusive, the matured sponge-stock being the sum total, not of the concourse of sexual elements, but of the essentially Protozoic process of spore-development.

In the fashioning of the motile ciliated gemmules, or pseud-embryos, upon the plan of the Metazoic morula and amphiblastula, and in the peculiar arrangement and separation of the constituent flagellate and amœboid factors of the adult sponge, nature would certainly seem to have marshalled her forces preparatory to crossing the border from the Protozoa to the Metazoa, and so far as a transitional group between the two series can be predicated, it is probably realized in the section of the Spongida. The step, as a complete one, however, is by no means accomplished in this group. As is at once made manifest by a closer insight, the sponges remain in every detail of structure, function, and development, typical and thoroughgoing Protozoa. Their position in, and affinities among, the several groups of this sub-kingdom are evidently close to, and inseparable from, that of the naked and independent Discostomata or Choano-Flagellata, and which, having due regard to the clearly defined laws of organic evolution, must be recognized as the ancestral progenitors or archetypes of all sponge-forms. The phylogeny or backward passage, again, from these independent collared types to the simpler monadiform Flagellata, is made apparent not only in the matured condition of such a form as *Phalansterium* —where the collar is rudimentarily developed—but also in the ontogeny or individual life-history of all other collar-bearing zooids, and which, whether they belong to the simple and independent Choano-Flagellata or to the interstitial system of a complex sponge-stock, commence existence as similar collarless uniflagellate monads.

CHAPTER VI.

SYSTEMS OF CLASSIFICATION OF THE INFUSORIA ADOPTED BY VARIOUS AUTHORITIES FROM THE TIME OF O. F. MÜLLER TO THE PRESENT DATE.

CONSIDERABLE advantage being derived from an examination and comparison of the various systems of taxonomy or classification that have at different epochs been adopted with relation to the assemblage of organisms described in this treatise, the more important are herewith submitted *in extenso*.

Commencing with the earliest essay at such systematic tabulation, as included by O. F. Müller in his 'Animalcula Infusoria' published in the year 1786, and reproduced at page 199, one is at once struck by the important influence that was exerted in its formulation by the then rudimentary condition of the optical appliances at the disposal of this authority. Thus, the entire series of seventeen genera embraced in his scheme are separated into two leading groups or sections distinguished by their exhibition or not of distinct locomotive appendages as viewed with the imperfect microscopes of that day. It is now well known, however, that every one of these, with the single exception of *Proteus*, possesses either well-developed cilia or flagella. That exceptional type, with the five Müllerian genera *Volvox*, *Vibrio*, *Gonium*, *Cercaria*, and *Brachionus*, are necessarily eliminated from the several classes and orders of the Infusoria as comprehended at the present day, the remaining eleven, though considerably limited in their significance, being still retained. The number of specific types included in Müller's system, deducting the Rotiferæ, Phytozoa, and other extraneous forms, closely approaches two hundred.

With Ehrenberg's 'Die Infusionsthiere,' a far more extended series of organisms, and corresponding elaboration of the classificatory system adopted (see pages 200 and 201), is introduced. The supposed possession by all typical Infusoria of a distinct oral aperture and numerous gastric cavities, is, as stated in a previous chapter, the foundation-stone of his system, subordinate to which the presence or, as in the case of Müller's system, presumed absence of locomotive appendages, the character of these appendages, and location of the oral and excretory apertures, receives attention. The number of true infusorial forms included in Ehrenberg's magnificent treatise may be set down as approximating three hundred and fifty, which are included in sixteen family and eighty generic groups.

Felix Dujardin's 'Histoire des Zoophytes Infusoires,' published in the year 1841, is mostly notable for the distinction given to the Flagellate section of the Infusoria, many members of which, bearing new generic titles, were now for the first time figured and described with considerable accuracy. These Flagellata, while included in Order III. of his classificatory system given at page 202, were not, however, invested with any specially distinctive title.

C. T. Von Siebold's scheme, reproduced at page 203, bearing the date of 1845, and already referred to at length at page 20, is chiefly remarkable for its subdivision of the Infusoria into the two primary groups of the Astomata and Stomatoda; the former including the Opalinidæ and all the Flagelliferous types, and the latter all the ordinary Ciliata.

The next system demanding notice is that of Maximilian Perty, embodied in his work 'Zur Kenntniss kleinster Lebensformen,' published in the year 1852. In this treatise marked progress is made upon the classificatory schemes previously noticed. The entire series of infusorial forms are included in one primary sub-kingdom designated the *Archezoa*—in all essential respects synonymous with the Protozoa of Von Siebold—and its representatives separated into the primary sections of the Filigera or Phytozoida and Ciliata, which practically correspond with the Flagellate and Ciliate subdivisions as recognized at the present day. Twenty-six family and one hundred generic groups are comprehended in Perty's classificatory table (see pages 203 and 204), the number of species incorporated falling short, however, of that made known by Ehrenberg.

Claparède and Lachmann's extensive work, 'Études sur les Infusoires,' published as a complete treatise in 1868, but which had previously appeared as separate contributions to the 'Memoirs of the Institute of Geneva' during the years 1858 to 1860, next demands attention. In this for the first time we find the Infusoria definitely restricted to the limits within which they are circumscribed in this volume, the leading subdivisions of the entire series included closely corresponding also, as shown at page 205, with those here accepted as affording the most convenient and natural arrangement. By promoting, in point of fact, the three orders of the Infusoria distinguished by these authorities by the titles of the Flagellata, Suctoria, and Ciliata, to the rank of classes, retaining meanwhile their fourth group of the Cilio-Flagellata as a subordinate order only of the class Flagellata, the main basis of arrangement of the extensive series of forms noticed in this treatise is at once arrived at. It is to be regretted that Messrs. Claparède and Lachmann did not bestow upon the ordinary Flagellate division the same attention which they gave to the three remaining groups. But two or three forms only referable to this important section are described, the order as recognized by them not being even so much as tabulated. The most important improvements upon the earlier classificatory schemes accomplished by Messrs. Claparède and Lachmann, consist of the introduction of the two groups of the Suctoria and Cilio-Flagellata, the former being compounded chiefly of forms previously maintained by Stein to be metamorphic conditions of various Vorticellidæ, while the latter one comprised only the family group of the Peridiniidæ.

The classification of Diesing, a compiler and not an independent investigator, of the present group of organisms, is reproduced (see page 206 *et seq.*) so far only as relates to the Flagellate series, he exhibiting a keener appreciation of their most salient diagnostic characters than had been displayed by any previous authority. Taking on trust the dictum of Ehrenberg, this writer, unfortunately, fell into the error of ascribing to every member of this group the possession of a distinct oral aperture, which structure is abundantly shown in this manual to have no definite existence among a very considerable series. Diesing's peculiar views respecting the affinities of certain of the Ciliata and Protozoa generally have been referred to at length at page 25 of Chapter I.

Professor Stein's system, which may be cited as representing the most advanced views of Continental biologists with reference to the classification and taxonomy of this highly interesting organic group, demands more extensive notice. In its concrete form, as reproduced at pages 209 and 210, such a tabulated list has not yet appeared, it being composed of the scheme relating to the Ciliata only, embodied by Stein in the second volume of his 'Organismus der Infusionsthiere,' published in the year 1867, to which is prefixed the list of families with included genera contained in the preface to his recently issued volume, illustrative of the Flagellata, published at the close of the year 1878. As previously remarked, no diagnoses or descriptive accounts of the numerous families, genera, or species so abundantly and admirably figured in this volume have as yet appeared, nor is any attempt made to subdivide the series as a whole into subordinate sections or orders. Critical remarks can consequently under present circumstances be passed only upon his proposed family grouping of the respective genera. In this connection, exception is here taken, in the first instance, to Stein's admission among the ranks of the Flagellate Infusoria of the several family groups of the Volvocina, Chlamydomonadina, and Hydromorina, whose representatives, with one or two exceptions, must undoubtedly, as first insisted by Von Siebold, be referred to the vegetable kingdom. Their claim for admission to Stein's scheme is, while the inevitable sequence of the very shallow basis upon which he considers the proof of their animal organization to be substantiated—that only of the possession of a nucleus and contractile vesicle—by no means supported by the verdict of such modern authorities as Cohn, Sachs, and Pringsheim, by all of whom *Volvox* and its allies more especially are relegated without hesitation among the lower Algals or Palmellaceæ. The broad distinction insisted upon by these writers as subsisting between unicellular plants and animals is identical with that already submitted by the author at page 36 *et seq.*, namely—the capacity of such animal forms to incept and digest food-matter in its solid state, and the corresponding absence of such an ingestive faculty in all vegetable organisms.

With scarcely an exception, none of the generic types included in Stein's three family groups just cited possess this ingestive property, and are consequently here refused admission within the essentially zoologic section of the Infusoria.

With reference to the remaining twelve Flagellate family groups included in Stein's classificatory system, some few, such as those of the Dendromonadina, Spongomonadina, Craspemonadina, Bikœcida, and Chrysomonadina, beyond doubt contain genera that exhibit well-marked natural affinities. Others, such as his Monadina, Astasiæ, and Scytomonadina, comprise the most incongruous elements, mouthed and mouthless, uniflagellate, biflagellate, and multiflagellate animalcules being indifferently intermingled. *Phalansterium*, a uniflagellate collared monad, is interpolated amongst the otherwise natural biflagellate group of the Spongomonadina, and with which, excepting for the secretion of a similar gelatinous zoocytium, the animalcules possess nothing in common. *Poteriodendron*, again, while represented in the figures given and accompanying index as possessing a collar homologous with that of *Codosiga* and its allies, but somewhat differently situated, instead of being placed among the Craspemonadina, is included in the family group of the Bicosœcidæ. Stein's apparently inconsistent location of *Poteriodendron* is nevertheless important, since it entirely supports the views concerning this type expressed on a succeeding page, and where it is held by the author to be actually a biflagellate organism closely allied to *Bicosœca* and synonymous with the *Dinobryon petiolatum* of Dujardin and the *Stylobryon petiolatum* of De Fromentel. The separation of the two genera *Epipyxis* and *Dinobryon* from all the other generic groups of the Chrysomonadina, with which in structure they fundamentally agree, is entirely artificial.

The scheme proposed by Stein for the subdivision into groups or orders of the Ciliate section of the Infusoria, such orders being distinguished by the titles of the Holotricha, Heterotricha, Hypotricha, and Peritricha, leaves, so far as our present knowledge extends, nothing to be desired, and is cordially adopted in the present work.

The system introduced by the author, and adopted for the purposes of classification and taxonomy throughout this treatise, alone awaits notice. Its chief features of distinction, as connected with the several schemes previously enumerated, are naturally connected with the class Flagellata, upon which the author's attention has for many years past been more exclusively concentrated. The result of such investigation has been the discovery of forms differing so widely from the previously known representatives of this group, that the introduction of new distinctive titles having the value of Orders, and carrying with them as thoroughgoing a significance as the foregoing ordinal appellations of the class Ciliata, has been rendered necessary. The broad grounds upon which these new orders are established—chiefly based upon the modifications exhibited by the oral system and appendicular structures—have been already discussed in Chapters II. and III., and are also succinctly indicated in connection with the abbreviated diagnoses of the subordinated family and generic groups in the tabular forms prefixed to the succeeding descriptive accounts of each more important group. So far as practical, the family names given in the systems of the earlier authorities quoted have been retained, with the simple adaptation of their terminal syllables in conformance with the recommendations of the British Association contained in their "Rules for Zoological Nomenclature" issued in the year 1878. In face, nevertheless, of the vast augmentation of specific types collected from every available source, many of them now figured and described in this volume for the first time, a corresponding increase of the number of family and generic titles has been unavoidable. Taken in their entirety, no less than nine hundred infusorial species, distributed among about eighty family and three hundred generic groups, are embraced by the author's system, being a sum total of more than double the number included in any previous treatise.

O. F. MÜLLER, 'Animalcula Infusoria,' 1786.

INFUSORIORUM DIVISIO METHODICA.

I. ORGANIS EXTERNIS NULLIS.

* *Crassiuscula.*

Gen. 1. MONAS: punctiforme.
,, 2. PROTEUS: mutabile.
,, 3. VOLVOX: sphæricum.
,, 4. ENCHELIS: cylindricum.
,, 5. VIBRIO: elongatum.

** *Membranacea.*

Gen. 6. CYCLIDIUM: ovale.
,, 7. PARAMÆCIUM: oblongum.
,, 8. KOLPODA: sinuatum.
,, 9. GONIUM: angulatum.
,, 10. BURSARIA: cavum.

II. ORGANIS EXTERNIS.

* *Nuda.*

Gen. 1. CERCARIA: caudatum.
,, 2. TRICHODA: crinitum.
,, 3. KERONA: corniculatum.
Gen. 4. HIMANTOPUS: cirratum.
,, 5. LEUCOPHRA: ciliatum undique.
,, 6. VORTICELLA: ciliatum apice.

** *Testâ tecta.*

Gen. 7. BRACHIONUS: ciliatum apice.

C. G. Ehrenberg, 'Infusionsthiere,' 1836.

SYNOPSIS OF THE TWENTY-TWO FAMILIES OF THE INFUSORIA.

						Family.
A. No intestine, *Anentera.*	No appendages (*Gymnica*).	Form persistent.	Fission complete.	Illoricate		I. *Monadina.*
				Loricate		II. *Cryptomonadina.*
			Fission incomplete, forming social colony-stocks.	Dividing in every direction, loricate, forming globose aggregates		III. *Volvocina.*
				Dividing in one direction, forming thread-shaped aggregates	Illoricate	IV. *Vibrionia.*
					Loricate	V. *Closterina.*
		Form changeable.	Illoricate			VI. *Astasiæa.*
			Loricate			VII. *Dinobryina.*
	Root-footed (*Pseudopoda*).	Illoricate				VIII. *Amœbæa.*
		Loricate	Protruding many pseudopodia from a single opening			IX. *Arcellina.*
			A single pseudopod projecting from one or each single aperture			X. *Bacillaria.*
	Ciliated (*Epitricha*).	Illoricate				XI. *Cyclidina.*
		Loricate				XII. *Peridinæa.*
B. With intestine, *Enterodela.*	Aperture single (*Anopisthia*).	Illoricate				XIII. *Vorticellina.*
		Loricate				XIV. *Ophrydina*
	Two apertures at opposite ends (*Enantiotreta*).	Illoricate				XV. *Enchelia.*
		Loricate				XVI. *Colepina.*
	Apertures diversely placed (*Allotreta*).	Illoricate	Mouth with a projecting proboscis, no tail			XVII. *Trachelina.*
			Mouth without a proboscis, tail developed			XVIII. *Ophryocercina.*
		Loricate				XIX. *Aspidiscina.*
	Apertures ventral (*Catotreta*).	Illoricate	Possessing simple cilia only			XX. *Colpodea.*
			Possessing locomotive organs of diverse form			XXI. *Oxytrichina.*
		Loricate				XXII. *Euplotina.*

Ehrenbergian Genera included in the foregoing Synopsis.

Family.		
I. Monadina	Genus	1, *Monas*; 2, *Uvella*; 3, *Polytoma*; 4, *Microglena*; 5, *Phacelomonas*; 6, *Glenomorum*; 7, *Doxococcus*; 8, *Chilomonas*; 9, *Bodo.*
II. Cryptomonadina	,,	1, *Cryptomonas*; 2, *Ophidomonas*; 3, *Prorocentrum*; 4, *Lagenella*; 5, *Cryptoglena*; 6, *Trachelomonas.*
III. Volvocina	,,	1, *Gyges*; 2, *Pandorina*; 3, *Gonium*; 4, *Syncrypta*; 5, *Synura*; 6, *Uroglena*; 7, *Eudorina*; 8, *Chlamydomonas*; 9, *Sphærosira*; 10, *Volvox.*
IV. Vibrionia	,,	1, *Bacterium*; 2, *Vibrio*; 3, *Spirochæta*; 4, *Spirillum*; 5, *Spirodiscus.*
V. Closterina ..	,,	1, *Closterium.*
VI. Astasiæa	,,	1, *Astasia*; 2, *Amblyophis*; 3, *Euglena*; 4, *Chlorogonium*; 5, *Colacium*; 6, *Distigma.*
VII. Dinobryina ..	,,	1, *Epipyxis*; 2, *Dinobryon.*
VIII. Amœbæa	,,	1, *Amœba.*
IX. Arcellina	,,	1, *Difflugia*; 2, *Arcella*; 3, *Cyphidium.*
X. Bacillaria	,,	(Desmidiaceæ); (Diatomaceæ); *Acineta.*
XI. Cyclidina	,,	1, *Cyclidium*; 2, *Pantotrichum*; 3, *Chætomonas.*
XII. Peridinæa	,,	1, *Chætotyphla*; 2, *Chætoglena*; 3, *Peridinium*; 4, *Glenodinium.*
XIII. Vorticellina ..	,,	1, *Stentor*; 2, *Trichodina*; 3, *Urocentrum*; 4, *Vorticella*; 5, *Carchesium*; 6, *Epistylis*; 7, *Opercularia*; 8, *Zoothamnium.*
XIV. Ophrydina ..	,,	1, *Ophrydium*; 2, *Tintinnus*; 3, *Vaginicola*; 4, *Cothurnia.*
XV. Enchelia	,,	1, *Enchelys*; 2, *Disoma*; 3, *Actinophrys*; 4, *Trichodiscus*; 5, *Podophrya*; 6, *Dendrosoma*; 7, *Trichoda*; 8, *Lacrymaria*; 9, *Leucophrys*; 10, *Holophrya*; 11, *Prorodon.*
XVI. Colepina	,,	1, *Coleps.*
XVII. Trachelina ..	,,	1, *Trachelius*; 2, *Loxodes*; 3, *Bursaria*; 4, *Spirostomum*; 5, *Phialina*; 6, *Glaucoma*; 7, *Chilodon*; 8, *Nassula.*
XVIII. Ophryocercina ..	,,	1, *Trachelocerca.*
XIX. Aspidiscina ..	,,	1, *Aspidiscus.*
XX. Colpodea	,,	1, *Colpoda*; 2, *Paramecium*; 3, *Amphileptus*; 4, *Uroleptus*; 5, *Ophryoglena.*
XXI. Oxytrichina ..	,,	1, *Oxytricha*; 2, *Ceratidium*; 3, *Kerona*; 4, *Urostyla*; 5, *Stylonychia.*
XXII. Euplotina	,,	1, *Discocephalus*; 2, *Himantophorus*; 3, *Chlamydodon*; 4, *Euplotes.*

F. Dujardin, 'Histoire des Zoophytes Infusoires,' 1841.

Section I. ASYMMETRICA.

Order I. Infusoria without visible Locomotive Appendages.

Family 1. Vibrionina : Gen. *Bacterium*, *Vibrio*, *Spirillum* (*Spirochæta* Ehr., *Spirodiscus* Ehr.).

Order II. Infusoria provided with Variable Expansions.

" 2. Amœbina : Gen. *Amœba.*

" 3. Rhizopoda : Gen. *Arcella* (*Cyphidium* Ehr.), *Difflugia*, *Trinema*, *Euglypha*, *Gromia*, *Miliola*, *Cristellaria*, *Vorticilialis.*

" 4. Actinophryina : Gen. *Actinophrys* (*Peritricha* Bory, *Podophrya* Ehr.), *Acineta*, *Dendrosoma.*

Order III. Infusoria provided with one or more Flagelliform Appendages.

Family 5. Monadina : Gen. *Monas*, *Cyclidium*, *Cercomonas*, *Amphimonas*, *Trepomonas*, *Chilomonas*, *Hexamita*, *Heteromita* (*Bodo* Ehr.), *Trichomonas*, *Uvella* (*Polytoma* Ehr.), *Anthophysa.*

" 6. Volvocina : Gen. *Volvox*, *Pandorina* (*Eudorina* Ehr.), *Gonium* (*Pectoralina* Bory), *Uroglena* (*Syncrypta* Ehr.).

" 7. Dinobryina : Gen. *Dinobryon*, *Epipyxis.*

" 8. Thecamonadina : Gen. *Trachelomonas* (*Chætotyphla* Ehr., *Chætoglena* Ehr.), *Cryptomonas* (*Cryptoglena*, Ehr.), *Phacus*, *Crumenula*, *Prorocentrum*, *Diselmis* (*Chlamydomonas* Ehr.), *Anisonema*, *Plœotia*, *Oxyrrhis.*

" 9. Euglenina : Gen. *Peranema*, *Astasia*, *Euglena* (*Raphanella* Bory, *Amblyophis* Ehr., *Chlorogonium* Ehr.), *Colacium*, *Distigma*, *Zygoselmis*, *Heteronema*, *Polyselmis.*

" 10. Peridinina : Gen. *Peridinium* (*Glenodinium* Ehr.), *Ceratium.*

Order IV. Ciliate Infusoria.

" 11. Enchelina : Gen. *Acomia*, *Gastrochæta*, *Enchelys*, *Alyscum*, *Uronema.*

" 12. Trichodina : Gen. *Trichoda*, *Trachelius*, *Acineria*, *Pelecida*, *Dileptus.*

" 13. Keronina : Gen. *Halteria*, *Oxytricha* (*Uroleptus* Ehr., *Urostyla* Ehr.), *Kerona* (*Stylonychia* Ehr.).

" 14. Plœsconina : Gen. *Plœsconia* (*Euplotes* Ehr., *Discocephalus* Ehr., *Himantophorus* Ehr.), *Chlamydodon*, *Diophrys*, *Coccudina*, *Aspidisca*, *Loxodes.*

" 15. Ervilina : Gen. *Ervilia*, *Trochilia.*

" 16. Leucophryina : Gen. *Spathidium*, *Leucophrys*, *Opalina.*

" 17. Paramecina : Gen. *Lacrymaria* (*Straulema* Bory, *Phialina* Ehr.), *Pleuronema*, *Glaucoma*, *Kolpoda*, *Paramecium*, *Amphileptus*, *Loxophyllum*, *Chilodon*, *Panophrys*, *Nassula*, *Holophrya*, *Prorodon.*

" 18. Bursarina : Gen. *Plagiotoma*, *Ophryoglena*, *Bursaria*, *Spirostoma*, *Kondylostoma.*

" 19. Urceolarina : Gen. *Stentor*, *Urceolaria*, *Ophrydium*, *Urocentrum.*

" 20. Vorticellina : Gen. *Scyphidium*, *Epistylis*, *Opercularia*, *Vorticella*, *Vaginicola.*

Section II. SYMMETRICA.

Genus *Coleps.*

C. T. VON SIEBOLD, 'Lehrbuch der Vergleichenden Anatomie,' 1845.

Class INFUSORIA.

ORDER I. ASTOMA (no oral aperture).

Family 1. ASTASIÆA: Gen. *Amblyophis*, *Euglena*, *Chlorogonium*.
,, 2. PERIDINÆA: Gen. *Peridinium*, *Glenodinium*.
,, 3. OPALINÆA: Gen. *Opalina*.

ORDER II. STOMATODA (with a distinct oral aperture).

,, 4. VORTICELLINA: Gen. *Stentor*, *Trichodina*, *Vorticella*, *Epistylis*, *Carchesium*.
,, 5. OPHRYDINA: Gen. *Vaginicola*, *Cothurnia*.
,, 6. ENCHELIA: Gen. *Actinophrys*, *Leucophrys*, *Prorodon*.
,, 7. TRACHELINA: Gen. *Glaucoma*, *Spirostomum*, *Trachelius*, *Loxodes*, *Chilodon*, *Phialina*, *Bursaria*, *Nassula*.
,, 8. KOLPODEA: Gen. *Kolpoda*, *Paramecium*, *Amphileptus*.
,, 9. OXYTRICHINA: Gen. *Oxytricha*, *Stylonychia*, *Urostyla*.
,, 10. EUPLOTA: Gen. *Euplotes*, *Himantophorus*, *Chlamydodon*.

MAXIMILIAN PERTY, 'Kleinster Lebensformen,' 1852.

Sub-Kingdom ARCHEZOA.

Class INFUSORIA.

SECTION I. PHYTOZOIDIA (Filigera).

Family 1. DINOBRYINA: *Dinobryon*.
,, 2. VOLVOCINA: *Syncrypta*, *Volvox*, *Sphærosira*, *Pandorina*, *Synaphia*, *Gonium*, *Hirmidium*.
,, 3. MONADINA: *Heteromitus*, *Amphimonas*, *Tetramitus*, *Trichomonas*, *Mallomonas*, *Pleuromonas*, *Trepomonas*, *Spiromonas*, *Cercomonas*, *Monas*, *Menoidium*, *Chromatium*, *Acariæum*, *Polytoma*, *Uvella*, *Anthophysa*.
,, 4. ASTASIÆ: *Euglena*, *Astasia*, *Peranema*, *Colacium*, *Eutreptia*, *Chlorogonium*, *Zygoselmis*, *Dinema*.
,, 5. THECOMONADINA: *Chætotyphla*, *Trypemonas*, *Chonemonas*.
,, 6. CRYPTOMONADINA: *Cryptomonas*, *Phacotus*, *Anisonema*, *Phacus*, *Lepocinctis*.
,, 7. PERIDINIDA: *Ceratium*, *Glenodinium*, *Peridinium*.

SECTION II. CILIATA (non-vibratile, slightly contractile cilia).

Family 8. ACTINOPHRYINA: *Actinophrys*, *Podophrya*, *Acineta.*

A. *METABOLICA* (*highly contractile and changeable in form*).

,, 9. OPHRYOCERCINA: *Trachelocerca*, *Lacrymaria.*

B. *MONIMA* (*contractile, but without jerking action or alteration of contour*).

,, 10. COLEPINA: *Coleps.*

,, 11. EUPLOTINA: *Euplotes*, *Himantophorus*, *Coccudina*, *Aspidisca.*

,, 12. COBALINA: *Alastor*, *Plagiotoma*, *Leucophrys*, *Opalina.*

,, 13. OXYTRICHINA: *Stichotricha*, *Mitophora*, *Oxytricha*, *Urostyla*, *Cerona.*

,, 14. TRACHELINA: *Trachelius*, *Harmodirus*, *Amphileptus*, *Loxophyllum*, *Dileptus*, *Pelecida*, *Loxodes.*

,, 15. TAPINIA: *Acropisthium*, *Acomia*, *Trichoda*, *Cyclidium*, *Bœonidium*, *Opisthiotricha*, *Siagontherium*, *Megatricha.*

,, 16. APIONIDINA: *Ptyxidium*, *Colobidium*, *Apionidium.*

,, 17. CINETOCHILINA: *Glaucoma*, *Cinetochilum.*

,, 18. DECTERIA: *Cyclogramma*, *Chilodon*, *Nassula*, *Prorodon*, *Habrodon.*

,, 19. APHTHONIA: *Pleuronema.*

,, 20. HOLOPHRYINA: *Holophrya*, *Enchelys*, *Spathidium.*

,, 21. PARAMECIINA: *Ophryoglena*, *Panophrys*, *Paramecium*, *Blepharisma*, *Colpoda.*

,, 22. BURSARINA: *Bursaria.*

C. *SPASTICA* (*contractile, form changeable, with a jerking action*).

,, 23. URCEOLARINA: *Stentor*, *Spirostomum*, *Cœnomorpha*, *Urocentrum.*

,, 24. OPHRYDINA: *Ophrydium.*

,, 25. VORTICELLINA: *Vorticella*, *Scyphidia*, *Epistylis.*

,, 26. VAGINIFERA: *Vaginicola*, *Cothurnia.*

CLAPARÈDE AND LACHMANN, 'Études sur les Infusoires,' 1858–1860.

ORDER I. FLAGELLATA. (Not tabulated.)

ORDER II. CILIO-FLAGELLATA.

Family 1. PERIDININA: *Ceratium*, *Peridinium*, *Dinophysis*, *Amphidinium*, *Prorocentrum*.

ORDER III. SUCTORIA.

" 2. ACINETINA: *Podophrya*, *Sphærophrya*, *Trichophrya*, *Acineta*, *Solenophrya*, *Dendrosoma*, *Dendrocometes*, *Ophryodendron*.

ORDER IV. CILIATA.

" 3. HALTERINA: *Strombidium*, *Halteria*.

" 4. COLEPINA: *Coleps*.

" 5. TRACHELINA: *Loxophyllum*, *Amphileptus*, *Trachelius*, *Loxodes*, *Trichopus*, *Chilodon*, *Nassula*, *Prorodon*, *Enchelyodon*, *Urotricha*, *Holophrya*, *Enchelys*, *Trachelophyllum*, *Phialina*, *Lacrymaria*.

" 6. DYSTERINA: *Huxleya*, *Œgyria*, *Dysteria*, *Iduna*.

" 7. COLPODINA: *Glaucoma*, *Pleuronema*, *Cyclidium*, *Colpoda*, *Paramecium*.

" 8. BURSARINA: *Ophryoglena*, *Bursaria*, *Frontonia*, *Metopus*, *Lembadium*, *Balantidium*, *Kondylostoma*, *Plagiotoma*, *Spirostomum*, *Leucophrys*, *Stentor*, *Freia*, *Chætospira*.

" 9. TINTINNODEA: *Tintinnus*.

" 10. OXYTRICHINA: *Aspidisca*, *Campylopus*, *Schizopus*, *Euplotes*, *Stylonychia*, *Stichochæta*, *Oxytricha*.

" 11. UROCENTRUM: *Urocentrum*.

" 12. VORTICELLINA: *Trichodina*, *Lagenophrys*, *Vaginicola*, *Cothurnia*, *Ophrydium*, *Gerda*, *Scyphidia*, *Epistylis*, *Zoothamnium*, *Carchesium*, *Vorticella*, (*Spirochona*).

R. M. DIESING, 'Revision der Prothelminthen.' Abtheilung Mastigophoren, 1865.

Sub-Order MASTIGOPHORA.

TRIBUS I. MASTIGOPHORA ATRICHOSOMATA (*Corpus nudum*).

Fam. I. MONADINEA.

Sub-Fam. I. **Monadinea haud loricata.**

* *ACERCOMONADINEA* (*Corpus ecaudatum*).

† *Os terminale* (*Acrostomata*).

MONOMASTIGA (*Flagellum unum*).

Animalcula monima.	Animalcula metabolica.
Gen. *Monas*, *Uvella*, *Anthophysa*, *Microglena*, *Glenouvella*.	Gen. *Peranema*, *Amblyophis*, *Colacium*.

DIMASTIGA (*Flagella duo*).

Gen. *Isomita*, *Dimastix*, *Glenomorum*, *Trepanomonas*.

TETRAMASTIGA (*Flagella quatuor*).

Animalcula monima.	Animalcula metabolica.
Pyramimonas.	*Polyselmis*.

POLYMASTIGA (*Flagella* 6, 10, *aut numeroso*).

Gen. *Chloraster*, *Spondylomorum*, *Phacelomonas*, *Lophomonas*.

†† *Os in pagina ventrali* (*Hypostomata*).

MONOMASTIGA.

Animalcula monima.	Animalcula metabolica.
Gen. *Plagiomastix*.	Gen. *Pyronema*.

DIMASTIGA.

Animalcula monima.	Animalcula metabolica.
Gen. *Heteromita*, *Chilomonas*, *Polytoma*, *Glenopolytoma*.	Gen. *Zygoselmis*, *Heteronema*.

Genera insufficienter cognita, *Gorgostomum*, *Doxococcus*, *Menoidium*.

** *CERCOMONADINEA* (*Corpus caudatum*).

† *Os terminale* (*Acrostomata*).

MONOMASTIGA.

Animalcula monima.	Animalcula metabolica.
Gen. *Bodo*, *Thaumas*, *Dicercomonas*.	Gen. *Astasia*, *Euglena*.

DIMASTIGA.

Animalcula monima.	Animalcula metabolica.
Gen. *Amphimonas.*	Gen. *Chlorogonium.*

†† *Os in pagina ventrali* (*Hypostomata*).

Gen. *Trichomonas.*

Sub-Fam. II. **Monadinea loricata.**

† *Os terminale* (*Acrostomata*).

α. *CORPUS LORICO INSTRUCTUM.*

MONOMASTIGA.

Animalcula monima.	Animalcula metabolica.
Gen *Cryptomonas*, *Petalomonas*, *Ophidomonas*, *Crumenula.*	Gen. *Lepocinctis.*

DIMASTIGA.

Gen. *Diseeræa*, *Diplotricha*, *Anisonema*, *Cryptoglena.*

TETRAMASTIGA.

Gen. *Phacotus*, *Carteria.*

β. *CORPUS URCEOLO CIRCUMDATUM.*

MONOMASTIGA.

Animalcula monima.	Animalcula metabolica.
Gen. *Lagenella*, *Trachelomonas*, *Chætotyphla*, *Chætoglena.*	Gen. *Dinobryon.*

Genus insufficienter cognitum, *Epipyxis.*

DIMASTIGA.

Gen. *Chonemonas.*

†† *Os inferum* (*Hypostomata*).

Gen. *Oxyrrhis.*

Fam. II. VOLVOCINEA.

* *VOLVOCINEA ECAUDATA.*

MONOMASTIGA.

Corpus urceolo inclusum vel lacerna involutum.

Gen. *Pandorina*, *Eudorina*, *Syncrypta.*

DIMASTIGA.

Synœcesium subglobosum.

Gen. *Stephanosphæra*, *Glœococcus*, *Chlamydomonas*, *Chlamydococcus*, *Volvox.*

Synœcesium tabulare.

Gen. *Gonium*, *Glenogonium.*

Genus insufficienter cognitum, *Trochogonium.*

Synœcesium lineare.

Gen. *Hirmidium.*

** *VOLVOCINEA CAUDATA.*

Gen. *Uroglena.*

Genus insufficienter cognitum, *Synura.*

TRIBUS II. MASTIGOPHORA TRICHOSOMATA (*Corpus ciliatum*).

Fam. III. MALLOMONADINEA.

Sub-Fam. I. **Mallomonadinea haud loricata.**

Gen. *Mallomonas.*

Sub-Fam. II. **Mallomonadinea loricata.**

Gen. *Prorocentrum.*

Fam. IV. PERIDINEA.

† *Os terminale* (*Acrostomata*).

MONOMASTIGA.

Gen. *Heteroaulax*, *Gonyaulax*, *Glenoaulax.*

†† *Os in pagina ventrali* (*Hypostomata*).

MONOMASTIGA.

* *Lorica sulco transversali antrorsum vel retrorsum collocato.*

Gen. *Proaulax*, *Amphidinium*, *Dinophysis.*

** *Lorica sulco transversali in medio fere corporis collocato.*

Gen. *Peridinium*, *Glenodinium.*

DIMASTIGA.

Gen. *Dimastigoaulax.*

F. Stein, 'Organismus der Infusionsthiere,' Abtheilung III. (Flagellata), Heft 1, 1878.

Class I. FLAGELLATA.

Family 1. Monadina : *Cercomonas*, *Monas*, *Goniomonas*, *Bodo*, *Phyllomitus*, *Tetramitus*, *Trepomonas*, *Trichomonas*, *Hexamita*, *Lophomonas*, *Platytheca*.

,, 2. Dendromonadina : *Dendromonas*, *Cephalothamnium*, *Anthophysa*.

,, 3. Spongomonadina : *Cladomonas*, *Rhipidodendron*, *Spongomonas*, *Phalansterium*.

,, 4. Craspemonadina : *Codonosiga*, *Codonocladium*, *Codonodesmus*, *Salpingœca*.

,, 5. Bikœcida : *Bikœca*, *Poteriodendron*.

,, 6. Dinobryina : *Epipyxis*, *Dinobryon*.

,, 7. Chrysomonadina : *Cœlomonas*, *Raphidomonas*, *Microglena*, *Chrysomonas*, *Uroglena*, *Syncrypta*, *Synura*, *Hymenomonas*, *Stylochrysalis*, *Chrysopyxis*.

,, 8. Chlamydomonadina : *Polytoma*, *Chlamydomonas*, *Chlamydococcus*, *Phacotus*, *Coccomonas*, *Tetraselmis*, *Gonium*.

,, 9. Volvocina : *Eudorina*, *Pandorina*, *Stephanosphæra*, *Volvox*.

,, 10. Hydromorina : *Chlorogonium*, *Chlorangium*, *Pyramidomonas*, *Chloraster*, *Spondylomorum*.

,, 11. Cryptomonadina : *Chilomonas*, *Cryptomonas*, *Nephroselmis*.

,, 12. Chloropeltidea : *Cryptoglena*, *Chloropeltis*, *Phacus*.

,, 13. Euglenida : *Euglena*, *Colacium*, *Ascoglena*, *Trachelomonas*.

,, 14. Astasiæa : *Eutreptia*, *Astasia*, *Heteronema*, *Zygoselmis*, *Peranema*.

,, 15. Scytomonadina : *Scytomonas*, *Petalomonas*, *Menoidium*, *Atractonema*, *Phialonema*, *Sphenomonas*, *Tropidocyphus*, *Anisonema*, *Colponema*, *Entosiphon*.

F. STEIN, 'Organismus der Infusionsthiere,' Heft 2, 1867.

Class II. CILIATA.

ORDER I. HOLOTRICHA.

Family 1. OPALININA: *Opalina*, *Hoplophrya*, *Anoplophrya*, *Haplophrya* (*Discophrya*).

" 2. TRACHELINA: *Amphileptus*, *Loxophyllum*, *Loxodes*, *Trachelius*, *Dileptus*.

" 3. ENCHELINA: *Trachelophyllum*, *Trachelocerca*, *Phialina*, *Lacrymaria*, *Enchelyodon*, *Enchelys*, *Coleps*, *Plagiopogon*, *Perispira*, *Urotricha*, *Actinobolus*, *Holophrya*, *Prorodon*.

" 4. PARAMÆCINA: Sub-Fam. *a*, Paramæcina: *Cyrtostomum*, *Nassula* (*Liosiphon*, *Cyclogramma*, *Acidophorus*), *Paramæcium*, *Colpoda*, *Ptychostomum*, *Conchophthirus*, *Isotricha*. Sub-Fam. *b*, Leucophryina: *Colpidium*, *Leucophrys*, *Panophrys*.

" 5. CINETROCHILINA: *Ophryoglena*, *Glaucoma*, *Cinetrochilum*, *Pleurochilidium*, *Trichoda*, *Cyclidium*, *Plagiopyla*, *Pleuronema*, *Lembadion*.

ORDER II. HETEROTRICHA.

" 1. BURSARINA: *Plagiotoma*, *Metopus*, *Nyctotherus*, *Balantidium*, *Bursaria*.

" 2. STENTORINA: *Freia*, *Stentor*.

" 3. SPIROSTOMEA: *Climacostomum*, *Spirostomum*, *Blepharisma*, *Condylostoma*.

ORDER III. HYPOTRICHA.

" 1. PERITROMINA: *Peritromus*.

" 2. CHLAMYDODONTA: *Chilodon*, *Opisthodon*, *Trichopus*, *Phascolodon*, *Chlamydodon*, *Scaphidiodon*.

" 3. ERVILIINA (Duj.): *Huxleya*, *Trochilia*, *Ervilia* (*Dysteria*, *Iduna*).

" 4. ASPIDISCINA (Ehr.): *Aspidisca*.

" 5. EUPLOTINA (Ehr.): *Uronychia*, *Styloplotes*, *Euplotes*.

" 6. OXYTRICHINA: *Urostyla*, *Epiclintes*, *Kerona*, *Stichotricha*, *Uroleptus*, *Gastrostyla*, *Pleurotricha*, *Onychodromus*, *Stylonychia*, *Oxytricha*, *Psilotricha*.

ORDER IV. PERITRICHA.

" 1. HALTERINA (C. & L.): *Strombidium*, *Halteria*.

" 2. TINTINNODEA (C. & L.): *Tintinnopsis*, *Tintinnus*.

" 3. CYCLODINEA: *Mesodinium*, *Didinium*, *Urocentrum*.

" 4. GYROCORIDA: *Gyrocorys*.

" 5. URCEOLARINA: *Trichodinopsis*, *Trichodina*, *Urceolaria*.

" 6. VORTICELLINA (Ehr.): *Astylozoon*, *Gerda*, *Scyphidia*, *Vorticella*, *Carchesium*, *Zoothamnium*, *Epistylis*, *Opercularia*.

" 7. OPHRYDINA (Ehr.): *Ophrydium*, *Vaginicola*, *Cothurnia*, *Lagenophrys*.

" 8. SPIROCHONINA: *Spirochona*.

" 9. OPHRYOSCOLECINA: *Entodinium*, *Ophryoscolex*.

CLASSIFICATORY SYSTEM ADOPTED IN THIS VOLUME.

Sub-Kingdom PROTOZOA.

Legion INFUSORIA.

Class I. FLAGELLATA vel MASTIGOPHORA.

Order I. TRYPANOSOMATA.

Genus 1, *Trypanosoma.*

Order II. RHIZO-FLAGELLATA.

Genus 1, *Mastigamœba;* 2, *Reptomonas;* 3, *Rhizomonas;* 4, *Podostoma.*

Order III. RADIO-FLAGELLATA.

FAMILY.

I. ACTINOMONADIDÆ: Genus 1, *Actinomonas.*

II. EUCHITONIDÆ: Genus 1, *Euchitonia;* 2, *Spongocyclia;* 3, *Spongasteriscus.*

Order IV. FLAGELLATA-PANTOSTOMATA.

I. MONADIDÆ: Genus 1, *Monas;* 2, *Scytomonas;* 3, *Cyathomonas;* 4, *Leptomonas;* 5, *Ophidomonas;* 6, *Herpetomonas;* 7, *Ancyromonas.*

II. PLEUROMONADIDÆ: Genus 1, *Pleuromonas;* 2, *Merotricha.*

III. CERCOMONADIDÆ: Genus 1, *Oikomonas;* 2, *Bodo;* 3, *Cercomonas.*

IV. CODONŒCIDÆ: Genus 1, *Codonœca;* 2, *Platytheca.*

V. DENDROMONADIDÆ: Genus 1, *Physomonas;* 2, *Cladonema;* 3, *Dendromonas;* 4, *Anthophysa;* 5, *Cephalothamnium.*

VI. BIKŒCIDÆ: Genus 1, *Hedræophysa;* 2, *Bicosœca;* 3, *Stylobryon.*

VII. AMPHIMONADIDÆ: Genus 1, *Goniomonas;* 2, *Amphimonas;* 3, *Deltomonas.*

VIII. SPONGOMONADIDÆ: Genus 1, *Cladomonas;* 2, *Rhipidodendron;* 3, *Spongomonas;* 4, *Diplomita.*

FAMILY.

IX. HETEROMITIDÆ: Genus 1, *Heteromita*; 2, *Colponema*; 3, *Spiromonas*; 4, *Phyllomitus*.

X. TREPOMONADIDÆ: Genus 1, *Trepomonas*.

XI. POLYTOMIDÆ: Genus 1, *Polytoma*.

XII. PSEUDOSPORIDÆ: Genus 1, *Pseudospora*.

XIII. SPUMELLIDÆ: Genus 1, *Spumella*.

XIV. TRIMASTIGIDÆ: Genus 1, *Callodictyon*; 2, *Trichomonas*; 3, *Dallingeria*; 4, *Trimastix*.

XV. TETRAMITIDÆ: Genus 1, *Tetramitus*; 2, *Tetraselmis*; 3, *Chloraster*.

XVI. HEXAMITIDÆ: Genus 1, *Hexamita*.

XVII. LOPHOMONADIDÆ: Genus 1, *Lophomonas*.

XVIII. CATALLACTIDÆ: Genus 1, *Magosphæra*.

Order V. CHOANO-FLAGELLATA vel FLAGELLATA-DISCOSTOMATA.

Section I. DISCOSTOMATA-GYMNOZOIDA.

I. CODONOSIGIDÆ: Genus 1, *Monosiga*; 2, *Codosiga*; 3, *Astrosiga*; 4, *Desmarella*.

II. SALPINGŒCIDÆ: Genus 1, *Salpingœca*; 2, *Lagenœca*; 3, *Polyœca*.

III. PHALANSTERIIDÆ: Genus 1, *Phalansterium*; 2, *Protospongia*.

Section II. DISCOSTOMATA-SARCOCRYPTA (*Spongida*).

Order VI. FLAGELLATA-EUSTOMATA.

I. PARAMONADIDÆ: Genus 1, *Paramonas*; 2, *Petalomonas*; 3, *Atractonema*; 4, *Phialonema*; 5, *Menoidium*.

II. ASTASIADÆ: Genus 1, *Astasia*; 2, *Colpodella*.

III. EUGLENIDÆ: Genus 1, *Euglena*; 2, *Amblyophis*; 3, *Phacus*; 4, *Chloropeltis*; 5, *Trachelomonas*; 6, *Raphidomonas*; 7, *Cœlomonas*; 8, *Ascoglena*; 9, *Colacium*.

IV. NOCTILUCIDÆ: Genus 1, *Noctiluca*; 2, *Leptodiscus*.

V. CHRYSOMONADIDÆ: Genus 1, *Chloromonas*; 2, *Chrysomonas*; 3, *Microglena*; 4, *Cryptomonas*; 5, *Nephroselmis*; 6, *Stylochrysalis*; 7, *Uvella*; 8, *Chlorangium*; 9, *Hymenomonas*; 10, *Chrysopyxis*; 11, *Epipyxis*; 12, *Dinobryon*; 13, *Synura*; 14, *Syncrypta*; 15, *Uroglena*.

FAMILY.

VI. ZYGOSELMIDÆ: Genus 1, *Eutreptia*; 2, *Zygoselmis*; 3, *Distigma*; 4, *Cryptoglena*; 5, *Sterromonas*; 6, *Dinomonas*.

VII. CHILOMONADIDÆ: Genus 1, *Chilomonas*; 2, *Oxyrrhis*.

VIII. ANISONEMIDÆ: Genus 1, *Heteronema*; 2, *Diplomastix*; 3, *Anisonema*; 4, *Entosiphon*.

IX. SPHENOMONADIDÆ: Genus 1, *Sphenomonas*.

Order VII. CILIO-FLAGELLATA.

I. PERIDINIIDÆ: Genus 1, *Hemidinium*; 2, *Gymnodinium*; 3, *Melodinium*; 4, *Glenodinium*; 5, *Peridinium*; 6, *Ceratium*; 7, *Dinophysis*; 8, *Amphidinium*; 9, *Prorocentrum*; 10, *Dimastigoaulax*.

II. HETEROMASTIGIDÆ: Genus 1, *Heteromastix*.

III. MALLOMONADIDÆ: Genus 1, *Mallomonas*.

IV. STEPHANOMONADIDÆ; Genus 1, *Stephanomonas*; 2, *Asthmatos*.

V. TRICHONEMIDÆ: Genus 1, *Trichonema*; 2, *Mitophora*.

Class II. CILIATA vel TRICHOPHORA.

Order I. HOLOTRICHA.

I. PARAMŒCIIDÆ: Genus 1, *Paramœcium*; 2, *Loxocephalus*; 3, *Placus*; 4, *Conchophthirus*.

II. PRORODONTIDÆ: Genus 1, *Prorodon*; 2, *Nassula*; 3, *Cyrtostomum*; 4, *Isotricha*; 5, *Holophrya*; 6, *Otostoma*; 7, *Helicostoma*.

III. TRACHELOPHYLLIDÆ: Genus 1, *Trachelophyllum*; 2, *Enchelyodon*; 3, *Urotricha*.

IV. COLEPIDÆ: Genus 1, *Coleps*; 2, *Plagiopogon*; 3, *Polykrikos*.

V. ENCHELYIDÆ: Genus 1, *Enchelys*; 2, *Metacystis*; 3, *Perispira*; 4, *Anophrys*; 5, *Colpoda*; 6, *Tillina*.

VI. TRACHELOCERCIDÆ: Genus 1, *Trachelocerca*; 2, *Lachrymaria*; 3, *Phialina*; 4, *Maryna*; 5, *Lagynis*; 6, *Chœnia*.

VII. TRACHELIIDÆ: Genus 1, *Trachelius*; 2, *Amphileptus*; 3, *Loxophyllum*.

VIII. ICHTHYOPHTHIRIIDÆ: Genus 1, *Ichthyophthirius*.

FAMILY.

IX. OPHRYOGLENIDÆ: Genus 1, *Ophryoglena*; 2, *Panophrys*; 3, *Cyclotricha*; 4, *Trichoda*; 5, *Lembadion*; 6, *Leucophrys*; 7, *Colpidium*; 8, *Plagiopyla*; 9, *Meniscostomum*; 10, *Chasmatostomum*; 11, *Pleurochilidium*.

X. PLEURONEMIDÆ: Genus 1, *Pleuronema*; 2, *Cyclidium*; 3, *Uronema*; 4, *Bœonidium*.

XI. LEMBIDÆ: Genus 1, *Lembus*; 2, *Proboscella*.

XII. TRICHONYMPHIDÆ: Genus 1, *Trichonympha*; 2, *Pyrsonema*; 3, *Dinonympha*.

APPENDIX.

XIII. OPALINIDÆ: Genus 1, *Opalina*; 2, *Anoplophrya*; 3, *Discophrya*; 4, *Hoplitophrya*.

Order II. HETEROTRICHA.

I. BURSARIIDÆ: Genus 1, *Bursaria*; 2, *Bursarella*; 3, *Balantidium*; 4, *Nyctotherus*; 5, *Metopus*; 6, *Metopides*; 7, *Plagiotoma*.

II. SPIROSTOMIDÆ: Genus 1, *Condylostoma*; 2, *Blepharisma*; 3, *Spirostomum*; 4, *Climacostomum*.

III. STENTORIDÆ: Genus 1, *Stentor*; 2, *Follicularia*; 3, *Chætospira*.

IV. TINTINNODÆ: Genus 1, *Tintinnus*; 2, *Tintinnidium*; 3, *Vasicola*; 4, *Strombidinopsis*.

V. TRICHODINOPSIDÆ: Genus 1, *Trichodinopsis*.

VI. CODONELLIDÆ: Genus 1, *Codonella*; 2, *Tintinnopsis*.

VII. CALCEOLIDÆ: Genus 1, *Calceolus*.

Order III. PERITRICHA.

I. TORQUATELLIDÆ: Genus 1, *Torquatella*.

II. DICTYOCYSTIDÆ: Genus 1, *Dictyocysta*.

III. ACTINOBOLIDÆ: Genus 1, *Actinobolus*.

IV. HALTERIIDÆ: Genus 1, *Halteria*; 2, *Strombidium*; 3, *Mesodinium*; 4, *Acarella*; 5, *Arachnopsis*; 6, *Didinium*.

V. GYROCORIDÆ: Genus 1, *Gyrocoris*; 2, *Urocentrum*.

VI. URCEOLARIIDÆ: Genus 1, *Trichodina*; 2, *Urceolaria*; 3, *Cyclochæta*; 4, *Licnophora*.

VII. OPHRYOSCOLECIDÆ: Genus 1, *Ophryoscolex*; 2, *Entodinium*; 3, *Astylozoon*.

FAMILY.

VIII. VORTICELLIDÆ: Sub-Fam. I., VORTICELLINA: Genus 1, *Gerda*, 2, *Scyphidia*; 3, *Spirochona*; 4, *Stylochona*; 5, *Rhabdostyla*; 6, *Pyxidium*; 7, *Vorticella*; 8, *Carchesium*; 9, *Zoothamnium*; 10, *Epistylis*; 11, *Opercularia*. Sub-Fam. II., VAGINICOLINA: Genus 1, *Vaginicola*; 2, *Thuricola*; 3, *Cothurnia*; 4, *Pyxicola*; 5, *Stylocola*; 6, *Platycola*; 7, *Lagenophrys*. Sub-Fam. III., OPHRYDINA: Genus 1, *Ophionella*; 2, *Ophrydium*.

Order IV. HYPOTRICHA.

I. LITONOTIDÆ: Genus 1, *Litonotus*.

II. CHLAMYDODONTIDÆ: Genus 1, *Phascolodon*; 2, *Chilodon*; 3, *Loxodes*; 4, *Opisthodon*; 5, *Chlamydodon*; 6, *Scaphiodon*.

III. DYSTERIADÆ: Genus 1, *Iduna*; 2, *Dysteria*; 3, *Cypridium*; 4, *Ægyria*; 5, *Trochilia*; 6, *Huxleya*; 7, *Trichopus*.

IV. PERITROMIDÆ: Genus 1, *Peritromus*.

V. OXYTRICHIDÆ: Genus 1, *Psilotricha*; 2, *Kerona*; 3, *Trichogaster*; 4, *Urostyla*; 5, *Onychodromus*; 6, *Amphisia*; 7, *Holosticha*; 8, *Plagiotricha*; 9, *Epiclintes*; 10, *Stichochæta*; 11, *Stichotricha*; 12, *Strongylidium*; 13, *Uroleptus*; 14, *Stylonethes*; 15, *Allotricha*; 16, *Pleurotricha*; 17, *Gastrostyla*; 18, *Opisthotricha*; 19, *Oxytricha*; 20, *Histrio*; 21, *Actinotricha*; 22, *Stylonychia*.

VI. EUPLOTIDÆ: Genus 1, *Aspidisca* (*Glaucoma*; *Microthorax*); 2, *Uronychia*; 3, *Euplotes*; 4, *Styloplotes*.

Class III. TENTACULIFERA.

Order I. TENTACULIFERA-SUCTORIA.

I. RHYNCHETIDÆ: Genus 1, *Rhyncheta*; 2, *Urnula*.

II. ACINETIDÆ: Genus 1, *Trichophrya*; 2, *Podophrya*; 3, *Hemiophrya*; 4, *Solenophrya*; 5, *Acineta*.

III. DENDROCOMETIDÆ: Genus 1, *Dendrocometes*.

IV. DENDROSOMIDÆ: Genus 1, *Dendrosoma*.

Order II. TENTACULIFERA-ACTINARIA.

I. EPHELOTIDÆ: Genus 1, *Ephelota*; 2, *Actinocyathus*.

II. OPHRYODENDRIDÆ: Genus 1, *Ophryodendron*; 2, *Acetinopsis*.

CHAPTER VII.

SYSTEMATIC DESCRIPTION OF THE INFUSORIA FLAGELLATA.

Class I. FLAGELLATA.

ANIMALCULES bearing one, two, or more long, lash-like flagella, which mostly represent the sole organs of progression, but are occasionally supplemented by cilia, pseudopodia, or other locomotive or prehensile appendages. Oral or ingestive system varying in character; definite, diffuse, or indistinct. One or more contractile vesicles almost invariably represented. Multiplying rapidly by binary fission and by the subdivision of their entire body-mass into sporular elements. The sporular reproductive process often preceded by the complete fusion or conjugation of two or more adult zooids.

The title of the Flagellata, as distinctive of a large and important series of infusorial types, was employed almost simultaneously by Johannes Müller and F. Cohn about the year 1853; it is practically synonymous with that of the Filigera introduced one year previously by M. Perty, and with the Mastigophora of R. M. Diesing.

Although thus receiving their characteristic name at a comparatively recent date, the members of this class were known to the majority of the earlier writers, being abundantly figured and described in the works of O. F. Müller, and C. G. Ehrenberg, while a first intelligible record of their existence is undoubtedly contained in Mr. John Harris's account of little fish-like animals (*Euglena viridis*) communicated to the 'Philosophical Transactions' for the year 1696, reproduced at pages 9 and 10. By these earlier authorities, however, the flagelliform organs were almost altogether overlooked, and it was not until the employment of more perfected instruments having a comparatively high magnifying power, at the hands of Felix Dujardin and Maximilian Perty, that these appendages were extensively recognized as representing the essential organs of locomotion, or their number, character, and mode of insertion made use of for the purpose of generic diagnosis. Much even then remained to be discovered with relation to their more minute organization. While Ehrenberg had declared that all these flagellate organisms possessed a distinct mouth, and in most instances numerous gastric cavities, Dujardin made the entire absence of an oral aperture a leading distinction of the Order III. or Flagelliferous section of his 'Zoophytes Infusoires.' So much uncertainty has prevailed, again, respecting the claims of the Flagellata for recognition as animal organisms—their external shape and mode of locomotion corresponding so closely with those of many undoubted unicellular plants or Protophytes, and with the spermatic elements, "antherozooids" or "zoospores," of the higher Cryptogamia—that almost down to the present time biologists have refused to admit them among the ranks of the typical Infusoria. The more perfect insight into the structure and life-history of the representatives of this class, obtained by the assistance of the higher magnifying glasses of recent construction, has, however, practically revealed in them the existence of an entirely new world of microscopic organisms, possessing the most evident animal attributes, and exhibiting with relation to each other an even more extensive range of structural variation than is met with among the hitherto more familiar Ciliate section of the Infusorial series.

The foremost place amongst those who by their original investigations have contributed most substantially towards our more correct knowledge of this previously comparatively neglected group, must undoubtedly be awarded to Professor Stein in connection with the recently published third volume, Part I., of his magnificent folio series devoted to the description and illustration of infusorial organization. As he himself justly remarks, this volume represents the most important of the three now issued, it dealing exclusively and on the most liberal and comprehensive scale with the class now under consideration. So far, however, Stein's volume is complete with reference only to the illustrations contained in the twenty-four magnificently executed plates, the one hundred and fifty-four pages of text that precede them being devoted chiefly to an exhaustive review of the work achieved by earlier investigators, with relation to both flagellate animal and vegetable organisms, and to a discussion of the claims of the innumerable forms he figures for comprehension among the animal series. A full description of the types there illustrated is reserved for a much looked forward to, but as yet unpublished, second part.* All the species delineated by Stein in the treatise quoted are represented as seen under the high magnification of from 600 to 1200 diameters and upwards, and which is indeed absolutely requisite for gaining a correct estimate of the often highly complex organization of these exceptionally minute beings. As now shown by Stein, numbers of these Flagellata possess not only a well-developed oral aperture, but frequently in addition an extensive pharyngeal dilatation, and in some cases even a buccal or pharyngeal armature comparable to that found in various higher Ciliata. Among the more important features of Stein's work may be also mentioned his comprehension of numerous types belonging to the collared series, first discovered by Professor H. James-Clark—here included in the order Choano-Flagellata, and his acquiescence, through such discovery, with the views maintained by Professor Clark, and supported by the author, respecting the affinities of the sponges. The limits assigned to the Flagellata by Professor Stein differ essentially from those recognized in this treatise. As already notified at page 197, the fundamental basis upon which he establishes this class relates merely to the presence of a nucleus and contractile vesicle, without any reference to food-ingesting properties, the result of such lax definition being the admission of such types as *Volvox*, *Gonium*, *Protococcus* (*Chlamydococcus*), and numerous other forms of whose essential vegetable affinities there is scarcely room for doubt. It is indeed contested by the author (see page 47) whether the types just enumerated possess contractile vesicles; the inability to detect such structures in numberless examples investigated with the greatest care, being accepted as a conclusive proof of their vegetable nature.

A conspicuous feature of the reproductive phenomena of the Flagellata is manifested by the tendency of almost all the forms to multiply, in addition to the ordinary process of binary fission, by encystment and the subsequent breaking up of their entire body-mass into sporular elements, such mode of reproduction being precisely parallel with what obtains among the unicellular plants or Protophytes. Sometimes the spores so produced are few in number and of conspicuous size, meriting the title, as here applied to them, of "macrospores"; while in other instances they are altogether innumerable, and of such minute calibre as to defy individual definition, even with the assistance of the highest magnifying powers of the compound microscope; the sporular bodies under such conditions being appropriately designated "microspores." It is further worthy of notice that the production of microspores is more usually preceded by the genetic union or coalescence of two, or it may be many, independent zooids, while that of macro-

* As a consequence of the present unfinished condition of Stein's monograph, the diagnoses of the innumerable new generic and specific types it embodies, given in this manual, have been framed by the author on the broad characters only indicated in Stein's drawings. The many deficiencies in these diagnoses which must necessarily exist can be supplied only at the hands of the original discoverer of the forms figured.

spores commonly follows upon the simple encystment of a single animalcule. The recognition of these important reproductive phenomena is chiefly due to the recent painstaking investigations of Messrs. Dallinger and Drysdale, whose researches in this direction are fully recorded in the descriptive accounts given of *Monas Dallingerii*, *Cercomonas typica*, *Tetramitus rostrata*, *Dallingeria Drysdali*, and several species of *Heteromita*.

With reference to the variously modified characters of the oral system, and of the locomotive and supplementary appendages, the class of the Flagellata may be conveniently subdivided into primary sections or Orders as below :—

A. Ingestive area diffuse.	Flagellum rudimentary, supplemented by an undulating membrane	Order I. Trypanosomata.
	Flagellum supplemented by lobate pseudopodia	,, II. Rhizo-Flagellata.
	Flagellum supplemented by ray-like pseudopodia ..	,, III. Radio-Flagellata.
	Flagella representing the sole organs of locomotion ..	,, IV. Flagellata-Pantostomata.
B. Ingestive area discoidal, limited to the anterior region ; no true mouth.	Flagellum issuing from the centre of a collar-like extensile membrane	,, V. Choano-Flagellata.
C. Ingestive area constituting a true and distinct mouth.	Flagellum not supplemented by cilia	,, VI. Flagellata-Eustomata.
	Flagellum supplemented by a more or less highly developed ciliary system ..	,, VII. Cilio-Flagellata.

Order I. TRYPANOSOMATA, S. K.

Animalcules flattened or lamellate, one or more of the lateral borders forming a frill-like undulating membrane by the vibrations of which progress is effected ; one extremity sometimes attenuate and somewhat resembling a flagellum. Oral or ingestive area undefined.

Two species only, representing but a single genus, can be as yet referred to this newly established order. So far as it can be at present determined, these two endoparasitic types would seem to lie at the base of all the succeeding more typical sections of the Infusoria Flagellata and Ciliata. Although no positive flagellum is present, the growth of such an organ is evidently foreshadowed in the slender tag-like appendage of *Trypanosoma sanguinis*, while, on the other hand, the undulating membranous border, constituting the essential organ of locomotion, may without hesitation be regarded as closely, if not absolutely, homologous with the similar undulating frill-like border present in the earlier developmental phases of *Stentor*, *Euplotes*, and other higher Ciliate types, and which eventually splits up to form the characteristic adoral fringe.

Genus I. TRYPANOSOMA, Gruby.

Animalcules free-swimming, compressed ; one side produced as a thin, undulating, frill-like border ; the anterior extremity sometimes produced as a long tag-like or flagellate appendage. No distinct oral aperture.

Occurring in the blood of Amphibia, and within the intestinal viscera of domestic poultry.

Trypanosoma sanguinis, Gruby. PL. I. FIGS. 1 AND 2.

Body compressed, semilunate, twisted; the convex border membranous and undulating, with its margin deeply toothed; the posterior extremity of the body portion pointed and curved inwards, the opposite one produced into a long tag- or tail-like appendage which almost equals in length the remainder of the body; surface of the body coarsely striate longitudinally; endoplasm or parenchyma slightly granular; endoplast ovate, central. Dimensions, 1–600''.

HAB.—Blood of the frogs, *Rana esculenta* and *R. temporaria*.

This species was first introduced to scientific notice by Gruby, who described and bestowed upon it the name here given in the 'Comptes Rendus' for November 1843. More recently this animalcule has been figured by Professor E. Ray Lankester in the 'Quarterly Journal of Microscopical Science' for October 1871, under the title of *Undulina ranarum*, its identity with Gruby's type being, however, subsequently admitted.

Professor Lankester's account given of the characteristic aspect and movements of this singular animalcule, in the serial quoted, is as follows:—"In making examinations of the blood of frogs, I have now and then met with the interesting little parasite drawn in the woodcut. When I first saw it, in some blood from a frog last summer, I took it for a very active white blood-corpuscle, since it is a very little smaller than one of the red corpuscles of the frog's blood. On using, however, a higher power (No. 10*a* immersion, of Hartnack), I made out its infusorial nature, though, on account of the great activity of its movements, I was long uncertain as to the nature of its locomotive organs. Numerous specimens occurred in the blood of a frog (*Rana esculenta*), examined at Leipzig in March last, and by the use of a small quantity of acetic acid vapour I was able to kill the little creature without injuring it, and then to make out its structure. It was seen to be a minute pyriform sac, with the narrower end bent round on itself somewhat spirally, and the broader end spread out into a thin membrane, which exhibited four or five folds, and was produced on one side into a very long flagellum. The wall of the sac was striated coarsely, as in *Opalina*; and the direction of the striæ on the two sides of the sac, as seen one through the other, showed that the small end of the sac was twisted as well as bent over on itself. A pale, clear nucleus and a very few granules were also seen. In life the broad membrane undulates vigorously in a series of waves, the flagellum taking part, and presents then a deeply toothed appearance. The movements produced by the activity of this membrane tend to urge the animal in a wide circle. The opposite extremity of the sac twists and untwists itself to a small extent also during life. The series of waves of the undulating membrane are not incessantly in one direction; after a certain time they change to the opposite direction, and then resume their original direction, an alternation of from right to left, and from left to right being kept up. When minute traces of acetic acid vapour are passed into the gas-chamber where this infusorian is, it soon becomes affected; the undulations become deranged, starting from both ends simultaneously and meeting in the middle, and at length ceasing."

Trypanosoma Eberthi, S. K. PL. I. FIGS. 3–6.

Body flattened, and semilunate when at rest, its convex membraniform border serrated or presenting a beaded aspect; straight, lanceolate, and pointed at each extremity when in motion, not produced at either end into a tag-like prolongation; the membranous border often spirally convolute around the thicker central portion, the entire body assuming under such conditions an auger-like aspect. Length 1–1760''.

HAB.—The intestinal viscera of various domestic poultry.

It is proposed to distinguish, under the above title, the organism figured and described by Dr. J. Eberth in Siebold and Kölliker's 'Zeitschrift' for the year 1861, p. 98, as a new infusorial form inhabiting the intestinal viscera—chiefly the cæcum and ileum—of ducks, geese, and other domestic poultry. No name is there bestowed upon it, and its accordance to a considerable extent with the *Trypanosoma sanguinis* of Gruby, and *Amœba rotatoria* of Meyer is acknowledged. Its distinction from Gruby's type is clearly manifested, however, by the entire absence of the anterior filamentous or tag-like appendage which forms so conspicuous a characteristic of that species, and which is so prominently figured in Professor Lankester's more recent delineation here reproduced. If the above-named structure in *T. sanguinis* is to be regarded as the analogue or rudiment of a true flagellum, it would appear almost desirable to create a new generic title for the reception of the present more simple form. On the other hand, however, a further investigation may not impossibly demonstrate that both this and the preceding type are but transitional phases of the same specific form, which, in common with many higher endoparasitic organisms, requires the association of two distinct hosts for the full development of its life-cycle, and exhibits under each condition an altogether distinct aspect. In this manner it may be proved hereafter, though only submitted now as a suggestion, that the flagellum- or filament-bearing *Trypanomonas sanguinis*, as found in the blood of the frog, represents the adult condition of the more minute *T. Eberthi*, which would probably be swallowed by the amphibians or their tadpoles, in company with the discharged fæces of the water-fowl. Or again, though this seems less likely, *T. sanguinis* may represent the larval condition, which being devoured with its host, the frog, by the water-fowl, may develop in the intestine of the latter to *T. Eberthi*.

Yet another interpretation may be suggested relative to the true nature and significance of the present species of *Trypanosoma*. It is, as already stated at page 100, a noteworthy fact that the spermatic elements of many Amphibia correspond structurally in a remarkable manner with the representatives of the present species as figured by Eberth. The long, slender bodies of such spermatozoa are, as first pointed out by Wagner and Leuckhart in the year 1837, and as still more fully demonstrated by C. T. Von Siebold,* supplemented throughout their length by a delicate frill-like border, developed straight along or in a spiral manner around it throughout the whole extent or greater part of its total length. Quite recently it has, moreover, been shown by Mr. Heneage Gibbes,† that the spermatozoa of the Mammalia possess also, though in a less developed degree, corresponding supplementary membranes. The high import attaching itself to this structural feature of Amphibian spermatozoa just described is obvious. It necessarily renders it quite possible that the form discovered by Dr. Eberth, and here provisionally accepted as an independent infusorial species, may ultimately prove to be the spermatic elements of frogs and other Amphibia, which, as commonly happens, have been devoured by the water-fowl, and retained their vitality while passing through its viscera.

Order II. RHIZO-FLAGELLATA, S. K.

Animalcules progressing by means of pseudopodic extensions of their sarcode after the manner of the ordinary Rhizopoda, but bearing at the same time one or more flagellate appendages; oral or ingestive area diffuse.

* "Ueber undulirender Membranen," 'Zeit. Wiss. Zool.,' Bd. ii., 1850.

† "On the Structure of the Vertebrate Spermatozoon," 'Quart. Jour. Mic. Sci.,' No. lxxvi., Oct. 1879.

The some half a dozen species as yet known that may be consistently referred to this order, intimately connect with each other the two classes of the Rhizopoda, as represented by the Amœbina, and the typical Infusoria-Flagellata. In accordance with the number and character of their flagelliform and pseudopodic appendages they admit of the following generic grouping:—

GENERA OF RHIZO-FLAGELLATA.

Flagellum single, anteriorly situated.	Repent	Body amœbiform, pseudopodia emitted from all parts of the periphery	Genus 1. *Mastigamœba.*
		Body monadiform, pseudopodia emitted only from the ventral surface	,, 2. *Reptomonas.*
	Sedentary, with radiating digitiform prolongations ..		,, 3. *Rhizomonas.*
Flagella multiple, inconstant in number and position			,, 4. *Podostoma.*

GENUS I. MASTIGAMŒBA, Schulze.

Animalcules repent, amœba-like, changeable in form, emitting pseudopodia from all parts of the periphery, the anterior extremity bearing a single, long, non-retractile, lash-like flagellum.

Mastigamœba aspera, Schulze. PL. I. FIG. 21.

Body when extended oval, depressed, pointed anteriorly; pseudopodia cylindrical, unbranched, digitiform, diverging in somewhat regular order from the lateral margins of the periphery, those at the posterior extremity of the body shorter than the others, emitting extremely fine ray-like sarcodic projections, similar to those of *Amœba* (*Pelomyxa*) *villosa;* flagellum issuing from the pointed anterior extremity, about equal in length to the body; entire external surface, including more especially the pseudopodia, beset with exceedingly minute refringent rod-like structures which communicate to it a hispid aspect. Contractile vesicles two in number, situated near the posterior extremity. A subspheroidal endoplast-like structure developed anteriorly; endoplasm enclosing numerous reddish-yellow spherules and colourless granules. Length of body 1–150″.

HAB.—Pond water.

Excepting for its smaller size and the presence of the anteriorly developed flagellum, the representatives of this species correspond in a remarkable manner with the *Dinamœba mirabilis* of Dr. Joseph Leidy, as recently figured in his magnificent monograph of the Freshwater Rhizopods of North America.

Mastigamœba simplex, S. K. PL. I. FIG. 30.

Body when extended usually widest and rounded at the anterior extremity, tapering posteriorly; pseudopodia irregular in shape, simple, lobate, or furcately branched, not differentiated from one another as in *M. aspera,* usually directed backwards; flagellum antero-terminal, about twice the length of the body; external surface entirely smooth; contractile vesicle anteriorly situated; endoplast spherical, subcentral; endoplasm transparent, colourless. Length of body 1–2000″.

HAB.—Pond water.

Deprived of its terminal flagellum, this species would seem closely to agree both in aspect and size with the *Amœba lacerata* of Dujardin. Like that form, the pseudopodia are altogether irregular in shape, and present a laciniate or ragged outline. The movements of this animalcule in the water are tolerably active, it creeping rapidly forwards over the surface of submerged objects by the continual rolling to the front of the granular contents of the body-sarcode in a manner identical with what obtains among the ordinary amœbæ; the long, whip-like flagellum is at the same time vigorously flourished in advance or thrust around in every direction, as though seeking for suitable food-substances. These latter when met with, are whipped backwards by the action of the flagellum, and striking against some portion of the periphery of the body, are at once engulfed by the soft yielding sarcode. On one occasion an example was observed dragging a *Navicula* almost equalling itself in size by an abnormal thread-like extension of one of its pseudopodia, as shown in the illustration given. The Protozoon figured and described by Bütschli under the title of "eine geisseltragender Rhizopode," * is apparently almost identical with this form; but the pseudopodia, in accordance with his illustrations, are smaller and more slender, and the flagellum, in comparison, is considerably longer.

Mastigamœba monociliata, Carter, sp. PL. I. FIGS. 22 AND 23.

Body amœboid, variable in form; pseudopodal extensions irregularly lobate, the posterior extremity having a brush-like villous tuft, anterior flagellum equalling the body in length. Dimensions unrecorded.

HAB.—Fresh water. Bombay, H. J. C.

This species is briefly described by Mr. H. J. Carter † as a new species of *Amœba*, upon which he proposes to confer the title of *Amœba monociliata*. From *Mastigamœba simplex*, which it most nearly resembles, it may be distinguished by the tuft of villi at the posterior extremity.

Mastigamœba ramulosa, S. K. PL. I. FIGS. 19 AND 20.

Body when extended elongate-ovate, about one and a half times as long as broad; the entire peripheral surface bearing subequal shortly branched pseudopodic prolongations, neither these nor the general surface of the body having secondary hispid pseudopodia; flagellum exceeding the body in length; endoplast spherical, subcentral; contractile vesicle posteriorly located. Length 1–400″.

HAB.—Marsh water.

This animalcule has as yet been met with by the author on one occasion only, being then found in marsh-water from the neighbourhood of Le Marais, Jersey, associated with the Ciliate types *Spirostomum ambiguum* and *Litonotus fasciata*. The conspicuously branched character of the abundant pseudopodia serves to distinguish it readily from either of the preceding species, and communicates to it as a whole an aspect suggestive of a minute Nudibranch, such as *Eolis* or *Dendronotus*. Like these molluscs, the little animalcule, under any disturbing influence,

* 'Zeit. Wiss. Zool.,' Bd. xxx. Heft 2, 1878.

† 'Ann. Nat. Hist.,' Jan. 1864.

immediately contracts into a subspheroidal contour, as shown in Pl. I. Fig. 20. It was observed that the granule circulation, conspicuously indicated in the central substance of the body-sarcode, did not extend into the branched pseudopodic extensions, neither on any occasion were these last-named appendages withdrawn entirely within the periphery.

Doubtful Species.

The free-swimming flagellate amœbæ, described by Tatem in the 'Monthly Microscopical Journal' for June 1869, appeared at first sight to require a position in or adjacent to the genus *Mastigamœba*, but the result of a recent investigation into the life-history of innumerable Pantostomatous Flagellate species, has inclined the author to regard the forms there figured and described as merely metamorphosed amœboid phases of some such type as *Monas fluida.*

GENUS II. REPTOMONAS, S. K.

(Latin, *repto*, to creep; *monas.*)

Animalcules repent, but slightly changeable in form, bearing a single anterior flagellum; locomotive pseudopodia produced only from the repent or ventral surface.

The limitation of the pseudopodia to the ventral region, and the conservation by the body, taken as a whole, of a persistent contour, distinguish this genus from *Mastigamœba*, which it otherwise closely approaches.

Reptomonas caudata, S. K. PL. I. FIGS. 31–33.

Body monadiform, elongate-ovate, somewhat inflated posteriorly; flagellum slender, exceeding the body in length, produced from the apex of the narrower and slightly pointed anterior extremity; a long, trailing, caudiform pseudopodium continued backwards from the posterior end of the ventral surface, and numerous similar but smaller pseudopodia emitted irregularly from the whole surface of this region; contractile vesicle single, situated near anterior extremity; endoplast spherical, subcentral. Length, exclusive of caudal pseudopodium, 1–1200" to 1–750".

HAB.—Hay infusions, and among naturally decaying grass.

This as yet single discovered species of the newly instituted genus *Reptomonas* was obtained by the author in tolerable abundance from a hay infusion made at St. Heliers, Jersey, in February 1879, a closely similar, if not absolutely identical, specific type having also been met with among wet grass gathered in the Regent's Park in October of the same year, and under the circumstances narrated at length at page 140. During progression the anterior extremity of the animalcule is usually elevated in the manner shown at Pl. I. Fig. 31, the flagellum meanwhile vibrating vigorously in all directions in search of food. On one occasion, as delineated at Fig. 33, a Bacterium thrown by the vibrations of this organ against the anterior margin was at once secured by an outflowing wave of the peripheral sarcode, and rapidly passed into the interior of the body. In many respects the animalcule here described presents a considerable resemblance to the *Cercomonas crassicauda* of Dujardin, as reproduced from Stein's work at Pl. XIV. Figs. 15 and 16. That type, however, in common with all the representatives of the genus *Cercomonas* as here accepted, is a free-swimming or natatory, and not a repent form.

GENUS III. RHIZOMONAS, S. K.

(Greek, *rhiza*, root; *monas.*)

Animalcules monadiform, adherent to submerged objects by root-like pseudopodic extensions of the posterior region; the anterior extremity bearing a single lash-like flagellum.

Rhizomonas verrucosa, S. K. PL. I. FIGS. 26 AND 27.

Body subspheroidal, its general surface bearing throughout even sized, conical pseudopodic elevations whose length nearly equals one-half the diameter of the body; similar but somewhat longer conical pseudopodia produced from the posterior extremity, and rooting the animalcule to the selected point of attachment; flagellum slender, its length equalling twice the diameter of the body; contractile vesicle single, subspherical; endoplast not observed. Diameter 1-1500".

HAB.—Hay infusions.

This remarkable form was obtained by the author from the hay infusion that yielded *Reptomonas caudata.* In its normal and fixed condition the vibrations of the flagellum are so rapid and powerful as to maintain the entire body in a state of active tremor—after the manner of the wings of many moths when hovering—thus rendering it exceedingly difficult to recognize its true form and proportions. This energetic motion becomes, however, even yet more pronounced when, either voluntarily or through a disturbance of the infusion, the animalcule is set free in the surrounding water. Under these circumstances it tumbles over and over or to and fro in apparently the most aimless and excited manner, allowing but an occasional and momentary distinct glimpse of either its body or flagellum. In very many instances it was observed that the attached animalcules, either singly or in associated groups of three or four, were immersed within a granular mucilaginous sheath apparently exuded from their own bodies, and out of which the long, powerful flagella alone projected. Such a solitary ensheathed zooid is delineated at Pl. I. Fig. 26.

GENUS IV. PODOSTOMA, Claparède & Lachmann.

Animalcules amœba-like, changeable in form, emitting pseudopodic prolongations, the free extremities of which are capable of further extension into long, thread-like, and actively motile flagella.

The single species upon which this genus is founded represents the most perfect known gradational form between the two classes of the Rhizopoda and Infusoria-Flagellata. Unlike *Mastigamœba*, to which the second place in this category may be allotted, the lash-like organ or flagellum is constant neither in its presence or position, but shares with the pseudopodia the capacity of being emitted from or withdrawn into the substance of the body at any point of the periphery; two or more of these organs may, moreover, be simultaneously extended from a single animalcule, while in *Mastigamœba* the flagellum is single and persistent as regards both its position and existence.

Podostoma filigerum, C. & L. Pl. I. Figs. 28 and 29.

Body repent or freely floating, highly polymorphic, almost spherical when contracted, substellate with attenuate pseudopodic prolongations when extended; the distal terminations of the pseudopodia produced as long, thread-like, vibratile flagella, which are capable of contracting in a spiral manner, or of being entirely withdrawn into the substance of the pseudopodium; contractile vesicle single, endoplast distinct, subspheroidal. Length of extended body 1–500″.

Hab.—Fresh water, among aquatic plants.

Overlooking the presence of the flagellate appendages, this animalcule, as remarked by Claparède and Lachmann, closely resembles in its stellate condition the *Amœba radiosa* of Ehrenberg, while at other times, in its contracted state, it might be as easily mistaken for *A. diffluens*. Any food-particle arrested by one of the flagellate appendages is immediately withdrawn with the latter into the substance of the pseudopodium that carries it, a slight depression momentarily marking the point of entrance. Bütschli,* while recently proposing to identify Ehrenberg's *Amœba radiosa* with this type, has sought to demonstrate that the radiating pseudopodia of the former are capable of similar attenuate prolongation in the form of flagella. An intimate acquaintanceship with the *Amœba* named inclines the author, however, to regard the two as distinct, and that Bütschli must have had Claparède and Lachmann's type, and not Ehrenberg's, under examination. In the latter species, however finely attenuate may be the extensions of the pseudopodia, they never assume the form and functions of vibratile and spirally contractile flagella. This decision is entirely confirmed by an examination of the exhaustive figures and accompanying description of *Amœba radiosa* embodied in Professor Leidy's monograph of the North American Rhizopoda, previously quoted.

Order III. RADIO-FLAGELLATA, S. K.

Animalcules emitting numerous ray-like pseudopodia, after the manner of the Radiolaria, and provided at the same time with one or more flagellate appendages; no distinct oral aperture. Mostly marine.

The several genera referred to this newly instituted Order of the Flagellata form two natural and well-differentiated groups. In the one—that of the Euchitonidæ—we find types which, except for the presence of the characteristic flagellum, are not to be distinguished from the ordinary representatives of that typical Radiolarian group known as the Polycystinæ; while in the second one—that of the Actinomonadidæ—are presented forms that most intimately unite the more typical flagellate monads with the Heliozoan group of the same Radiolarian class. Since it is now demonstrated of all the other leading groups of the Radiolaria so far investigated, that their initial conditions take the form of simply flagellate monadiform zoospores, it may be consistently predicated that in the two above-named family divisions is permanently retained that primitively developed locomotive organ which among the more ordinary Radiolaria becomes aborted at an early epoch of their existence.

The direct metamorphosis, observed by the author, of a flagelliferous zooid into an adult Radiolarian type of structure, as exemplified in the genus *Actinophrys*, will be found illustrated at Pl. I. Figs. 9–11. As first observed, see Fig. 9, the monadiform germ closely corresponded in appearance with the *Peranema globulosa*

* "Beiträge zur Kenntniss der Flagellaten," 'Zeit. Wiss. Zool.,' Bd. xxx., 1878.

of Dujardin. In the midst of its natatory course it was observed to project blunt digitiform processes from all sides of the periphery, as shown at Fig. 10. Its motions now became more sluggish, the flagellum was completely withdrawn, and then suddenly, as though by magic—the bursting of a rocket or other firework affording perhaps the most suitable comparison—fine ray-like pseudopodia were shot out in every direction, and the animalcule was at once metamorphosed into a typical *Actinophrys.* According to Cienkowski, the monadiform germs or so-called "zoospores" of the Radiolarian type *Collosphæra spinosa*, Hkl., are furnished with two subequal flagellate appendages. An account of Cienkowski's investigations in this connection, translated from the German, is published in the 'Quarterly Journal of Microscopical Science,' vol. xi., No. xliv., 1871.

FAMILIES AND GENERA OF RADIO-FLAGELLATA.

Fam. I. *Actinomonadidæ.* Animalcules naked, no exoskeleton or central capsule.	Animalcules free-swimming or attached posteriorly by a thread-like pedicle		1. *Actinomonas.*
Fam. II. *Euchitonidæ.* Animalcules with a siliceous test or lorica, and an indurated central capsule.	Test external to capsule with cyclic chambers ..		2. *Euchitonia.*
	Test external to capsule simply trabecular.	External trabecular lattice-work more or less evenly ovate ..	3. *Spongocyclia.*
		External trabecular lattice-work forming arm-like processes ..	4. *Spongasteriscus.*

Fam. I. ACTINOMONADIDÆ, S. K.

Animalcules ovate or spheroidal, fixed or freely motile, entirely naked, possessing neither an indurated test nor a central capsule; fine ray-like pseudopodia projecting from all parts of the periphery, supplemented at one point by a long vibratile flagellum.

Genus I. ACTINOMONAS, S. K.

(Greek, *actis*, ray; *monas.*)

Animalcules ovate or spherical, uniflagellate, free-swimming, or attached posteriorly by a temporarily developed thread-like pedicle; endoplasm soft and plastic, emitting ray-like pseudopodia from all points of the periphery; food-particles attracted by the vibrations of the flagellum, and then seized by the pseudopodia and introduced into the substance of the body at any part of its circumference; endoplast and contractile vesicles usually conspicuous.

The two species upon which the new genus *Actinomonas* is here founded represent some of the most remarkable and interesting types of the class Flagellata. Divested of their radiating pseudopodia, there is nothing to distinguish them from the typical members of the genus *Oikomonas*, while by the retention of the pseudopodia and removal only of the terminal flagellum, a form is produced scarcely distinguishable from the stalked Radiolarian recently described by F. E. Schulze under the title of *Actinolophus pedunculatus.* Through this generic type, in fact, the two Protozoic groups of the Radiolaria and the Infusoria-Flagellata would appear to be as effectually bridged as are the last-named group and the ordinary Rhizopoda by the several genera, *Mastigamœba*, *Rhizomonas*, *Reptomonas*, and *Podostoma.*

Actinomonas mirabilis, S. K. Pl. I. Fig. 18.

Body subspherical or ovate, seated on a slender pedicle, which usually equals two or three times the diameter of the body; endoplasm transparent, slightly granular; flagellum very long and slender, extended rigidly and arcuately in advance; pseudopodia equalling in length the diameter of the body, very numerous, radiating from all points of the periphery; contractile vesicles two in number, situated close to each other in the posterior region of the body; endoplast spherical, subcentral. Diameter 1–2000″.

Hab.—Salt water.

Several examples of this interesting type were met with at St. Heliers, Jersey, in May of the year 1878, in a jar of sea-water preserved for some weeks, containing various protozoa and hydroid zoophytes collected on the adjacent coast. At first sight the aspect presented by these animalcules so closely resembled that of the ordinary members of the genus *Spumella* or *Oikomonas*, with, perhaps, some little extra haziness around the peripheral margin, that they were nearly passed over as such, and it was not until the aid of a more powerful object-glass was brought to bear upon them that their true nature became apparent. It was then demonstrated that the hitherto hazy environment of the periphery of the body consisted of fine, closely-set, slender pseudopodia radiating in every direction, agreeing in form and structure with those of *Actinophrys*, *Actinolophus*, or any other typical Radiolaria, and subservient to a closely similar function. Through its possession of a long terminal flagellum, however, *Actinomonas* possesses considerable advantages over such a type as *Actinolophus*. While the last-named form has to wait patiently for the advent of food-particles within grasping reach of its tenacious pseudopodia, *Actinomonas*, by the vibrations of its flagellate appendage, draws towards it all such substances floating in the vicinity, and throws them back among the pseudopodic processes, by which they are immediately seized and dragged into the substance of its body. The capture and ingestion of food-matter in this manner, at all parts of the circumference, were witnessed on several occasions. Physiologically, the extended peripheral pseudopodia of *Actinomonas* are closely analogous to the extensile sarcode collar of the Choano-Flagellate order hereafter described, a similar trap-like function, in combination with the flagellum, being common also to that diversely modified pseudopodic structure. The developmental and reproductive phenomena of this remarkable type have yet to be determined.

Actinomonas pusilla, S. K. Pl. I. Figs. 7 and 8.

Body subspheroidal; pedicle equal to, or very slightly exceeding in length, the diameter of the body; flagellum slender, extended rigidly and arcuately from the apical extremity; pseudopodia equalling in length the diameter of the body, projected from all parts of the periphery, much less numerous than in the preceding species. Diameter of body 1–3250″.

Hab.—Salt water.

This species may be distinguished from the preceding by its more minute size, the shorter comparative length of the pedicle, and the considerably less numerical development of the radiating pseudopodia. It was obtained in some abundance in sea-water containing *Zoothamnium dichotomum* attached to *Fuci*, remitted to the author by Mr. Thomas Bolton from the Birmingham Aquarium in February of the present year (1880). It was observed that the specimens often attached themselves to the neighbouring vegetable debris by several radiating pseudopodia simultaneously, as shown at Fig. 8, as well as by the temporarily modified posterior one that usually fulfilled the office of a pedicle. Disengaging themselves from their single or several points of attachment, the animalcules were frequently seen to swim freely in the water with great rapidity after the manner of *Oikomonas* or *Spumella*.

Fam. II. EUCHITONIDÆ, S. K.

Animalcules free-floating, secreting a variously constructed cancellate siliceous test or lorica, which is distinguished by the invariable presence of a central differentiated capsule; ray-like pseudopodia extending from all parts of the periphery, supplemented anteriorly by a comparatively large and well-developed flagellate appendage. Entirely pelagic.

As the members of this family possess characters that unite them more intimately with the typical Radiolaria than with the ordinary Flagellata, a description of each specific form is not included in this treatise, but a brief diagnosis only of a characteristic representative of each generic group.*

GENUS I. EUCHITONIA, Haeckel.

Test siliceous, consisting of a flattened, biconvex, cyclically chambered, central capsule, with radially developed projecting arms, which are disposed in the same plane and chambered cyclically in correspondence with the central disc; the interspaces between the radiating arms filled in by a loose, unsymmetrical, siliceous network.

Euchitonia Virchowii, Hkl. PL. I. FIG. 24.

Central capsule discoidal, with from two to three concentric chamber-cycles; radiating prominences three in number, their length slightly exceeding the diameter of the central disc, the two anterior slightly narrower than the single isolated median posterior one, and basally united; cyclical chambers, of which the radiating arms are composed, varying from four to six in number; flagellum massive, equalling or exceeding the length of the test, projecting from the angle between the two anterior arms. Diameter of the central capsule 1–375″.

HAB.—Pelagic: Messina.

In addition to the foregoing type, as many as six other specific forms are referred by Haeckel to the genus *Euchitonia*, in his magnificent monograph 'Die Radiolarien,' Berlin, 1862, under the respective titles of *E. Bœkmanni*, *E. Gegenbauri*, *E. Krohnii*, *E. Muelleri*, *E. Leydigii*, and *E. Kœllikeri*.

GENUS II. SPONGOCYCLIA, Haeckel.

Test siliceous, consisting of a central capsule composed of concentric and symmetrical chamber-cycles, surrounded by an irregular, sponge-like lattice-work of siliceous trabeculæ, this sponge-like lattice-work not developed peripherally into distinct arm-like processes.

* Professor St. George Mivart recognizing the important distinction furnished by the presence of flagella in the three genera included in this family division, has proposed ('Linnean Society's Journal,' vol. xiv., No. 74, 1878) to separate them from the ordinary Radiolaria as a distinct section of the "Flagellifera."

Spongocyclia charybdæa, Hkl. PL. I. FIG. 25.

General contour of test escutcheon-shaped, flattened and angular anteriorly, slightly widest centrally, tapering and obtusely pointed at the posterior extremity; central capsule composed of from seven to fourteen concentric chamber-cycles, its diameter equalling one-half of the entire test; flagellum stout, exceeding the length of the test, projecting from the centre of the anterior border. Length 1–72".

HAB.—Pelagic: Messina.

Additional species, figured and described by Haeckel, are distinguished by the respective titles of *Spongocyclia cycloides*, *S. elliptica*, *S. orthogona*, and *S. scyllæa.*

GENUS III. SPONGASTERISCUS, Haeckel.

Test siliceous, consisting of a central discoidal capsule composed of concentric and symmetrical chamber-cycles, surrounded by an irregular trabeculate siliceous lattice-work, as in *Spongocyclia*, but which, in place of being simply subcircular or escutcheon-shaped, is developed into distinct angular arm-like processes, which lie in the same plane as the flattened central disc.

Spongasteriscus quadricornis, Hkl.

Central capsule circular, flattened, composed of from eight to sixteen concentric chamber-cycles, radiating arm-like processes four in number, subequal, triangular, forming two basally united pairs at the anterior and posterior regions, their length equal to one-third of the diameter of the central disc; flagellum projecting from the notch between the anterior pair of angular processes. Diameter of central disc 1–96".

HAB.—Pelagic: Messina.

One additional species is described by Haeckel under the title of *Spongasteriscus tetraceras.*

Order IV. FLAGELLATA-PANTOSTOMATA, S. K.

Animalcules simply flagelliferous, having in their characteristic adult state no supplementary lobate or ray-like pseudopodic appendages; oral or ingestive area entirely undefined, food-substances being incepted indifferently at all points of the periphery.

Among the typical Infusoria-Flagellata, this order may be said to represent the lowest and least specialized, it being directly allied through the small group of the Rhizo-Flagellata, previously described, with the Amœban order of the Rhizopoda. Many of the generic and specific forms at present referred to this section must be regarded as occupying therein a purely provisional position, it not being improbable that the animalcules, upon further acquaintance, may be found to possess a distinct oral aperture, and thus demand transfer to the succeeding order of the Flagellata-Eustomata. While again, in a very considerable number of instances, the ingestion of food-substances at all points of the periphery has been directly observed, it would seem highly probable that where neither this phenomenon nor the presence of an

Families and Genera of FLAGELLATA-PANTOSTOMATA.

A. PANTOSTOMATA-MONOMASTIGA. Flagellum single.

Family.		Genus.
I. Monadidæ. Animalcules naked, usually free-swimming; flagellum terminal, no pedicle or caudal appendage.	Entirely free-swimming. — Globose or ovate. — Anterior border rounded. — Polymorphic	1. *Monas.*
	Entirely free-swimming. — Globose or ovate. — Anterior border rounded. — Persistent in shape ..	2. *Scytomonas.*
	Entirely free-swimming. — Globose or ovate. — Anterior border truncate or excavate ..	3. *Cyathomonas.*
	Entirely free-swimming. — Fusiform or acicular, persistent in shape	4. *Leptomonas.*
	Entirely free-swimming. — Vermicular — Spirally twisted, form persistent	5. *Ophidomonas.*
	Entirely free-swimming. — Vermicular — Polymorphic and highly flexible	6. *Herpetomonas.*
	Adherent at will by the single trailing flagellum	7. *Ancyromonas.*
II. Pleuromonadidæ. Animalcules naked, tailless; flagellum lateral or ventral.	No trichocysts	8. *Pleuromonas.*
	With trichocysts	9. *Merotricha.*
III. Cercomonadidæ. Animalcules naked, with a tail-like caudal filament.	Attached or free-swimming, caudal filament retractile	10. *Oikomonas.*
	Attached or free-swimming, caudal filament non-retractile	11. *Bodo.*
	Entirely free-swimming, never attached	12. *Cercomonas.*
IV. Codonœcidæ. Animalcules loricate.	Loricate, erect, stalked or sessile	13. *Codonœca.*
	Lorica decumbent	14. *Platytheca.*
V. Dendromonadidæ. Animalcules illoricate, with an oblique frontal border; mostly social and constructing tree-like zoodendria; flagella unequal, one long and one short.	Solitary, attached by a thread-like pedicle	15. *Physomonas.*
	Associated on a simple or branching pedicle or zoodendrium. — Animalcules attached simply to termination of zoodendrium. — Zoodendrium flexible, thread-like	16. *Cladonema.*
	Associated on a simple or branching pedicle or zoodendrium. — Animalcules attached simply to termination of zoodendrium. — Zoodendrium rigid and erect	17. *Dendromonas.*
	Associated on a simple or branching pedicle or zoodendrium. — Animalcules attached in clusters to termination of zoodendrium. — Zoodendrium more or less flexible, opaque, and composite	18. *Anthophysa.*
	Associated on a simple or branching pedicle or zoodendrium. — Animalcules attached in clusters to termination of zoodendrium. — Zoodendrium rigid, hyaline and homogeneous	19. *Cephalothamnium.*
VI. Bikœcidæ. Animalcules inhabiting horny loricæ, front border oblique; flagella uneven, one long and one short.	Loricæ solitary .. .. .. — Sessile	20. *Hedræophysa.*
	Loricæ solitary .. .. .. — Stalked	21. *Bicosœca.*
	Loricæ united serially and forming a compound polythecium	22. *Stylobryon.*
VII. Amphimonadidæ. Animalcules naked, free-swimming, or attached singly and permanently by the posterior extremity, or by a tail-like filament; flagella even.	Free-swimming, anterior border oblique	23. *Goniomonas.*
	Sedentary .. .. — Attached by a thread-like pedicle	24. *Amphimonas.*
	Sedentary .. .. — No distinct pedicle	25. *Deltomonas.*

B. PANTOSTOMATA-DIMASTIGA. Flagella two in number.	VIII. SPONGOMONADIDÆ. Animalcules symmetrically ovate, mostly social and secreting variously modified protective coverings; flagella of even length.	Animalcules inhabiting a branching tubular zoothecium	Tubules of zoothecium separate ..		26. *Cladomonas.*
			Tubules of zoothecium more or less extensively united		27. *Rhipidodendron.*
		Animalcules inhabiting a common mucilaginous or granular zoocytium			28. *Spongomonas.*
		Animalcules inhabiting separate horny loricæ			29. *Diplomita.*
	IX. HETEROMITIDÆ. Animalcules naked, free-swimming, or temporarily attached by the posterior flagellum.	Flagella distinct throughout.	Ovate	No ventral groove	30. *Heteromita.*
				With a distinct ventral groove	31. *Colponema.*
			Body elongated, spirally twisted		32. *Spiromonas.*
		Flagella basally united			33. *Phyllomitus.*
	X. TREPOMONADIDÆ. Animalcules free-swimming, entirely unsymmetrical.	Insertion of flagella widely separated			34. *Trepomonas.*
	XI. POLYTOMIDÆ. Animalcules ovate, free-swimming, with an indurated external envelope, multiplying by endogenous subdivision.	Adherent at will by a basal flexure of the flagellum			35. *Polytoma.*
	XII. PSEUDOSPORIDÆ. Animalcules repent and natatory, flagella even.	Animalcules polymorphic, endoparasitic			36. *Pseudospora.*
C. PANTOSTOMATA-POLYMASTIGA. Flagella three or more in number.	XIII. SPUMELLIDÆ. Flagella three in number, diverse, one long and two short.	Animalcules attached by a temporarily developed pedicle			37. *Spumella.*
	XIV. TRIMASTIGIDÆ. Flagella three in number, subequal.	All three flagella vibratile			38. *Callodictyon.*
		Two flagella vibratile, one trailing			39. *Trichomonas.*
		One flagellum vibratile, two trailing ..	Free-swimming or adherent		40. *Dallingeria.*
			Entirely free-swimming		41. *Trimastix.*
	XV. TETRAMITIDÆ. Flagella four or five in number.	Four flagella	Animalcules naked, polymorphic		42. *Tetramitus.*
			Animalcules loricate		43. *Tetraselmis.*
		Five flagella, one vibratile, four reflected			44. *Chloraster.*
	XVI. HEXAMITIDÆ. Flagella six in number.	Four anterior flagella vibratile, two posterior ones adherent			45. *Hexamita.*
	XVII. LOPHOMONADIDÆ. Flagella numerous, animalcules solitary.	Animalcules solitary, endoparasitic			46. *Lophomonas.*
	XVIII. CATALLACTIDÆ. Flagella numerous, animalcules forming social colony-stocks.	Animalcules united in spheroidal clusters, pelagic			47. *Magosphæra.*

oral aperture has been detected, e. g. *Herpetomonas*, *Polytoma*, *Hexamita*, and *Trichomonas*. that the animalcules derive their nutriment, as in the case of the Opalinidæ, by the direct absorption, at all points, of the proteaceous material held in solution in the fluid media they inhabit. Whether this latter be the hæmal or perivisceral fluid of a higher animal, an animal maceration, or a vegetable infusion, protein in its concentrated and more or less diffused condition is invariably present, and its direct absorption under such circumstances by the contained unicellular animalcules would be strictly analogous to the alimentary process as performed by the individual cell-units of the intestinal tract of all the more highly organized Metazoa. These beings, in fact, live continually immersed within a, so to say, ready prepared bath of nutritive broth, and require no display of energy beyond the passive one of assimilation or endosmosis for the satisfying of their creature wants. So far, a group of Flagellata presenting the physiological characteristics here submitted, has been entirely overlooked, its representatives being simply collated with the ordinary mouthed or mouthless species. Even Stein, in his recently published monograph,* erroneously represents such unmistakable Pantostomatous forms as *Oikomonas*, *Spumella*, and *Anthophysa* as possessing a well-defined oral aperture.

The *Flagellata-Pantostomata*, in common with the order of the Eustomata, may be conveniently divided into three minor sections or sub-orders, with reference to the number of flagellate appendages, as indicated in the foregoing schedule.

A.—Pantostomata-Monomastiga

(one flagellum only).

Fam. I. MONADIDÆ, Ehrenberg.

Animalcules naked or illoricate, entirely free-swimming; flagellum single, terminal; no distinct oral aperture; an endoplast or nucleus and one or more contractile vesicles usually present.

Genus I. MONAS, Müller.

Animalcules free-swimming, exceedingly minute, globose, ovate, or elongate, plastic and unstable in form, possessing no distinct cuticular investment; flagellum single, terminal; food-substances incepted at all parts of the periphery, not provided with a distinct mouth; a nucleus or endoplast and one or more contractile vesicles mostly conspicuous; multiplying by longitudinal or transverse fission, or by encystment and the subdivision of the entire substance of the body into a less or greater number of sporular elements.

Inhabiting salt and fresh water, especially abundant in infusions.

In the genus *Monas*, as here delimited, are included the simplest known forms of the typical Infusoria-Flagellata. Its specific representatives exhibit, so far as at present discernible, no higher degree of organization than that of mere specks of more or less granulate and vacuolar nucleated protoplasm, and possess as a locomotive appendage a single thread-like vibratile flagellum. Their extreme simplicity of contour, combined with their very minute size and apparent absence of all readily appreciable differential characteristics, necessarily renders it an exceedingly difficult task to discriminate between the innumerable so-called species that have from time to time been referred to this genus. A large proportion of these latter are without doubt

* 'Infusionsthiere,' Abth. iii., 1878: Der Flagellaten.

simply varieties of the same type, transitional or larval conditions of other Flagellate Infusoria or Radiolaria, which commence their existence as similar simple uniflagellate beings, or it may be the initial or zoospore phases of Algæ, Palmellaceæ, or other Protophytic plants. Such being granted, it is only in a provisional sense, and until their correct status shall have been decided by the light of more modern investigation, that the majority of the specific forms collated under the present generic title are admitted to this volume. Of those four or five types alone that are placed first on the list can it be said that sufficient is known to permit of their recognition as distinct and independent beings, and it is upon these few only that the amended diagnosis of the genus, as here given, is constructed. While thus obliged to leave a considerable number of species in an undecided and probational position, the main object aimed at by the author will, it is hoped, be accomplished, and the genus *Monas* be established upon a secure and substantial footing.

By the earlier writers, every animalcule whose dimensions were so minute that it presented under the highest magnifying powers then available the aspect of a mere motile speck, was consigned to this genus, while by even the most recent investigators an almost equally incongruous assemblage of microscopic beings is similarly dealt with. Thus Cienkowski, in his recent accounts of monadiform organisms, includes under this same generic title both uniflagellate and biflagellate animalcules; Stein, again, in his recently published volume of plates, without detailed descriptions, of the Infusoria-Flagellata, delineates as typical representatives of the genus *Monas* those triflagellate, voluntarily attached, or free-swimming forms out of which, upon ample grounds, Cienkowski formulated some years previously the genus *Spumella.* Typical members of the present genus, as here defined, are in the same work referred by Stein to the genus *Cercomonas;* a step in the right direction being at the same time accomplished by his elimination of the stomatode forms *Monas grandis*, *M. semen*, and *M. ochracea* of Ehrenberg, and creation for the same of the independent genera *Cœlomonas*, *Raphidomonas*, and *Chrysomonas.*

Particular and accurate attention should, above all things, be directed, in the future investigation of these minute beings, to the manner in which food-matter is ingested, it being only those entirely free-swimming, uniflagellate forms which are capable of incepting such pabulum at all parts of their periphery, after the manner of an *Amœba*, or which, as is probably the case of *Monas Dallingeri*, absorb nutriment in a fluid form through the same generally diffused area, that can rightly lay claim to the present generic title.

Monas Dallingeri, S. K. Pl. XIII. Figs. 1–9.

Body ovate, rounded posteriorly, the anterior extremity more pointed and slightly curved, surface smooth; flagellum from one to one and a half times the length of the body, flexible throughout when young, rigid towards the base in older specimens; no endoplast or contractile vesicle as yet detected. Locomotion straight and uniform, without jerking or irregularity. Length 1–4500″ to 1–4000″.

HAB.—Fish macerations.

The author has much pleasure in connecting with this species the name of the authority who, in conjunction with Dr. J. Drysdale, has contributed so largely to our knowledge of the minute organisms now under consideration. In their published 'Researches into the Life-history of the Monads,' already quoted at pages 29 and 133, this particular form is figured and described * under the title of the simple "uniflagellate" or "multiple-fission" monad, and was obtained in great abundance in a maceration of cod's head three months old. Its life-cycle, as worked out by these indefatigable investigators, yields to none in the interest and completeness of

* 'Monthly Microscopical Journal,' vol. xi., No. lxii., 1874.

the phenomena elicited, and represents, indeed, the only member of the genus *Monas par excellence*, as here recognized, with whose entire developmental manifestations we are at present conversant.

The reproductive phenomena of this particular species, as reported by Messrs. Dallinger and Drysdale, may be briefly epitomized as follows. The extraordinarily rapid multiplication of this type being unaccounted for by the ordinary process of transverse fission, or by the production of minute spores requiring time to develop to maturity, a further investigation elicited that under certain conditions there intervened a supplementary process of fission, by which as many as from thirty to sixty individuals of appreciable size were produced from a previously single zooid. The indications given by an individual about to increase by this multiple mode of fission were its adoption, first, of a somewhat rounded outline, then of a more irregular and slightly amœboid form, and finally of a simple spheroidal contour. In this last condition only, the flagellum disappeared, and the animalcule entered upon a perfectly quiescent or encysted state. Patiently watched with an amplification of about 3000 diameters, a cruciform mark or constriction was observed to appear suddenly, dividing the sphere into four equal portions (Pl. XIII. Fig. 3), other divisional lines quickly following, until the entire body was partitioned by deep curved indentures with innumerable segments. An active whirling motion of the sarcode then ensued, lasting from ten to as many as seventy minutes, and at the end of this period it broke up into numerous sausage-shaped bodies as shown at Fig. 5. These now exhibited a quick writhing motion upon each other, which lasted for a space of seven to thirty minutes, the whole mass finally falling to pieces or detaching itself separately as uniflagellate monads, identical in shape, though of smaller size, with the original or parent animalcules. No separate investing membrane or indurated cyst was at any time associated with this process of multiplication, the separate segments being held together until the time of their final liberation by mere cohesion of their constituent sarcode. Reproduction by spores, produced by the genetic union or coalescence and encystment of two individuals, was likewise ascertained by Messrs. Dallinger and Drysdale to play an important part in the developmental life-cycle of this form. The zooids upon whom this special and more important mode of propagation devolves are of slightly larger size and more rounded outline than the ordinary forms; the anterior extremity, or that nearest to the flagellum, is also conspicuously and coarsely granulate.* Moving among the smaller animalcules, they fix themselves to one of these as shown at Fig. 7, and the two swim about joined to one another for a considerable interval. The smaller monad is at length completely absorbed into the substance of the larger one, whose movements now become sluggish, and terminate in its assumption of a slightly flattened subspherical and encysted state (Fig. 8). The encystments, after remaining quiescent for about thirty-six hours, open slowly, liberating, as shown at Fig. 9, what appears to be merely a glairy fluid, differing slightly in density only from the surrounding water. Examined with the highest available amplifying glasses—that is, a $\frac{1}{50}$-inch objective, with a magnifying power of from 2500 to 15,000 diameters, no granular composition indicating the presence of spores could be detected in the discharged fluid, but in about seven hours after its emission minute points, hitherto too small for detection, made their appearance, and rapidly increased in size. Movements in these granular points were detected in the course of the next five hours, and soon after this they swam off, corresponding in all respects, except for their slightly smaller size, with the typical monads from whence they originally sprang.

Monas fluida, Duj. Pl. XIII. Figs. 10–18.

Body soft and semifluid, exceedingly variable in shape; its most regular contour elongate-ovate or subcylindrical, with the length equal to about three times the diameter, but more frequently widest anteriorly,

* By accident the artist has omitted to reproduce the more coarsely granular aspect of the anterior region.

tapering towards the opposite extremity, and there prolonged in an attenuate tail-like manner, the sarcode of this tail-like prolongation often ragged in outline or irregularly branched; flagellum flexible throughout, equalling the body in length; contractile vesicle posteriorly located; endoplast conspicuous, spherical, subcentral. Length of elongate-ovate zooids 1-1500″.

HAB.—Vegetable infusions.

The species agreeing with the foregoing diagnosis, and, so far as it is possible to determine, identical with the *Monas fluida* of Dujardin, has been obtained abundantly by the author from hay infusions in fresh water. It usually makes its appearance on the fourth day of maceration, and is often for the next day or two the most abundant and dominant type, finally succumbing, however, in its turn to the onslaughts of its more powerful congeners *Dinomonas vorax* and *tuberculatus* hereafter described. The varieties of contour assumed by this remarkably plastic monad are too numerous for description; but a few of the more prominent of these are illustrated in the accompanying figures. In the most attenuate example the entire length of the body, including the tail-like prolongation, is equal to seven or eight times its greatest breadth. The characteristic plasticity of the sarcode of this type would seem in all instances to attain its highest development at the posterior extremity; on many occasions individuals were observed to adhere by this region to the glass object-carrier, and to become drawn out into an attenuate shape by the mere force of the capillary currents induced by the partial evaporation of the water. In this method of adhesion the species may be said to advance a step towards the development of a temporarily adhesive pedicle as obtains in the genus *Oikomonas.* Not unfrequently the anterior extremity is abruptly or obliquely truncate, the animalcule in the latter instance, when a subcylindrical contour is preserved, presenting an appearance, excepting for the absence of the secondary flagellum, closely corresponding with that of *Chilomonas.* The inception of particles of indigo at various points of the periphery was frequently observed, as also the coalescence of two animalcules, and the assumption by both these and by the solitary zooids of an encysted state. The *Monas succissa* of Perty, characterized by its ragged and not unfrequently bifurcate posterior border, is possibly identical with this species. On altogether insufficient grounds Diesing has proposed to elevate this last-named type, as described by Perty, into a new genus, conferring upon it the title of *Dicercomonas.*

Monas ramulosa, Stein, sp. PL. XIII. FIGS 22-24.

Body elongate, subcylindrical, widest posteriorly, tapering and conical at the anterior extremity, three or four times as long as broad, the entire peripheral surface frequently produced into a greater or less number of attenuate lobate or digitiform prolongations; flagellum as long or longer than the body; contractile vesicle spherical, posteriorly located, sometimes subdivided into three or four smaller vacuoles; endoplast subcentral or anteriorly situated; endoplasm granulate. Length 1-650″ to 1-325″.

HAB.—Fresh water.

This animalcule is figured, but not described, in Stein's recent work 'Infusionsthiere,' Abth. iii., 1878, under the name *Cercomonas ramulosa;* but as in no one of the examples delineated is an indication given of the caudal filament which so essentially characterizes the last-named genus as here amended, its transfer to the present one has been decided on. In some respects the general contour and remarkable modification of the cuticular surface approximate this type to the *Monas fluida* of Dujardin; but the prolongations of the surface of the periphery take a more definite digitate appearance. Should this species, in common with many other members of the group, pass through a repent phase of existence, its correspondence under such conditions with the members of the Rhizo-flagellate genus *Mastigamœba* of Max Schulze must be eminently conspicuous.

Monas obesa, Stein, sp. Pl. XIII. Figs. 20 and 21.

Body elongate, subcylindrical, widest and rounded posteriorly, attenuate and conically pointed anteriorly, about three times as long as broad, the periphery usually produced at variable points into one or more attenuately pointed, rectilinear, pseudopodal prolongations; flagellum equal to or exceeding the length of the body; endoplast located in the median line towards the anterior extremity; contractile vesicle spherical, posteriorly situated, sometimes divided into two secondary vesiculæ; endoplasm coarsely granular. Length 1-650". Hab.—Fresh water.

This species is figured by Stein,* under the title of *Cercomonas obesa;* but is evidently, as in the case of his *Cercomonas ramulosa*, correctly referable to the present generic group. In addition to the two examples figured by him as possessing respectively one and two posteriorly, but not terminally, developed pseudopodal prolongations, a third specimen, as reproduced at Fig. 20, is represented with an anterior conical prolongation only that projects close to the insertion of the flagellum. To some extent the body-contour of this type corresponds with that of *Sterromonas formicina*, represented at Pl. XXIV. Figs. 39 and 40.

Monas irregularis, Perty. Pl. XIII. Fig. 19.

Body more or less globular, hyaline; flagellum slender throughout, mostly curved at its distal extremity, over twice the length of the body; contractile vesicles two in number, minute, situated close to the lateral border; endoplast distinct, located centrally towards the anterior extremity. Length 1-2500" to 1-1250". Hab.—Pond water.

The animalcule figured, and briefly alluded to by Cienkowski under the above title,† is here provisionally accepted as the type of this species. The specific form upon which Perty originally conferred this name, while corresponding in general contour and proportions, is represented as not unfrequently exhibiting capillary or angular peripheral extensions. This phase possibly represents the typical amœboid condition assumed previous to the act of encystment and multiplication by segmentation. In one of Cienkowski's figures the retention of a large particle of food within a vacuole at the posterior extremity is clearly indicated.

Monas parasitica, Cienkowski, sp.

Body irregularly ovate, rounded anteriorly, smooth and transparent; flagellum very long and slender, more or less curved, three or four times longer than the body; contractile vesicles two or three in number, anteriorly situated; endoplast central, spherical. Length 1-1000".

Hab.—Fresh water.

Described by Cienkowski as *Pseudospora parasitica*. In its normal free-swimming and flagellate condition this species frequently exhibits posterior lobate extensions of the periphery; the amœboid phase preceding encystment is of short duration.

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* 'Infusionsthiere,' Abth. iii., 1878. † 'Archiv für Mik. Anat.,' Bd. i., 1865.

The body occupies but a small space within the membranous envelope of the cyst, and breaks up into numerous sporular fragments, the indigestible residue of the incepted food-particles being cast aside within the cavity of the cyst.

Monas nitellarum, Cienk., sp.

Body minute, globose; flagellum very slender and attenuate, six or seven times as long as the body; encystment spherical, double walled. Diameter 1–2500″. HAB.—Fresh water, among decaying matter.

Synonymous with the *Pseudospora nitellarum* of Cienkowski.

Monas concava, Duj.

Body circular, meniscoidal, concave on one side and convex on the other, thin centrally, the margin tumid; flagellum long and slender, vibrating throughout its length. Diameter 1–2000″. HAB.—Marsh water.

It is impossible to decide whether this and the three following species referred by Dujardin * to the genus *Monas*, belong to that generic group as here constituted, or whether they do not represent imperfectly observed or imperfectly developed animalcules of other Flagellata. Their admission here must consequently be regarded as entirely provisional.

Monas elongata, Duj.

Body elongate, nodular, flexible, and changeable in form, vacuolate; flagellum long and slender. Length 1–1250″.

HAB.—Putrid infusions with marsh water.

Monas attenuata, Duj.

Body ovoid, tapering at the two extremities, nodular and vacuolate; flagellum thick at its base, continuous with the pointed apical extremity. Length 1–1500″. HAB.—Putrid marsh water.

Dujardin intimates that a slightly more pronounced development of the posterior extremity would necessitate the allotment of this form to the genus *Cercomonas.*

Monas oblonga, Duj.

Body oblong, irregular, tuberculate, enclosing numerous vacuoles; flagellum distinct, somewhat thickened at the base. Length 1–3000″ to 1–1600″. HAB.—Vegetable infusions.

Monas varians, Duj.

Body oblong, tapering anteriorly, its substance soft and glutinous, exceedingly plastic and changeable in form. Length 1–800″ to 1–625″.

HAB.—Ditch water.

Monas constricta, Duj.

Body elongate, four or five times as long as broad, blunt, and rounded posteriorly, narrower and often constricted in the centre. Length 1–1250″.

HAB.—Infusions of gelatine with chlorate of potash.

* 'Histoire des Zoophytes Infusoires,' Paris, 1841.

This species is probably identical with the form described further on under the title of *Sterromonas formicina*, the second flagellum being of such small size as to have easily evaded the resolving capacities of the magnifying lenses at Dujardin's disposal. At the same time, another species—*Oikomonas mutabilis*—presents in its free-swimming condition a somewhat similar elongate and constricted contour.

Monas Oberhauserii, Fres.

Body cylindrical, rounded at each extremity, hyaline, faintly carmine-coloured, enclosing a variable number of intensely crimson globules; flagellum apparent only through the movements of the animalcule, which are rotatory and tumbling. Length 1-2000″ to 1-1150″.

HAB.—Sulphur spring at Frankfort.

This monad is probably identical with the *M. Okeni* of Ehrenberg. The *M. bipunctata* of Fresenius, found under similar conditions, but of smaller size, with an elongate-oval figure, and enclosing one or more red points at each extremity, apparently represents an earlier stage only of this form. The *Monas truncata* of Fresenius, possessing two flagellate appendages, has been selected by Stein as the type of the new genus *Goniomonas*.

Monas lamellula, Müller.

Body minute, compressed, diaphanous, two or three times as long as broad; flagellum long and undulating; movements forward in a zigzag manner. Length 1-2000.″ HAB.—Salt water.

Originally described by O. F. Müller as a marine form, but reported to De Fromentel, also from fresh water.

In accordance with the views of the author, both this and the ten succeeding specific types—embodied by De Fromentel in his 'Études sur les Microzoaires,' Paris, 1876, and identified by him on the most slender grounds with the species bearing the same titles first described by O. F. Müller, Ehrenberg, and Dujardin—might be advantageously consigned to the appended list of "Doubtful species" In no single instance are the characters given sufficiently explicit for their absolute identification as typical representatives of the genus *Monas*.

Monas Kolpoda, Ehr.

Body convex on one side, flattened on the other, the anterior extremity pointed and bearing a long flagellum; parenchyma enclosing green granules; movement oscillating. Length 1-1600″. HAB.—Fresh water.

The above diagnosis, as recently given by De Fromentel, scarcely agrees with the original one of Ehrenberg, who characterizes this species as oval or egg-shaped, having a length of 1-7200″ only.

Monas ovalis, Ehr.

Body ovate, colourless; motion tremulous. Length 1-9600″.

De Fromentel describes this species as differing from *M. deses* only in its absence of colour and the less development of the flagellum. Ehrenberg gives as its habitat the water from the fresh-water mussel, *Anodon*.

Monas gibbosa, Duj.

Body oblong or spheroidal, the surface having irregular distensions and gibbosities; flagellum long and undulating, usually springing from a narrowed anterior region of the body. Length 1–2500″.

This type was encountered by Dujardin in an infusion of gelatine, in company with *Monas lens*, and of which, as he remarks, it possibly represents an altered condition or variety. De Fromentel refers a form to this species agreeing with it in general contour, but having the cuticular surface striate and granular, and with a conspicuous lateral contractile vesicle.

Monas globulus, Duj.

Body subglobose, compressed and pointed anteriorly, constant in form; flagellum springing from the narrower anterior end; surface smooth or faintly granulate. Length 1–1700″. HAB.—Salt water.

Dujardin describes this form as differing from *Monas* (*Heteromita*) *lens* in the more spherical form of its body, and in the absence of the superficial tuberosities which frequently distinguish that species. De Fromentel reports the same type from fresh water.

Monas mica, Müller.

Body oval, inconstant in form, tapering anteriorly, transparent, coarsely granulate; movement slow and oscillating. Length 1–1200″.

HAB.—Fresh water.

This species is recognized under the above title by Müller, Ehrenberg, and De Fromentel.

Monas vinosa, Ehr.

Body globular; colour wine-red; motion tremulous. Length 1-12000″ to 6000″. HAB.—Vegetable infusions.

The *Monas rubra* of De Fromentel, of equally minute dimensions, and thus characterized: "Body rounded, furnished with a long and relatively thick flagellum; colour bright red; motion slow and tremulous," is apparently identical with the above form. Both are, however, probably rightly referable to the Palmellaceæ or Protophytes.

Monas nodosa, Duj.

Body irregularly oblong, tapering posteriorly; the frontal margin truncate; flagellum springing from the centre of this truncate border; surface nodular. Length 1–2000″. HAB.—Salt water.

De Fromentel ascribes to this species a fresh-water habitat.

Monas viridis, Duj.

Body spherical, one half transparent, the other green; flagellum long and slender; living socially. Diameter 1–2000″. HAB.—Fresh water.

This species is probably the motile spore of some Algal. Dujardin refers it with doubt to the genus, but De Fromentel has thought fit to retain it.

Monas depressa, From.

Body elongate, the two extremities rounded ; the ventral side flattened, the dorsal one convex ; flagellum always directed beneath. Length 1-1600″.

HAB.—Fresh water.

This is probably a species of *Petalomonas.*

Monas sphærica, From.

Body irregularly spherical; surface granulate, enclosing minute red corpuscles ; flagellum slender, about three times the length of the body ; contractile vesicle conspicuous, postero-lateral. Diameter 1–1000″.

HAB.—Fresh water.

This species is almost the only representative of the genus satisfactorily delineated by De Fromentel, its larger size permitting, with the magnification of 400 diameters customarily employed by him in his investigation of these minute organisms, a tolerably fair appreciation of its form and structure. No details are appended as to the special conditions or circumstances under which it was encountered, but it would seem not altogether improbable that it represents the motile form of the trimastigate type *Spumella vivipara.*

Monas ovata, From.

Body oval, widest posteriorly; transparent, with yellow granulations towards the posterior extremity; the anterior end pointed and hyaline; flagellum long, slender, and undulating. Length 1–2000″.

HAB.—Fresh water.

Doubtful Species.

The *Monas crepusculum* of Müller and Ehrenberg, represented by minute spherical points only, under a magnification of 800 diameters, and the *M. punctum* and *pulvisculus* of the same authorities, figured in De Fromentel's recent work,* cannot be admitted as independent species, being indistinguishable from the early germinating conditions of numerous other larger animalcules. The following species of the older writers, reproduced by Pritchard,† are in most instances too ill-defined for future identification, but may be added to complete the list :—

M. erubescens, Ehr., spherical, rose-coloured; motion slow and continuous; diameter 1–1728″. HAB.—Salt water.

M. enchelys, Ehr., colourless ; motion slow, continuous. In marsh water. 1–1200″ to 1–960″.

M. umbra, Ehr., ovate, colourless; motion rapid. Among fresh Confervæ. 1–2400″.

M. hyalina, ovate, colourless; active, seems to leap or jump. In stale water. 1–6000″ to 1–2880″.

M. gliscens, ovate, colourless; motion gliding. In infusions of stinging-nettle. 1–4500″.

M. cylindrica, solitary, elongate, colourless; motion revolving. In salt water. 1–1150″.

M. Okeni, elongate, red; motion revolving, vibratory; social. In running water. 1–2300″.

M. socialis, conical, colourless; social. In water-butts. 1–700″.

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* De Fromentel, 'Études sur les Microzoaires,' Paris, 1876.

† 'A History of the Infusoria,' by Andrew Pritchard, 4th ed. 1860.

M. simplex, spindle-shaped, colourless; motion gliding or rotatory. In water of the Nile and at Berlin. 1–1720″.

M. inanis, fusiform, colourless; motion vacillating. In stagnant and foul water. 1–3600″.

M scintillans, fusiform; very active, motion vacillating. Among fresh-water Confervæ. 1–6000″ to 1–4600″.

M. Dumalii (described by Dujardin as possessing two flagella, and therefore referable to the Dimastigous group), of a deep red colour; in vast numbers in the salt-marsh water of the Mediterranean, to which they give a deep blood-colour.

M prodigiosa, a minute red monad, producing the blood-like spots occasionally appearing in bread and other farinaceous substances. (Cohn asserts this organism to be a *Vibrio*, and not a *Monas*.)

M. astasioides, Pty., of variable form, often with one or two longitudinal lines and a central vacuole. 1–1340″.

M. piscatorum, irregularly oval, pointed anteriorly; colourless; flagellum short, scarcely 1½ times the length of the body; movements sluggish. 1–1400″.

M. succissa, oval; usually truncate, rarely pointed behind; colourless, with large vacuoles; flagellum twice the length of the body; movement active and revolving. In fresh pond water. 1–1800″.

M. cordata, cordate as seen on one side, oval and truncate on another, rounded anteriorly, hyaline or granulate; swims fast, with an oscillating motion, seldom revolving; flagellum difficult to discern, more than double the length of the body. In pond water. 1–1140″ to 1–1080″.

M. urceolaris, small, urceolate, obliquely emarginate in front; colourless; flagellum indicated only by movement produced in the water; motion slow. In running streams. 1–2640″.

The *Monas excavata* of Perty, having two filaments, is not referable to this present genus, and the *M. rotulus*, *farcimen*, and *hilla* of the same authority are most probably the zoospores of Palmellaceæ or higher Algæ.

GENUS II. SCYTOMONAS, Stein.

Animalcules free-swimming, ovate, persistent in form, having a simple terminal flagellum; no distinct oral aperture.

This genus, represented by a single minute species, figured but not yet described at length by Stein, differs from *Monas* only in its persistent shape and accompanying greater rigidity of the peripheral or ectoplasmic layer.

Scytomonas pusilla, Stein. PL. XIII. FIGS. 41 AND 42.

Body elongate-ovate or pyriform, narrowest anteriorly, about twice as long as broad; flagellum equalling or slightly exceeding the length of the body; contractile vesicle single, situated a little in advance of the centre of the body. Length 1–1600″.

HAB.—Fresh water. Dividing by longitudinal fission.

GENUS III. CYATHOMONAS, De Fromentel.

Animalcules free-swimming, ovate or cylindrical; abruptly truncate or excavate at the anterior margin; a single long flexible flagellum projecting from the centre of this truncate area; contractile vesicle usually conspicuous; increasing by longitudinal fission; no distinct oral aperture.

The genus *Cyathomonas* has been instituted by De Fromentel ('Microzoaires,' 1876) for the reception of certain flagellate types, differing from *Monas* only in the abruptly truncate or excavate contour of the frontal border. No details respecting the mode of inception of food are recorded, and, in the absence of all evidence as to the existence of a distinct mouth, it appears desirable to retain the genus among those forms most closely allied to it structurally, in which food-particles are known to be ingested at all points of the periphery. The several species described are very briefly characterized, the descriptions and accompanying drawings being the result of an examination with a magnifying power of 400 diameters only, which is altogether insufficient for the full and exhaustive investigation of these minute beings.

Cyathomonas turbinata, From.

Body elongate, turbinate, about twice as long as broad; the posterior extremity pointed, the anterior border truncate; flagellum somewhat short, not exceeding the length of the body; parenchyma transparent, granulate; dividing by longitudinal fission. Length 1-1200″. HAB.—Fresh water.

Cyathomonas spissa, From. PL. XIII. FIGS. 46 AND 47.

Body elongate-ovate, or subcylindrical, about twice as long as broad, pointed posteriorly, widest in the centre, and slightly narrowing again at the truncate anterior margin; flagellum short; contractile vesicle situated laterally in the anterior third of the body; parenchyma granular; dividing by longitudinal fission. Length of body 1-2000″. HAB.—Fresh water.

The difference between this form and *Cyathomonas turbinata*, From., appears to be too slight for specific separation. The figures given closely correspond with one another, the contractile vesicle indicated in the present variety affording, indeed, the only mark of distinction.

Cyathomonas viridis, From.

Body subcylindrical, about twice as long as broad, rounded posteriorly, the anterior border truncate; flagellum long and slender; parenchyma green, and granulate. Length 1-2000″. HAB.—Fresh water.

Cyathomonas alba, From.

Size and contour identical with that of *C. viridis*, but the parenchyma hyaline and less granular. This and the preceding form are evidently varieties only of one species.

Cyathomonas lychnus, From.

Body hemispherical, truncate anteriorly; posterior and peripheral portion coloured green, the anterior border hyaline; flagellum long and slender. Diameter 1-3000″. HAB.—Fresh water.

Cyathomonas turbo, From. PL. XIII. FIG. 48.

Body top-shaped, tapering and pointed posteriorly, the anterior border truncate; flagellum very long and undulating, three or four times the length of the body; parenchyma granulate; contractile vesicle antero-lateral. Length of body 1-1600″. HAB.—Fresh water.

Cyathomonas emarginata, From.

Body elongate, subcylindrical, slightly tapering posteriorly, the anterior border truncate, notched or emarginate on one side; flagellum long and slender, nearly twice the length of the body; parenchyma clear yellow, with red granules interspersed; contractile vesicle conspicuous, situated in the posterior third of the body. Length of body 1–1000″.

HAB.—Fresh water.

Cyathomonas elongata, From.

Body elongate, about two and a half times as long as broad, tapering posteriorly, slightly constricted immediately behind the truncate anterior border; flagellum long and slender; parenchyma clear yellow, enclosing a few red granules; contractile vesicle situated in the posterior third of the body. Length 1800″. HAB.—Fresh water.

The distinction between this and the preceding type is apparently insufficient for their specific separation.

GENUS IV. LEPTOMONAS, S. K.

(Greek, *leptos*, slender; *monas*.)

Animalcules free-swimming, persistent in shape, elongate fusiform or aciculate, bearing a single long undulating flagellum at the anterior extremity; no distinct oral aperture yet detected.

The above generic title combined with the following specific one is here introduced for the reception of the monoflagellate animalcule figured and briefly described, without any name, by O. Bütschli in the 'Zeitschrift für Wissenschaftliche Zoologie,' Bd. xxx. Hft. ii., for January 1878. While corresponding with the ordinary representatives of the genus *Monas* in its simple monoflagellate type of structure, it is to be distinguished from them by its persistent acicular form. From what little is at present known of it, it is almost impossible to decide whether this organism possesses a sound claim to the separate generic distinction here accorded it, or whether it is not the developmental phase of some other flagellate species. It was originally proposed to employ the generic title of *Rhaphimonas*—with reference to its acicular contour—for the distinction of this specific form. The contemporary adoption of the almost identical one of *Raphidomonas* by Stein, in connection with the *Monas semen* of Ehrenberg, has, however, made it desirable to substitute a new name for the present form. By accident, the previously selected title has been employed by the author in an article on parasitic Infusoria contributed to the 'Popular Science Review' for October 1880.

Leptomonas Bütschlii, S. K. PL. XIII. FIGS. 25 AND 26.

Body elongate fusiform, pointed at each extremity, but most attenuate posteriorly, eight or nine times as long as broad; flagellum nearly twice the length of the body; a contractile vesicle situated at a short distance from the anterior extremity, and a little behind this a dark, granular, nucleus-like body. Length 1–2250″.

HAB.—Parasitic, within the intestinal tract of the Nematozoon *Trilobus gracilis*.

This species was found by Bütschli in considerable quantities in the intestinal tract of the above-named host; some freely detached, and others united to one another in clusters by their posterior extremities. Their movements when liberated into the surrounding water, were swift and vigorous.

Genus V. OPHIDOMONAS, Ehr.

Animalcules free-swimming, very elongate, thread-like or vermicular, persistent in shape but more or less spirally curved; a single flagellum at the anterior extremity; parenchyma usually enclosing numerous refringent corpuscles.

The single species referred to this genus by Ehrenberg in his 'Infusionsthiere,' under the title of *Ophidomonas jenensis*, but without any accompanying illustration, was represented as a loricated animalcule. In a more recent publication, however,* he gives an illustration of both this and a second presumed form of the same genus, *O. sanguinea*, which by no means supports such an interpretation. The close correspondence in general contour of the members of this genus with those of *Vibrio* or *Spirillum* is at first sight very striking; the larger size and presence of a flagellum at the anterior extremity only of the thread-like body in the case of *C. jenensis*, afford, nevertheless, substantial marks of distinction. The motions of these organisms in the living state are furthermore entirely distinct from those of *Spirillum* and its allies, the body being drawn through the water after the manner of the ordinary Flagellata by the vibrations of the single anterior flagellum, while with the *Spirilla* the posterior flagellum represents the organs of locomotion, and propels the body in advance. The existence of an endoplastic or contractile vesicular system remains to be demonstrated, as also whether or not solid food-particles can be ingested.

Ophidomonas jenensis, Ehr. Pl. XIII. Figs. 27 and 28.

Body elongate, vermicular, obtusely rounded at each extremity, more or less spirally twisted; about one-twelfth as broad as long; flagellum undulating, nearly equalling one-half of the body in length; colour olive-brown, enclosing one or more rows of clear refringent corpuscles. Length 1-570″. Hab.—Spring water. Increasing by transverse fission.

Ophidomonas sanguinea, Ehr.

Body very long, slender, and flexible; about twenty-four times as long as broad; parenchyma usually transparent, and enclosing minute brilliant crimson corpuscles, sometimes suffused with a paler tint of the same colour. Length 1-570″. Hab.—Pond and brackish water.

Although reported by Ehrenberg as an inhabitant of brackish water, examples according in all essential points with the type of this species, as figured by that authority, have been obtained by the author in pond water. Such personal acquaintance with it has, however, given rise to the opinion that this organism is in no way related to the preceding form, but represents rather the filamentous condition of a *Spirillum* closely, if not absolutely, identical with the organism figured and described by Messrs. P. Geddes and J. Ewart in the 'Proceedings of the Royal Society,' p. 482, pl. xi. fig. 4, 1878. No flagellate appendages could be discovered with the comparatively low magnifying power then at disposal, and its movements

* 'Abhandl. Berlin Akad.,' 1862.

as observed were more repent than natatory, being chiefly confined to worm-like writhings among the vegetable debris in which it was discovered. All the specimens met with by the author possessed the perfectly transparent parenchyma with the enclosed brilliant crimson corpuscules distinctive of the species. The form figured and referred to this type by Cohn (reproduced by T. Jeffrey Bell, 'Quart. Jour. Mic. Sc.,' pl. xx., 1876) is altogether distinct, and an undoubted *Vibrio* with a long flagellum at each extremity. A far greater likeness exists, on the other hand, between Ehrenberg's original drawings of *Ophidomonas sanguinea* and the "linear filaments of *Bacterium rubescens*," figured by Professor E. Ray Lankester in a subsequent number of the same journal.

Genus VI. HERPETOMONAS, S. K.

(Greek, *herpeton*, snake; *monas*.)

Animalcules free-swimming, elongate or vermicular, highly flexible; the posterior extremity often the most attenuate, but not constituting a distinct caudal appendage; flagellum single, terminal; contractile vesicle usually conspicuous. Habits mostly endoparasitic.

This new genus is instituted for the reception of the form figured by Stein, 'Infusionsthiere,' Abth. iii., 1878, under the title of *Cercomonas muscæ-domesticæ*, and identified by that authority with the *Bodo muscæ-domesticæ* of Burnett and the *Cercomonas muscarum* of Leidy. The entire absence of a distinct caudal filament serves, however, at once to distinguish it from the typical representatives of either of the two last-named genera, and approximates it the more nearly to *Leptomonas* or *Ophidomonas*. A second minute form recently discovered by Mr. T. R. Lewis in the blood of rats is provisionally referred to this generic group.

Herpetomonas muscæ-domesticæ, Burnett sp. Pl. XIII. Figs. 29–34.

Body vermicular, highly flexible and polymorphic, usually thickest centrally and tapering to a sharp point at each extremity, from ten to twenty times as long as broad; flagellum equalling or slightly exceeding the body in length, thick at its base and becoming gradually more attenuate towards the distal end; parenchyma granular; contractile vesicle single, located near the anterior extremity; endoplast inconspicuous. Length 1–650″ to 1–430″.

Hab.—Intestine of common house-fly, *Musca domestica*.

The synonyms of this species have been recorded in the preceding diagnosis of the genus. According to the recent figures, with their descriptive indices given by Stein, a more marked flexibility of the body, permitting the animalcule to assume various snake-like and other contorted shapes, is especially characteristic of the younger and smaller zooids.

Herpetomonas Lewisi, S. K. Pl. XIII. Figs. 35–40.

Animalcules exceedingly minute, attenuate and vermicular under normal conditions, but highly polymorphic and capable of assuming a variety of contours; flagellum single, terminal, two or three times the length of the extended body; no contractile vesicle, endoplast, or other internal differentiation as yet detected. Length 1–1500″.

Hab.—The blood of Indian rats.

The circumstances under which the animalcules distinguished by the foregoing title were first discovered by Mr. T. Richards Lewis, are so graphically described by himself in the 'Quarterly Journal of Microscopical Science' for January 1879, that an abstract *in extenso* from that serial is herewith submitted. Having been directed by the Indian Government to prosecute inquiries respecting the *Spirillum* of Bombay fever, he remarks :—"Whilst doing this I had occasion to examine the blood of a considerable number of animals, and eventually (July 1877) detected organisms in the blood of a rat, which at first sight I took to be of the nature either of vibrions or spirilla. The blood, when transferred to the microscope, appeared to quiver with life, but for some considerable time nothing could be detected to account for this animated condition, as the blood-corpuscles were somewhat closely packed. On diluting the blood with a half per cent. solution of salt, motile filaments could be seen rushing through the serum and tossing the blood-corpuscles about in all directions. Their movements were of a more undulatory character than are the movements of spirilla, and the filaments were thicker, and more of a vibrionic aspect. They were pale, translucent beings, without any trace of visible structure or granularity; but as their movements were so rapid, exact information as to their microscopical characters could not be ascertained at the time. The slides were, therefore, placed under a bell-glass until these should diminish.

"On the following morning the activity of the filaments was much less. Their movements were more restricted and more undulatory in character, and the blood-corpuscles, having become somewhat agglutinated, had apparently squeezed out the organisms, so that the latter occupied the serum-areas of the preparations. After watching their movements for some time under a Hartnack's No. 9 immersion objective, it was observed that every now and then blood-corpuscles, some considerably distant from any visible motile filament, would suddenly quiver. On carefully arranging the light it was eventually observed that this movement was due to the existence of a very long and exceedingly fine flagellum, apparently a posterior flagellum, as the organisms seemed generally to move with the thicker end forwards, the flagellum being seen following it, and lashing the fluid during the moment it remained in focus. I have not been able to detect any flagellum at the opposite end. They may sometimes be kept alive for two or three days, but generally the greater portion will have died within twelve or twenty-four hours; and not only have died, but also disappeared from view.

"When very carefully watched, the plasma constituting the thicker portion of their substance may be seen suddenly to swell out at certain places, sometimes so as to divide the 'body' into two parts; at other times two or three such constrictions and dilatations may be detected, the dilatations being possibly observable only on one side. At other times they assume an arrow-shaped aspect; occasionally something like granularity may be observed before their disappearance, but not a trace of them is left after their disintegration. It seems as though they had been dissolved in the serum in which they were found. I have examined the blood of a great number of rats for the purpose of ascertaining what proportion of them contains these organisms in their blood, and find that of those specially examined for this purpose, their existence was demonstrated in 29 per cent. Sometimes, however, the number detected were very few, not more than one or two in a slide, but in the greater number of cases they were very numerous, every slide containing several hundreds."

Mr. Lewis further remarks that the nearest approach to a description of these hæmatozoa met with by him is contained in O. F. Bütschli's account of a flagellate parasite obtained from the intestinal canal of the free nematode *Trilobus gracilis.** He also gives quotations from Dr. Bastian's 'Beginnings of Life,' where, on the authority of Dr. Gros, minute worms or "vermicules" are recorded to have been observed in the blood of a field-mouse in such numbers as to cause the blood to present an animated aspect, as also that the blood of the mole has been found to exhibit a similar phenomenon. It is a remarkable circumstance that the rats

* This form has been previously figured and described under the title of *Leptomonas Bütschlii.*

affected with these minute parasites occupied a restricted portion only of the premises on which they were first discovered. One point especially worthy of remark, as recorded by Mr. Lewis, has reference to the position of the flagellum. If, as he is inclined to maintain, this organ is produced from the posterior extremity, and propels instead of draws the animalcule through the inhabited serum, we have presented a structural and functional feature without parallel among the other representatives of these *Protozoa flagellata*, the recognition of which would demand the creation of a distinct generic and family group for the reception of these singular organisms. The correspondence of these animalcules, this last-named interpretation of the flagellum being correct, with the spermatozoa or male genetic elements of ordinary Metazoic animals, is most remarkable, and not unnaturally affords a foundation for the suggestion that further investigation may possibly demonstrate their identity with the discharged spermatic elements of the minute Nematodes, Micro-filariæ, or other Metazoic endoparasitic forms known to flourish amid the same surroundings.

GENUS VII. ANCYROMONAS, S. K.

(Greek, *ancyra*, anchor; *monas.*)

Animalcules ovate or elongate, free-swimming or adherent at will; flagellum single, trailing, adhesive or anchorate at its distal extremity, vibratile throughout the remainder of its length; endoplast and contractile vesicle conspicuous.

The single type referred to this genus is of much interest, it combining in its single trailing filament the functions of both the trailing and vibratile flagella of such genera as *Heteromita* or *Anisonema.* It is further remarkable as corresponding in its mature form with the earlier or larval condition of the representatives of these two last-named generic types, in the former of which more especially (see *Heteromita rostrata* and *H. uncinata*) it has been demonstrated by Messrs. Dallinger and Drysdale that the trailing or anchorate flagellum is the first to make its appearance, and continues for a while the sole organ of locomotion.

Ancyromonas sigmoides, S. K. PL. XIII. FIGS. 49–53.

Body persistent in form, gibbously ovate or sigmoidal, about three times as long as broad, the anterior extremity pointed and recurved ventrally, the posterior one sometimes rounded, but more often shortly pointed and slightly recurved in an opposite direction; flagellum continuous with the recurved anterior extremity, reflected backwards or ventrally, about twice the length of the body, the distal extremity adhesive or anchorate, the remaining portion vibratile or undulating; endoplast spherical, subcentral; contractile vesicle situated close to the anterior extremity. Length 1–5000″ to 1–4000″.

HAB.—Salt water, among decaying *Fucus.* Increasing by oblique fission and by encystment and breaking up of the body into spores.

This species was obtained at St. Heliers, Jersey, in September 1878, in vast quantities, among a mucilaginous exudation from fronds of the seaweed *Fucus siliquosa* that had been macerated in sea-water for the space of one week. As first seen with a magnification of 800 diameters only, the author was inclined to anticipate that the long, reflected and adherent flagellum was only one of two flagellate appendages, and that another finer vibratile one was stationed at the anterior extremity which would thus identify the animalcule with the typical representatives of the genus

Heteromita. A more careful investigation, however, aided by the employment of a $\frac{1}{50}$-inch objective with a magnification of from 2500 to 5000 diameters, conclusively demonstrated that no other flagellate appendage existed, and that the single one present fulfilled in a remarkable manner the functions performed in *Heteromita* by two such organs. In the free-swimming animalcules, which were less numerous than the adherent ones, progression was effected in a straight line, accompanied by an oscillating motion, the single flagellum trailing in the rear like the posterior one of *Heteromita*, but slowly undulating throughout its length, and accomplishing by its vibrations the advancement made. In the temporarily adherent forms, fixed to the glass object-carrier or fragments of vegetable debris by the adhesive extremity of the same flagellum, a similar undulating action of the remaining length of this organ was apparent, this undulating action causing the entire organism to oscillate slowly up and down (see Pl. XIII. Fig. 50), and inducing at the same time a current to set in towards the animalcule's body. Viewed in profile, the motile flagellum seen just beneath the ventral surface of the body, presented at times an appearance closely corresponding with that of a minute undulating membrane; the body, however, in the next minute tilting away from the flagellum, exhibited its true nature. The phenomena attending the process of fission in this species were further observed to be somewhat abnormal. This takes place obliquely, the first indication of the impending process being a lengthening out of the body, accompanied by the greater prolongation of the more or less pointed posterior extremity until it attains a curvature, though in a reversed direction, corresponding with that of the anterior end, and develops at its apex a flagellum similar in all ways to the anterior one originally possessed. No trace of segmentation, however, has as yet made its appearance, and the animalcule remains riding at anchor or floats through the water, presenting (as shown at Pl. XIII. Fig. 51) a symmetrically sigmoidal contour closely identical with that of *Trepomonas agilis*, as seen from a lateral point of view (see Pl. XIX. Fig. 11), the two similar flagella divergent from each recurved point assisting to complete this likeness. Presently a faint oblique line makes its appearance, extending from above the median point of the dorsal surface of the original animalcule, downwards and backwards to behind the median point of the ventral region. This faint line gradually increases in the clearness of its delineation, and soon assumes the aspect of a distinct groove, which gradually deepens until the anterior and posterior halves become separated from one another as two precisely similar and undistinguishable units. Both bear the characteristic reflected flagellum, and likewise the central endoplast and antero-terminal contractile vesicle, these respective structures having also made their appearance previous to the commencement of the fissive process, the former by the segmentation of the original endoplast, and the latter by independent development. The encystment of zooids which previously exhibited an irregular amœboid phase, and the subdivision of these into eight or sixteen macrospores, giving rise to animalcules similar in shape to, but of much smaller size than the adults, have been observed, but not as yet the coalescence or genetic union of two or more units, and the breaking up of their united masses into more minute and abundant microspores.

Fam. II. PLEUROMONADIDÆ, S. K.

Animalcules naked or illoricate, entirely free-swimming, flagellum single, lateral or ventral; no distinct oral aperture.

Genus I. PLEUROMONAS, Perty.

Animalcules free-swimming, kidney-shaped, bearing a single vibratile flagellum which projects from the centre of the concave ventral side; no distinct oral aperture.

Monadiform beings, coinciding in form with the representatives of the genus *Pleuromonas*, as formulated by Max Perty, have been met by the author on several occasions. Seeing, however, that similar forms represent the earlier or larval conditions of other Flagellate organisms, such as *Salpingœca fusiformis* and *Anthophysa vegetans*, the present retention of this genus must be regarded as entirely provisional. It is, further, by no means improbable that the type *P. jaculans*, upon which the genus has been founded, is identical with the *Heteronema* (*Bodo*) *saltans* of Ehrenberg, and which, in addition to exhibiting similar leaping movements, appears under insufficient magnifying power to possess a single flagellum only.

Pleuromonas jaculans, Pty. PL. XIII. FIGS. 43 AND 44.

Body kidney-shaped, colourless, slightly granulate ; flagellum about three times the length of the body. Movements eccentric, jerking and leaping. Length 1-6000″ to 1-3160″. HAB.—Stale water and infusions.

The *Pleuromonas granulosa* of De Fromentel thus characterized :—Body ovoid, granular, rounded posteriorly, the anterior extremity attenuate, sharply recurved; flagellum proceeding from the apex of the anterior extremity, and often folded between the recurved portion and the body; parenchyma granulate; contractile vesicles two in number, posteriorly situated. Length 1–800″—cannot be generally associated with *P. jaculans*, and would seem to either represent the type of a new genus, or possibly an imperfectly observed *Heteromita*.

GENUS II. MEROTRICHA, Mereschkowski.

Animalcules free-swimming, persistent in form, more or less ovate; flagellum single, issuing from a pit-like depression of the ventral surface; parenchyma enclosing trichocyst-like corpuscles. HAB.—Fresh water.

Merotricha bacillata, Mereschk. PL. XIII. FIG. 45.

Body evenly ovate or elliptical, one and a half times as long as broad ; ventral depression with associated flagellum situated at a short distance from the anterior extremity; a sheaf-shaped fascicle of rod-like trichocysts occupying a median position at the anterior extremity; cuticular surface entirely smooth ; endoplasm coloured green; contractile vesicle situated immediately behind the fascicle of trichocysts. Dimensions unrecorded.
HAB.—Fresh water : Lake Onega, Mereschkowski.

This species, described by C. von Mereschkowski, in company with many newly discovered Protozoic types,* is of special interest, it representing one of the very few Flagellate animalcules in which the presence of trichocysts has been recorded.

Fam. III. CERCOMONADIDÆ, S. K.

Animalcules naked, free-swimming or adherent, provided with a permanent or temporarily developed caudal filament ; vibratile flagellum single, terminal ; no distinct oral aperture.

* "Studien über Protozoen des Nordlichen Russland," 'Archiv f. Mikrosk. Anatomie,' Bd. xvi., 1878.

GENUS I. OIKOMONAS, S. K.

(Greek, *eoika*, resembling; *monas.*)

Animalcules exceedingly minute, plastic and unstable in form, ovate, globular, or elongate, sometimes free-swimming and sometimes attached by a temporarily developed thread-like prolongation of the posterior extremity of the body; flagellum single, anteriorly located, subservient when swimming to the purpose of locomotion and in the attached condition to bringing food-particles within reach, these incepted at any portion of the periphery; contractile vesicle and endoplast usually conspicuous.

HAB.—Fresh and salt water, abundant in infusions.

This new generic title is introduced for the reception of all those uniflagellate species that correspond precisely in their free-swimming state with those of the preceding genus *Monas*, but which possess in addition the faculty of attaching themselves at will to foreign bodies through the medium of a thread-like extension of the sarcode of the posterior end of the body. Preferring again to pursue a nomadic life, this extemporized pedicle is withdrawn into the substance of the parenchyma, and the animalcules swim away under conditions and appearances identical with those presented during their previous wandering state. As a necessary consequence, an acquaintanceship of some duration is in most instances absolutely requisite for the precise determination as to which of the two genera, *Monas* or *Oikomonas*, certain animalcules should be referred. In their more typical fixed or stalked condition the identification of the representatives of the last-named genus presents no difficulty; but the same zooid, as hereafter shown, sometimes exhibits in its nomadic state an aspect so entirely divergent from the fixed one, that unless the passage from the one to the other has been actually witnessed, their specific relationship would not so much as be suspected. With the typical form *Oikomonas mutabilis*, here introduced, has naturally to be included the *Monas termo* of Professor H. James-Clark, recently demonstrated by that authority * to possess a stalked as well as a free-swimming condition. The possession of a single flagellum only instead of one long and one or two shorter ones, serves to distinguish *Oikomonas* respectively from the two genera *Physomonas* and *Spumella*.

Oikomonas mutabilis, S. K. PL. XIII. FIGS. 55–64.

Body plastic and variable in form—in the attached condition—symmetrically ovate, pyriform, or subspherical, seated on a slender pedicle about equal to the body in length—in the free-swimming condition—changing from spherical or ovate to an elongate contour, about three times as long as broad, with a rounded and wider posterior extremity, a slightly constricted central portion, and a bluntly pointed and somewhat truncate anterior border; flagellum long and slender, inserted at the apical extremity, when swimming held arcuately and apparently rigidly in advance; parenchyma colourless, more or less granular, enclosing anteriorly a spherical endoplast, and posteriorly two contractile vesicles. Dimensions of subspherical attached body 1–1500″; length of elongate free-swimming zooids 1–750″.

HAB.—Vegetable infusions in fresh water; gregarious; motion in the water straight and even.

* 'Memoirs Boston Soc. Nat. Hist.,' vol. i., part iii., 1868.

This species has been obtained abundantly in a maceration of hay in spring water, in which at times it absolutely swarmed. The relationship of the elongate free-swimming zooids to the sedentary ovate or subspheroidal ones, was not for a long while determined, the former being indeed chronicled in the author's note-book as elongate nomadic monads, most nearly resembling the *Monas constricta* of Dujardin, and representing probably an early and monoflagellate condition only of the species described later on under the name of *Sterromonas formicina*. The identity of the two was demonstrated while examining a group of stalked individuals that had become isolated within a small space in the glass slide, through the gradual evaporation of the water. As this space became still more limited by the encroachment of air the animalcules apparently took alarm. Detaching themselves, the pedicle contracted and disappeared within the posterior protoplasmic substance, the body became at once less broadly ovate, and assumed within a few seconds the elongate contour, with a slightly constricted central region identical with the free-swimming types before observed. In this elongate form the monads swam round and round the confines of the liquid space, now less than the diameter of the field of the $\frac{1}{16}$-inch objective, vainly seeking a pathway for escape, and were ultimately dried up. This identity of the locomotive and fixed forms being once discovered, the further verification of the fact proved a comparatively easy task, the transformation being observed not only of the fixed to the free-swimming type, but that also of the latter to the sedentary one. In this instance the animalcule became attached by an irregularly-shaped mucilaginous extension of the posterior extremity, which gradually assumed a slender and thread-like aspect accompanied by a shortening and thickening of the outline of the body. The rigid extension of the flagellum in both the attached and motile phases of this species imparts to it, in the latter instance, a stiffness of motion in the water, corresponding closely with that of *Sterromonas*, with which it was at first supposed to be identical. This apparent stiffness is shown by the application of reagents, or when the animalcules become exhausted through the want of oxygen, to be a mere optical aspect, the rotation of the distal end of the flagellum being then conspicuous, while the whole organ as death approaches loses its seeming rigidity, and becoming flexible, feebly undulates throughout its length. Reproduction by the longitudinal fission of detached ovate examples of this species, accompanied by a division of the conspicuous spherical endoplast, has been noticed, as also the encystment and the breaking up of the encysted zooids into spore-like bodies. Young individuals of elongate, conical outline, with a truncate anterior end and rigidly projecting flagellum, which exhibited a similar stiff comportment during natation, occurred abundantly among the adult animalcules. The smaller of these immature forms measured about one quarter only of the length of the full-grown specimens, every gradation in size from the one to the other being traceable. The ingestion of food during the sedentary condition at different points of the periphery was frequently observed.

Oikomonas termo, J.-Clk. sp. PL. XIII. FIGS. 78–80.

Body ovate or subspherical, somewhat compressed, rounded posteriorly, free-swimming, or attached by a thread-like pedicle of variable length ; the anterior margin notched or emarginate and exhibiting a projecting lip-like angle ; flagellum springing from the notch produced by the lip-like prominence extended rigidly in advance and slightly curved, about twice the length of the body ; parenchyma colourless, more or less granular ; contractile vesicle posteriorly located ; endoplast spherical, subcentral. Length of body 1–5000″ to 1–3000″. HAB.—Fresh water and vegetable infusions.

This species, regarded by Professor H. James-Clark (*l. c.* p. 306) as probably identical with the *Monas termo* of Müller and Ehrenberg, is referred by O. Bütschli to the genus *Spumella* of Cienkowski. The absence, however, of the two shorter flagella at once demonstrates the necessity of their generic separation.

It is in connection with this form that Professor James-Clark has sought to demonstrate the existence of a distinct mouth, which, in consequence of his having witnessed the entrance of food at this spot on many occasions, he maintained to be situated between the base of the flagellum and the lip-like prominence. O. Bütschli again has more recently advocated the recognition of the lip-like prominence as the recipient of the food-substances that are thrown backwards against the body by the vibratile action of the flagellum. On repeated occasions, however, the author has satisfied himself that the ingestive area has no such restricted limits, but that it is distributed throughout the entire peripheral surface, from any point of which, if a food-particle strikes it, a film of sarcode flows out to seize it. It is at the same time requisite to observe that in the majority of instances these particles are thrown back with such precision as to fall upon the lip-like prominence or other portion of the anterior border, a prolonged observation of the same animalcule being usually requisite for the detection of those more exceptional instances in which it impinges upon, and is engulphed by, the lateral or posterior region. The contractile vesicle and endoplast in this species, in accordance with Bütschli's observations, lay close by side of one another towards the anterior border of the body. Professor James-Clark, however, gives a more posterior location to the last-named structure, a similar position being distinctive of the examples observed and here figured by the author. When swimming, this species glides along smoothly in a straightforward direction, propelled by the whirling motion of the distal extremity of the flagellum, which otherwise presents that rigid arcuate aspect which characterizes the fixed condition; the body varies to no appreciable extent in this locomotive form from the more typical sedentary phase. The *Monas neglecta* of James-Clark, separated from *M.* (*Oikomonas*) *termo* by that authority on account of the more active pulsation and slightly more anterior location of the contractile vesicle, and by the greater length and more sigmoid flexure of the anterior flagellum, but agreeing in all other essential details with the present species, while referable to the genus *Oikomonas*, appears to possess almost too slender a claim for independent specific recognition.

Oikomonas obliquus, S. K. Pl. XIII. Fig. 72.

Body subspherical, rounded posteriorly, with a strongly developed conical anterior lip-like prominence; flagellum about three times the length of the body, projecting from the notch produced by the abrupt rising of the anterior lip, rigid and slightly arcuate, deflected at an angle of about 45° from the perpendicular axis of the body; pedicle slender, about equal to the body in length; parenchyma very clear and transparent. Greatest length 1-7500″. Hab.—Pond water.

Although somewhat resembling *Oikomonas termo*, this species may be readily distinguishable from that form by its exceedingly minute size and the remarkably oblique flexure of the flagellum. This organ in both the latter and preceding type is continuous at its base with the axial line of the body, but becomes slightly curved in the distal portion of its course; here, however, we find it bent aside from its point of origin at an angle of no less than forty-five degrees. In connection with this species a remarkable phenomenon was observed relating to the inceptive capacities and subsequent method of getting rid of effete and unassimilated food-particles. Finely pulverized carmine was voraciously swallowed by the monads, and in many instances in such a quantity that the entire parenchyma became filled with small spherical aggregations of this pigment, leaving no space for further importations. It was now determined to ascertain in what manner the indigestible portions would be disposed of; this after a little patient waiting was fully revealed. Piece by piece these effete rejectamenta were released from the *posterior* extremity of the body close to its juncture with the pedicle, and falling to the ground, formed around the base of this structure a small heap, which at the end of half an hour—the little monad still continuing to incept fresh particles —had accumulated to dimensions equal to and in some cases larger than its own body. The possession by this species of a definite excretory area, not sufficiently limited to be called an aperture, was thus demonstrated, and is of interest, with relation to the somewhat similar but more highly complex excretory phenomena exhibited by the compound type *Anthophysa vegetans* hereafter described.

Oikomonas Steinii, S. K. sp. PL. XIII. FIGS. 65–70.

Body in its motile condition very variable, spheroidal, ovate or elongate, in the sedentary state more or less regularly pyriform and attached by the tapering posterior extremity, which is not sufficiently prolonged as to constitute a distinct pedicle; flagellum undulating, not extended rigidly or in an arcuate form, equalling the body in length; contractile vesicle single, subcentral, endoplast posteriorly located. Length 1-1500″.

HAB.—Vegetable infusions.

The above title is here proposed for the form figured by Stein in his recently published volume under the name of *Cercomonas termo*, and presumed to be identical with the *Monas termo* of Müller and Ehrenberg. It being, however, entirely separate from the type previously connected with that title by Professor Clark, it becomes incumbent to introduce a new one for its distinction. Whether or not the present form or Professor Clark's species represents precisely the animalcule upon which Müller and Ehrenberg conferred the particular title of *Monas termo*, it is next to impossible to determine, there being, in addition to these, a whole host of monadiform beings that present, under a similar comparatively low magnifying power, an aspect identical with that reported by the earlier authorities of the type in question. The new species next described, exhibits, in both habits and external form, broad general features that, without the employment of a high objective, entirely coincide with those of the present species, and is, therefore, quite as probably identical with the Müllerian or Ehrenbergian type.

Oikomonas Steinii is, according to Stein's illustrations here reproduced, eminently social, assembling in clusters upon the surface of the Bacteria-films or vegetable debris contained in the infusions that give it birth. One of the altogether irregular contours that may be assumed at will by the adult zooids of this species is represented at Pl. XIII. Fig. 67. In their younger and more minute condition they present, as shown at Figs. 69 and 70, a much more regular ovate contour, the posterior extremity being sometimes acutely pointed. Stein's proposed reference of this type to the genus *Cercomonas* is, however, by no means justified, no structure taking the form of a permanent tail-like appendage being exhibited in any of his accompanying figures.

Oikomonas rostratum, S. K. PL. XIII. FIGS. 73–77.

Body evenly ovate or pyriform in its free-swimming condition; gibbously ovate with a wider central region in the attached state, the anterior extremity usually rostrate and curved ventrally, the posterior one attached immediately to the object of support, or so attenuated as to form a more or less distinct pedicle, this pedicle never exceeding and rarely equalling the entire length of the animalcule's body; flagellum extended obliquely and rigidly from the curved anterior end, equalling the body in length;

contractile vesicles two in number, subcentral; endoplast posteriorly located. Length 1–2000" to 1–1500".

HAB.—Hay infusions in both salt and fresh water.

While agreeing considerably, both in general habits and external contour, as seen under moderate amplification, with *O. Steinii*, last described, this species may be readily distinguished from that type, on closer examination, by the recurved and rostrate form of the anterior extremity, the rigid and arcuate flexure of the flagellum, the presence of two contractile vesicles, and the frequent though not invariable development of a more or less distinct pedicle. The type was obtained by the author in equal abundance in hay infusions in both salt and fresh water, experimented with in the months of January and February, at St. Heliers, Jersey, in the year 1879. Examples in the latter medium appeared at the end of the first, while those in the salt water were not observed until the end of the second week. When crowded together in their attached state on the finer vegetable fibres and other debris, with their bodies swaying to and fro and their anterior beak-like extremities and flagella maintained in an active condition of elevation and depression, they present (as shown at Pl. XIII. Fig. 73) a most grotesque resemblance to a group of little birds bowing and chattering to one another. Figures 74 and 76 of the same plate indicate the very considerable latitude of motion which the rostrum and accompanying flagellum possesses. The ingestion of solid food-particles at various points of the periphery was observed on numerous occasions, as also the formation by these animalcules of smooth spheroidal encystments.

Oikomonas quadratum, S. K. PL. XIII. FIG. 71.

Body variable in shape, in its most typical sedentary condition, irregularly quadrate or subpyriform, tapering and attenuate posteriorly, attached to the chosen fulcrum of support by an attenuate thread-like pedicle equal to or exceeding the length of the body; flagellum very long, curved or flexuose, twice or thrice the length of the body; parenchyma transparent, finely granular; contractile vesicle single, situated towards the anterior border; endoplast subcentral. Length 1–1500".

HAB.—Pond water.

This species was obtained in November 1871 on Anacharis in pond water containing *Codosiga botrytis*, *Anthophysa vegetans*, and other ordinary fresh-water Flagellata. It is readily distinguished from the preceding species by the great attenuation of the posterior region and marked quadrate contour frequently exhibited by the entire body. In the social group represented at Pl. XIII. Fig. 71, the example occupying the lowermost position to the extreme left, illustrates most conspicuously this characteristic quadrate outline. In the two examples marked *a* and *b* the ingestion of food-substances at opposite points of the periphery, as observed by the author, is delineated. The contour adopted by the animalcule in its free-swimming condition has not as yet been recorded.

GENUS II. BODO, Ehrenberg.

Animalcules ovate or elongate, free-swimming or temporarily attached, exceedingly plastic and changeable in form, the anterior extremity having a single vibratile flagellum, the posterior one prolonged into an attenuate and persistent caudal filament; no distinct oral aperture; occurring mostly as endoparasites within the intestinal viscera of various Vertebrates and Invertebrates.

The genus *Bodo*, as originally instituted by Ehrenberg, included an heterogeneous assemblage of Flagellata, some with and some without a conspicuous caudal prolongation or filament, while in almost all the existence of an anterior flagellate appendage was entirely overlooked. Out of the total of eight species enumerated and figured by this authority in his grand work 'Die Infusionsthiere,' there can be but little doubt that his *Bodo socialis* is identical with the *Spumella vulgaris* of Cienkowski, and his *B. grandis* with a species of *Anisonema* or *Heteromita*. The residual forms, while for the most part too imperfectly figured and described for identification, include nevertheless two conspicuous species which, having formed the subject of investigation of various later authorities, are found to yield sufficiently well-marked characters for generic diagnosis, and are consequently here retained as typical representatives of the genus. The two in question are the *Bodo intestinalis* and *B. ranarum* of Ehrenberg as hereafter described, and around which may be grouped a considerable number of animalcules that appear to exhibit a fundamental correspondence in all essential points with the terms submitted in the foregoing diagnosis. In no instance, as yet, has the inception of solid food by any representative of the genus *Bodo* been actually witnessed, although one species, *B. julidis*, described by Professor Leidy, would appear, so far as may be decided on by his drawings, to be capable of incepting such solid food-particles on its lateral border, and therefore probably at all parts of its periphery. It is by no means improbable, however, that in the majority of instances, and in a manner corresponding to that of the Opalinidæ, these endoparasitic animalcules assimilate the nutrient intestinal juices of their hosts by direct absorption or endosmosis, and are thus independent of a special oral area. A further investigation into the alimentary capacities and more intimate structural details of the various members of this genus is much to be desired.

From the genus *Cercomonas* of Dujardin, with which in many respects it most closely corresponds, *Bodo*, as here delimited, is to be distinguished by the capacity and general tendency possessed by its representatives of forming a temporary or permanent adhesion to neighbouring objects through the medium of its persistent caudal prolongation; *Cercomonas*, while similarly caudate, is entirely free-swimming. The distinction between these two genera as here constituted is therefore precisely parallel to that which obtains between the two generic groups *Monas* and *Oikomonas*. With *Oikomonas* in its attached condition, the members of the present generic group still more closely coincide, their distinction in this instance being manifested, however, by their retention of the caudal filament in both their free and attached conditions.

Stein, in his volume of the Flagellata, figures as representatives of the genus *Bodo*, various species of *Heteromita* and *Amphimonas*, as defined by Dujardin, these two last-named genera being consequently though without sufficient grounds suppressed. Typical members of the genus *Bodo* as here constituted do not appear as yet to have fallen within the cognizance of this authority.

Bodo intestinalis, Ehr. Pl. XIV. Fig. 14.

Body colourless, transparent, elongate-ovate, conical or clavate, rounded anteriorly, attenuate and pointed posteriorly, about three times as long as broad; tail-like filament about equalling the body in length. Length 1–1700″.

Hab.—Intestinal viscera of various frogs, toads, and tailed Amphibia.

The examples referred to this species, figured and described by Perty under the title of *Cercomonas intestinalis*, and found in the intestine of *Triton cristatus*, are represented with a caudal filament two or three times as long as the body. It possibly represents a distinct variety. Professor Leidy has obtained the same species from the rectum of the American toad, *Bufo americanus.* The *Monas intestinalis* of Dujardin, discovered among the excrement of *Triton palmipes*, is apparently also synonymous with this type.

Bodo ranarum, Ehr.

Body colourless, transparent, subovate, about twice as long as broad, pointed at each extremity, but more so posteriorly; caudal filament shorter than the body. Length 1–1440″.

HAB.—Intestinal mucus of various frogs and toads.

The habitat of this species being identical with the preceding, suggests the possibility of its being merely a transitional condition of it. Its specific distinction is at the same time recognized by Perty, Schmarda, and Diesing.

Bodo hominis, Davaine sp.

Body pyriform, anterior flagellum much longer than the body; caudal filament rigid, nearly equalling it in length. Length 1–2500″.

HAB.—The human intestine, found associated with the fœcal evacuations of cholera patients and in typhoidal affections; in the latter instance the animalcules are usually of smaller size; occasionally also abundantly in the gelatinous excreta of infants.

This type is identical with the *Cercomonas hominis* of Davaine referred to in Leuckart's 'Menschlichen Parasiten,' Bd. i. p. 143, 1863.

Bodo helicis, Leidy sp. PL. XIV. FIGS. 12 AND 13.

Body exceedingly plastic and changeable in form, elongate-ellipsoid, fusiform, or ovate; caudal filament equal to or exceeding the body in length; anterior flagellum short; parenchyma colourless, finely granular, enclosing an anterior and posterior vesicula, representing probably the imperfectly observed endoplast and contractile vesicle. Length 1–1500″ to 1–1200″.

HAB.—Copulatory tubes of various land-snails, *Helicidæ.*

This species was originally described under the generic title of *Cryptobia* and *Cryptoicus* by Professor Leidy, but has since been referred to Ehrenberg's genus *Bodo* by Diesing. Among the numerous examples represented in the woodcut accompanying Professor Leidy's original description, several of the animalcules, as shown at Fig. 13, exhibit lateral protuberances with enclosed particles, which have apparently been engulphed laterally in the same manner that food-substances are ingested by the genera *Oikomonas*, *Spumella*, and other Pantostomata.

Bodo julidis, Leidy. PL. XIV. FIGS. 1–3.

Body changeable in form, globose, oval, or pyriform; caudal filament twice the length of the body, capable of active movements and frequently twisted at its extremity in a loop-like manner; parenchyma translucent greenish, slightly granular, enclosing one or two large spherical vacuoles, and numerous minute ones. Diameter 1–3000″.

HAB.—The large intestine of *Julus marginatus.*

According to Professor Leidy, this species occurs often in numbers which must be estimated by millions, within the intestinal canal of the above-named Myriapod, its companion in such habitat being the ciliate animalcule *Nyctotherus velox*.

Bodo colubrorum, Hammerschmidt.

Body hyaline, ovato-lanceolate; anterior flagellum longer than the body, the caudal filament of about equal length. Length 1–3450″ to 1–2880″.

HAB.—Cloaca of the common snake, *Tropidonotus natrix*.

Bodo lymnæi, Stiebel sp PL. XIV. FIGS. 9–11.

Body hyaline, changeable in shape, more usually pyriform; caudal filament equalling the body in length, anterior flagellum scarcely as long. Length 1–1200″. HAB.—Viscera of the pond-snail, *Lymnæus stagnalis*.

Although first referred to the present genus by Diesing, this form was previously described by Stiebel, Karsch, and Ecker as a species of *Cercomonas*. The phenomena of encystment of this type have been recorded at some length by the last-named authority.* On examining the dead and opaque eggs of the mollusc above named, many of them were found to be densely packed with minute cysts having a diameter of from 1–500″ to 1–350″; these bursting, gave birth to swarms of monadiform germs, which speedily acquired the form and dimensions of the parent zooids. While thus observing the development of the motile zooids from the indurated encystments, Ecker does not appear to have witnessed the production of these cysts by the adult animalcules. Taking into consideration the disparity in size between the motile zooids and the cysts, there are, nevertheless, substantial grounds for anticipating that these comparatively large sporocysts are produced through the coalescence of a considerable number of monadiform units. Ecker's representation of a characteristic cyst with the liberated germs is reproduced at Pl. XIV. Fig. 11.

Bodo melolonthæ, Leidy.

Body spherical, caudal filament equal in length to the diameter of the body. HAB.—Intestine of the American cockchafers, *Melolontha quercina* and *M. brunnea*.

Bodo muscarum, Leidy.

Body elongate, caudal filament four or five times longer than the body, often enclosing a nucleus-like structure. Length 1–2160″.

HAB.—Occurring in immense quantities within the intestine of the common house-fly, *Musca domestica*.

This species is probably identical with the *Cercomonas muscæ-domesticæ*, as figured by Stein, and here referred to the new genus *Herpetomonas*.

Bodo maximus, Schmarda. PL. XIV. FIGS. 4–6.

Body elongate-pyriform or clavate, rounded anteriorly, attenuate and pointed posteriorly, from two to three or four times as long as broad; caudal

* A. Ecker, "Zur Entwicklungsgeschichte der Infusorien," 'Zeitschrift für Wissenschaftliche Zoologie,' Bd. iii., 1851.

filament equal to or double the length of the body; usually enclosing a conspicuous central vacuole. Length 1–600" to 1–420".

HAB.—Fresh water: Alexandria, Schmarda.

Excepting for its large size, the characters of this species, as described and figured by Schmarda,* closely correspond with those of *Bodo intestinalis.* No indication of an anterior flagellum is given by that authority, though such doubtless exists. In several instances two or three individuals are represented in Schmarda's drawings, as reproduced at Pl. XIV. Fig. 5, grouped upon a single stem-like caudal filament; this circumstance, taken with its non-parasitic habit, makes it rather doubtful whether this type is a true representative of the genus *Bodo.*

Bodo urinarius, Hassall. PL. XIV. FIGS. 7 AND 8.

Body plastic and variable in shape, subglobose, ovate, or clavate, in the latter instance widest and rounded anteriorly; a flagellum equal in length to the extended body projecting from each extremity. Length of body 1–1000". HAB.—Urine of the human subject.

An abstract of the description of this species, as communicated by Dr. Hassall to the 'Lancet' for November 1859, is herewith appended. The animalcules in question (*B. urinarius*) are about 1–1000" in length and 1–3000" in breadth, presenting when living and active a rounded or oval form and granular aspect, not unlike that of a delicate mucous corpuscle; sometimes they are broader at one end, and are furnished with one, but usually two, long lashes or cilia produced from opposite extremities, and with which they move themselves with great rapidity. The rounded or oval forms most constant when the animalcules are first placed in a drop of urine beneath the microscope, gradually, as the fluid evaporates, assume a flattened and somewhat twisted outline, their motions becoming more sluggish, and death soon following. It is when they are thus dying or just dead that the flagella become most conspicuous, these organs during their active state being indistinguishable. Not unfrequently the animalcules attach themselves posteriorly to the glass object-carrier, and thus remain for a considerable time swaying to and fro like an inflated balloon held down by cords. Multiplication by longitudinal fission was frequently observed, the animalcules undergoing this process presenting as they swam about the appearance of two conjugated individuals. The species was observed to become developed in alkaline urine containing much animal matter, and which had been freely exposed to the air. On their first appearance they are equally diffused throughout the bulk of liquid, but after multiplying to a considerable extent collect upon the surface, and form there a greasy-looking scum. Indigo mixed with the urine apparently expedited their further development in great multitudes. In all cases—about fifty—in which the presence of this animalcule was detected the urine was either feebly acid or alkaline, and the subject exhibited symptoms of weakness and debility.

GENUS III. CERCOMONAS, Dujardin.

Animalcules entirely free-swimming, ovate, globular, or elongate, more or less plastic, developing a single long flagellum at the anterior extremity of the body, and a similar or dissimilar caudal filament at the opposite or posterior extremity; no distinct oral aperture.

HAB.—Fresh water and infusions.

* 'Denkschrift d. k. Akad. d. Wiss. Wien,' 1850.

The *Cercomonas* figured and described without a specific name by Messrs. Dallinger and Drysdale in the 'Monthly Microscopical Journal' for August 1873 is here adopted as the type-form of the present genus, it so far, representing the only species of whose distinct individuality, as derived from a knowledge of its entire life-cycle, we can be absolutely certain. There can be but little doubt that many of the species on which the title of *Cercomonas* was first conferred by Dujardin are transitional conditions of other genera, such as *Monas*, *Oikomonas*, *Amphimonas*, and *Heteromita*, those only being consequently here retained whose characters accord substantially with the foregoing diagnosis, and which have been described with sufficient distinctness for future identification. In none of the forms yet known are any details recorded respecting the manner in which food is ingested, but it may at the same time be predicted that if a distinct mouth existed in the species so carefully investigated by Messrs. Dallinger and Drysdale it would scarcely have escaped attention. In one of the figures given by Stein of his *Cercomonas longicauda*, a green vegetable corpuscle is represented as enclosed within the endoplasmic substance, but no indication is given of any special inceptive area. The essentially free-swimming habits of the type-form here described at once distinguishes it from the somewhat similar tailed but adherent members of the genus *Bodo*.

Cercomonas typicus, S. K. PL. XIV. FIGS. 22–30.

Body ovate, rounded posteriorly, pointed and slightly curved anteriorly, surface smooth; flagellum long and slender, about twice the length of the body; posterior filament usually shorter than the flagellum. Length 1–3500″. HAB.—Fish macerations.

This form is identical with the "Cercomonad" described by Messrs. Dallinger and Drysdale in the above-named Journal. Its multiplication by the several processes of coalescence, encystment, and resolution of the amalgamated zooids into spores of infinitesimal minuteness, similar to those already described of *Monas Dallingerii*, was accurately determined. Rapid increase by the more simple process of transverse fission was likewise abundantly observed; the time occupied by a zooid in thus dividing itself into two was ascertained in an average of forty cases to be exactly four minutes and forty seconds. Adult individuals preparing to conjugate or coalesce with one another assume the amœbiform condition represented at Pl. XIV. Figs. 23 and 24; they then, with the aid of their extemporized pseudopodia, creep about, retaining for a while their flagellate appendages, and present under such conditions an aspect not unlike that of the Rhizo-flagellate form *Mastigamœba simplex*. Two of these amœboid zooids coming in contact fuse intimately with one another, and losing their flagella become transformed into a smooth, quiescent cyst, from which myriads of almost imperceptible spores are subsequently liberated.

Cercomonas longicauda, Duj. PL. XIV. FIGS. 17–20.

Body elongate-ovate, fusiform, flexible, terminating posteriorly in a long, undulating, tail-like filament, about twice the length of the body; anterior flagellum slender, usually shorter; contractile vesicle single, laterally located; endoplast spherical, subcentral. Length of body 1–2700″.

HAB.—Vegetable infusions.

This species being figured with fuller details by Stein in the third volume of his 'Infusionsthiere,' has permitted the addition of those data concerning the relative positions of the endoplast and contractile vesicle which are wanting in Dujardin's diagnosis. In one of the illustrations given by the first-named authority the animalcule is represented in profile, and in a creeping state, presenting under such conditions a considerable resemblance to the permanently repent form *Reptomonas caudata*, previously described. In another example, delineated by Professor Stein, the animalcule encloses within the substance of its parenchyma a recently-devoured spore-like corpuscle. Multiplication by longitudinal fission, preceded by the development, in the first instance, of a second anterior flagellum and caudal filament, is likewise represented in Stein's figures here reproduced.

Cercomonas crassicauda, Stein. PL. XIV. FIGS. 15 AND 16.

Body elongate-ovate, from two to two and a half times as long as broad, its substance granulate; caudal filament usually very thick at its base, tapering to a fine point at its distal end, about equal in length to the body; anterior flagellum finer and longer than the caudal filament; contractile vesicles two or three in number, located near the anterior extremity; endoplast subcentral. Length of body 1–930".

HAB.—Fresh water and infusions.

The animalcule according with the above diagnosis and accompanying illustrations, while referred by Stein * to the *Cercomonas crassicauda* of Dujardin, appears scarcely to conform with the animalcule upon which this title was originally conferred. The species as described by the last-named writer is said to correspond closely in general appearance with *Monas lens*, and is regarded as a probable transient phase of that type. It is further spoken of as attaching itself at will by its posterior extremity, which then becomes drawn out in a tail-like manner, and is again absorbed into the substance of the parenchyma on its resumption of a free-swimming state. It is evident that we have here a form closely related to one of the several species of the newly-introduced genus *Oikomonas*, and an animalcule, so far as it is possible to decide in the absence of any explanatory text, entirely distinct from the *Cercomonas crassicauda* of Friedrich Stein. In several of the examples figured by this last authority, lobate or more or less attenuate pseudopodal prolongations are, as shown at Pl. XIV. Fig. 16, protruded from around the base of the caudal filament, representing probably the amœboid phase preceding encystment or genetic union.

Cercomonas globulus, Duj.

Body subglobose, somewhat pointed anteriorly, surface slightly tubercular; flagellum and posterior filament subequal in length, two or three times as long as the body, the former more slender and undulating, the latter stiff. Length of body 1–2000". HAB.—Marsh water.

Cercomonas fusiformis, Duj.

Body fusiform, inflated centrally, tapering at the two extremities; flagellum and posterior filament long and slender. Length of body 1–1700". HAB.—Infusions of moss.

Cercomonas cylindrica, Duj. PL. XIV. FIG. 21.

Body elongate-cylindrical, about four times as long as broad, tapering posteriorly, surface smooth; flagellum and posterior filament slender, equalling the body in length. Length of body 1–2500".

HAB.—Infusions of moss.

* 'Infusionsthiere,' Abth. iii., 1878.

Doubtful Species.

The *Cercomonas detracta*, *C. viridis*, *C. lacryma*, *C. acuminata*, *C. truncata*, and *C. lobata* of Dujardin would appear in a similar manner to represent transitional or amœboid phases of other monadiform types. The *Cercomonades intestinalis*, *curvata*, *vorticellaris*, *ranarum* and *facula* of Perty are apparently for the most part referable to the genus *Bodo* of Ehrenberg, and in no instance conform with the amended diagnosis of the genus here adopted. Stein's recently figured *Cercomonas termo* (*Oikomonas Steinii*), *C. muscæ-domesticæ*, *C. ramulosa* and *C. obesa* exhibit, in no instance, that essential characteristic of a true representative of the genus *Cercomonas*, as manifested by the possession of a persistent caudal filament; these three types are here distributed among the two genera *Herpetomonas* and *Monas* proper.

Fam. IV. CODONŒCIDÆ, S. K.

Animalcules inhabiting a horny sheath or lorica; flagellum single, terminal; no distinct oral aperture.

GENUS I. CODONŒCA, James-Clark.

Animalcules solitary, uniflagellate, inhabiting an erect pedicellate lorica, to the bottom of which they are fixed in a sessile manner, and not attached to the same by a secondary flexible pedicle. HAB.—Salt and fresh water.

This genus was established by Professor H. James-Clark for the reception of a single species, differing most essentially from *Bicosœca* in the absence of the flexible pedicle, which in the latter genus unites the animalcule with the base or fundus of the lorica, and by its possession of a single flagellum only. To the single marine species first discovered by Professor Clark, a second, fresh-water type is here added.

Codonœca costata, Jas.-Clk. PL. XIV. FIG. 53.

Lorica campanulate, divided by a constriction into two regions; the basal third obconical, tapering gradually towards its junction with the pedicle, the anterior two-thirds bulging out abruptly but narrowing again slightly towards the terminal aperture; the inflated portion sulcated longitudinally by about twenty or thirty equal furrows, which impart a scalloped aspect to the anterior margin; pedicle equal in length to the lorica, somewhat uneven. Contained animalcule elongate-ovate, the posterior end rounded, half filling the narrower proximal third of the lorica, the anterior end somewhat pointed; flagellum vibratile, projecting considerably beyond the orifice of the lorica; colour dingy yellow. Length of lorica 1-1500″. HAB.—Salt water.

The singular form and elegant sculpturing of the lorica of this species in some respects agrees with that of the collared monad *Salpingœca ampulla*, hereafter described. But a single example of this type has been so far met with by the author, and in that instance an empty lorica only, attached to sea-weed obtained from the Crystal Palace aquarium.

Codonœca inclinata, S. K. PL. XIV. FIG. 54.

Lorica simply ovate, not sulcate longitudinally, attached obliquely to a pedicle of twice its length. Contained animalcule ovate, occupying the posterior two-thirds of the cavity of the lorica; the flagellum projecting considerably beyond its aperture. Length of lorica 1–1650″.

HAB.—Pond water.

The length of the pedicle and its oblique mode of attachment to the lorica, serve to distinguish this type from any other flagellate form here described. It was at first regarded by the author as a species of *Bicosœca*, with the animalcule in a semi-contracted state, and was so described in the 'Monthly Microscopical Journal' for December 1871. The sessile mode of attachment of the zooid to the bottom of its lorica, added to the presence of a single flagellum only, indicates, however, the necessity of referring it to the present genus.

GENUS II. PLATYTHECA, Stein.

Animalcules solitary, ovate, enclosed within a depressed, laterally attached or decumbent lorica; flagellum single, terminal, projecting through the orifice of the lorica.

Platytheca micropora, Stein. PL. XIII. FIG. 54.

Lorica ovate, depressed, transparent, not quite one and a half times as long as broad, rounded and widest posteriorly, tapering towards the anterior border and there perforated by an exceedingly minute pore-like orifice through which the flagellum of the enclosed animalcule is protruded; body of animalcule depressed pyriform, pointed anteriorly, scarcely filling one-half of the cavity of the lorica; one or more contractile vesicles situate near the anterior extremity; endoplast posteriorly located. Length of lorica 1–1200″. HAB.—Fresh water.

This animalcule, while figured by Stein in the recently published volume of his 'Infusionsthiere,' is referred to in the accompanying index as a somewhat doubtful Flagellate type, the flagellum not exhibiting the usual characteristic vibratile movements, and presenting the aspect rather of a fine setum or pseudopodium. The examples delineated were found attached to the superficial cells of the roots of duckweed (*Lemna*). Division by fission is shown to take place within the cavity of the comparatively capacious lorica.

B.—PANTOSTOMATA-DIMASTIGA.

Fam. V. DENDROMONADIDÆ, Stein.

Animalcules illoricate, mostly sedentary, with a more or less obliquely truncate anterior border, caused by the lip-like projection of one of its lateral angles; rarely solitary, usually attached singly or in groups to the extremities of a variously-branching pedicle or zoodendrium; flagella two in number, unequal, one long and one short, inserted close to each other towards the centre of the anterior border; parenchyma transparent, granular; endoplast and one or more contractile vesicles usually conspicuous, the latter mostly posteriorly located; no distinct oral aperture, food being incepted indifferently at all parts of the periphery; increasing by longitudinal subdivision.

The representatives of the Dendromonadidæ present collectively a type of modification closely analogous to that which obtains among the more highly organized Peritrichous family group of the Vorticellidæ. Here as there, while some few are distinguished by their solitary habits, the large majority are conspicuous for the extensive tree-like colony-stocks produced by their associated numbers. These, indeed, frequently present in miniature so striking a resemblance to the tree-like colony-stocks of *Epistylis* and other compound Vorticellidæ that, in the absence of magnifying power sufficient for the demonstration of their true nature, they have frequently been described as diminutive forms or earlier growths of such higher Ciliata. The probable derivation of the more complex dendritic forms, such as *Anthophysa* and *Dendromonas*, from such a primary solitary type as *Physomonas*, and through such a simply aggregated stock-form as *Cladonema*, can scarcely be doubted, the fundamental contour and structure of the individual animalcules, as manifested by the oblique lip-like anterior border and flagella of diverse lengths, throughout this natural family group being identical.

GENUS I. PHYSOMONAS, S. K.

(Greek, *physa*, bladder; *monas.*)

Animalcules solitary, occasionally free-swimming, but normally attached by a slender, flexible, posteriorly developed, thread-like pedicle; body subspheroidal, anterior border obliquely truncate, provided with a projecting lip-like prominence; flagella two in number, unequal, one long and one short; endoplast and one or more contractile vesicles mostly conspicuous; no distinct oral aperture, food being incepted at all parts of the periphery. Inhabiting fresh or salt water. Increasing by longitudinal fission and by the subdivision of the entire body into spores.

Physomonas socialis, S. K. PL. XIV. FIGS. 37–45.

Body subglobose, transparent and slightly granular, obliquely truncate anteriorly; primary flagellum two or three times the length of the body, secondary one less than one-half the length of the primary one; pedicle slender and flexible, equalling in length the larger flagellum; contractile vesicles largely developed, two in number, contracting and expanding alternately, located side by side a little behind the median line; endoplast spherical, subcentral. Diameter of body 1–5000″ to 1–2500″.

HAB.—Pond water with decaying vegetable matter. Increasing by longitudinal fission, and by encystment and the breaking up of the body into spores.

It was originally suspected that this species was either a mere variety of *Spumella guttula*, having but one short secondary flagellum, or that the last-named type represented the present form immediately antecedent to the process of fission, and when the development of supplementary flagella gives the earliest indication of the approaching change. It has, however, been met with by the author on so many occasions, and is found to exhibit persistently such important and fundamental differences with relation to both its structural and reproductive features, as to necessitate its recognition as both a distinct specific and generic form. Such structural differences are conspicuously manifested, in addition to the character furnished by the flagella, in the less perfectly spheroidal or globose condition of the body, and in its possession of two largely developed contractile vesicles in place of the single one characteristic of *S. guttula;* there is, further, no trace of the linear granular band or groove near the anterior extremity, erroneously supposed by Stein and Cienkowski to represent a distinct oral aperture. In its free-swimming condition, again, the present type usually exhibits but little alteration of its sedentary shape, while *S. guttula* is subject under like conditions to the most protean metamorphoses. With respect to the reproductive process, both Stein and Cienkowski accord in attributing to *S. guttula* the production of endogenous spore-masses formed from an isolated central portion of the animalcule, while in *Physomonas socialis*, as here shown, the entire body-mass becomes split up to produce the sporular elements.

Detailing at length the more important features of the reproductive phenomena of the present type, as observed by the author, it may be remarked that, in addition to the ordinary process of longitudinal fission, the encystment of animalcules, accompanied or not by the coalescence of two zooids, and succeeded by the breaking up of the encysted body into comparatively large macrospores, has been witnessed, as also the escape of these latter as simple uniflagellate monadiform germs closely corresponding in contour with the type upon which Perty has instituted the genus *Pleuromonas*, already described. Various phases of this reproductive process will be found delineated at Pl. XIV. Figs. 43–45. As there shown, the animalcules mostly remain attached to their pedicles throughout these transformations, the last-named structure indeed losing its vitality and becoming as rigid and indurated as the peripheral wall of the encystment. The example indicated by the letter *c* in the group delineated at Fig. 43, is of especial interest, it indicating by the two pedicles that support the single cyst, that this latter structure has been formed by the coalescence of two zooids in their attached condition: the two others (*a* and *b*) close to this are as evidently the result of solitary encystment. As made apparent by the principal group illustrative of this species (Fig. 37), it may be described as eminently social, numbers being usually found crowded together on the vegetable debris obtained from those localities which it favours, and these exhibiting by their combined restless movements as they sway to and fro on their slender elastic pedicles —their vibrating flagella producing strong currents in the surrounding water—a scene of animation that is scarcely rivalled by the social groups of the larger and more highly organized representatives of the Ciliata. Although the adult zooids of the same colony correspond in size, a considerable difference is found to subsist between those derived from separate localities. The two extremes in this respect are recorded in the foregoing diagnosis; an intermediate calibre, that of 1–3000″, would, however, appear to be most common.

The binary character of the contractile vesicle in this species was determined on numerous occasions, but is necessarily difficult to recognize unless the animalcules face the observer in such a way that the two vesicles are placed side by side, and not one in front of the other. On first examining this type, and mastering the details of its organization and reproductive phenomena, in the year 1871, the writer was disposed to identify it with the *Bodo socialis* of Ehrenberg. The present specific title is even now retained with reference to the probability of such identity. A species of *Physomonas*, closely agreeing with the present form, but having the body more globular and with that anteriorly emarginate aspect caused by the greater extension of one side of the anterior border less marked, has been obtained by the author in sea-water, at St. Heliers, Jersey: this type or variety may be provisionally distinguished by the title of *Physomonas marina*. The characters afforded by the flagella, together with the dimensions of the body, coincide precisely with those of *P. socialis*.

Genus II. CLADONEMA, S. K.

(Greek, *klados*, branch; *nema*, thread.)

Animalcules forming social colony-stocks, irregularly pyriform, with an obliquely truncate anterior border, attached singly to the extremities of a perfectly flexible, hyaline, slender and thread-like, branching pedicle;

flagella two in number, one long and one short; endoplast and one or more contractile vesicles usually conspicuous; no distinct oral aperture, food being incepted at all parts of the periphery. Inhabiting fresh water.

The representatives of this genus differ only from those of *Physomonas*, in that the resultants of division by longitudinal fission, instead of being cast off as free-swimming animalcules, remain adherent by their slender thread-like pedicles, and which, taken in the aggregate, present necessarily a more or less regular dichotomous plan of growth.

Cladonema laxa, S. K. PL. XVII. FIGS. 5–7.

Bodies irregularly pyriform, compressed, the anterior border widest, obliquely truncate; attached separately to the extremities of a slender, flexible, thread-like, irregularly-dichotomously branching pedicle; contractile vesicle posteriorly located; endoplast spherical, subcentral. Length of bodies 1–3250″.

HAB.—Pond water, on *Myriophyllum*. Colony-stocks including from three or four to as many as twenty or more zooids.

This species was first briefly described by the author, with an accompanying figure, in the 'Monthly Microscopical Journal' for December 1871, under the title of *Anthophysa laxa;* the isolated instead of clustered mode of attachment of the animalcules to their pedicle, added to the flexible, thread-like aspect and consistence of this structure, distinguishes it, however, so conspicuously from the representatives of either the genus *Anthophysa* or other allied forms described in this treatise, that a new generic title has been created for its reception. Except for the somewhat more elongate contour of their bodies, the colony-stocks of the present form might be aptly compared to a number of zooids of *Physomonas socialis*, with their flexible thread-like pedicles intimately united. The process of multiplication by longitudinal fission, as shown at Pl. XVI. Fig. 6, and also that of the ingestion of solid food-particles at various points of the periphery, may be observed with great facility in the somewhat large and distinctly isolated zooids of this species. At Fig. 7 of the plate just quoted, an example is given of food-inception towards the posterior region of the lateral border. As originally figured and described, this species was reported as forming colony-stocks of three or four zooids only. More luxuriant examples, including as many as twenty or more animalcules, remitted by Mr. Thomas Bolton, of Birmingham, have, however, since been examined, and have supplied the material for the accompanying illustration.

GENUS III. DENDROMONAS, Stein.

Animalcules irregularly pyriform, the anterior border obliquely truncate, stationed singly at the extremities of an erect, rigid, perfectly hyaline and homogeneous, variously branching pedicle or zoodendrium; flagella two in number, one long and the other short; endoplast and one or more contractile vesicles usually conspicuous; no distinct oral aperture, food-substances being incepted at all parts of the periphery. Inhabiting fresh water.

The rigid and erect composition and mode of growth of the pedicle in this genus distinguish its representatives from those of *Cladonema*. The hyaline and homogeneous consistence of the pedicle, added to the solitary disposition of the zooids, serves to separate it from *Anthophysa*.

Dendromonas virgaria, Weisse sp. Pl. XVII. Figs. 1–4.

Bodies irregularly and obliquely pyriform, compressed; zoodendrium erect, slender, evenly dichotomous; contractile vesicles two in number, posteriorly situated; endoplast spherical, subcentral. Length of bodies 1–3250″. Height of zoodendrium 1–130″.

Hab.—Pond water. Over one hundred zooids frequently included in a single colony-stock.

This species was briefly described by the author, though without an accompanying illustration, in the 'Monthly Microscopical Journal' for December 1871 under the title of *Anthophysa Bennetti.* It being, however, evidently identical with the form referred by Stein in his recently published volume—in connection with the present generic name—to the *Epistylis virgaria* first described by Weisse, such prior specific title is now substituted. There can further be little doubt that the type figured by Stein himself in 'Wiegmann's Archives' for the year 1849, here reproduced at Pl. XVII. Fig. 2, as the probable young condition of *Epistylis anastatica*, represents likewise the species now under discussion. Among all of the numerous stock-building pedicellate varieties of the Flagellata figured and described in this treatise, few perhaps excel the present one in the exuberance of growth and graceful symmetry of the erect, branching zoodendrium. The associated colony-stocks of this species have been frequently observed by the author in such abundance on the finely divided leaves of *Myriophyllum* and other water plants, as to present the aspect of a perfect forest growth of tiny crystal trees, each terminal leaflet replete with life, and quivering with the combined vibratory action of their flagella. The separate animalcules of *Dendromonas virgaria* correspond essentially with those of *Anthophysa vegetans*, and need an equally high microscopic power for their satisfactory examination. As recently figured by Stein, a much more angular outline is given to their bodies than was presented by those observed by the author, while a single contractile vesicle only is delineated by this authority stationed close to the anterior border. It is possible, under such circumstances, that the two represent distinct varieties. Examples of this species have been recently remitted to the author by Mr. John Hood, of Dundee.

Dendromonas pusilla, Schmarda sp. Pl. XVII. Fig. 8.

Bodies ovate, stationed singly at the extremities of an irregularly branching, paniculate zoodendrium. Length of bodies 1–3000″, of branching zoodendrium 1–160″. Hab.—Fresh water.

This species is figured and described by Schmarda * under the title of *Epistylis pusilla.* His delineation given, here reproduced, represents the animalcule as seen under a magnification altogether inadequate for the exhibition of the flagellate or other appendages which the zooids severally possessed, these being consequently represented as simply ovate and entirely naked. There can be but little doubt that the type thus figured represents a stock-building flagellate animalcule nearly allied to *Dendromonas virgaria*, from which, however, it differs in the comparatively irregular plan of subdivision exhibited by the erect zoodendrium.

Genus IV. ANTHOPHYSA, Bory.

Animalcules obliquely pyriform, attached in clusters to the extremities of a rigid or slightly flexible, granular and opaque, not hyaline and homogeneous, simple or more or less branching pedicle or zoodendrium; flagella

* 'Denkschrift d. Konig. Acad. Wien,' 1850.

two in number, one considerably longer than the other; no distinct mouth, food being incepted at any point of the periphery; an endoplast and one or more contractile vesicles usually conspicuous. Inhabiting fresh water.

Anthophysa vegetans, Müller sp.

PL. XVII. FIGS. 13–26, AND PL. XVIII. FIGS. 1–10.

Bodies irregularly pyriform, obliquely truncate anteriorly, slightly compressed; attached in rosette-like clusters of fifty or sixty or more zooids to the terminations of an irregularly branching, and in the more robust condition erect, dark brown, longitudinally striate, horn-like pedicle; this pedicle in weakly or overgrown examples simply granular and highly flexuose; contractile vesicles two or more in number, posteriorly located; endoplast spherical, subcentral. Length of bodies 1–4000″ to 1–3500″.

HAB.—Fresh water, abundant.

Among the earlier writers there has been a general tendency to confound the animalcules of this species—first described by Müller under the title of *Volvox vegetans*, but since more generally known by Bory's title of *Anthophysa Mülleri*—with *Uvella*, this view being even reproduced and adhered to in Pritchard's 'History of the Infusoria,' ed. iv., 1861, and yet more recently in De Fromentel's 'Études sur les Microzoaires.' Such widespread but mistaken opinion as to the affinities of *Anthophysa* has no doubt arisen from the considerable resemblance in mere outward form subsisting between the detached rosette-like clusters, or "cœnobia" as they are designated by Stein, of the present species and the permanently free-floating spheroidal colonies of the genus *Uvella* and its allies. Ehrenberg indeed, regarding the floating clusters and attached colony-stocks as independent organisms, conferred upon the latter the title of *Epistylis vegetans* and on the former that of *Uvella uva* and *U. chamæmorus*. The Uvella-like aspect of the floating clusters is nevertheless purely superficial, the individual zooids exhibiting, on closer examination, an essentially distinct type of structure. In further illustration of the diversity of opinion that originally prevailed concerning the nature and affinities of *Anthophysa*, it may be mentioned that Bory de St. Vincent referred it to that doubtful organic group "*le règne Psychodiaire*," proposed by him for the reception of all such types as appeared, with the means then at disposal for their investigation, to form an intermediate link between the animal and vegetable kingdoms.*

By M. Kützing *Anthophysa vegetans* was regarded as a true plant or aquatic fungus of which the branching stem represented the mycelium, and the terminal groups of monads the reproductive bodies or zoogonidia. Viewing it from this aspect this authority placed it among other fungi, and conferred upon it the generic name of *Stereonema*. That the branching stems or zoodendria of this social monad bear a strong likeness to the mycelium of certain cryptogamic types, is not to be denied, more especially as this portion of the organism, usually of a rusty brown hue, is frequently found thickly encrusting aquatic plants without presenting any trace of the clusters of animalcules which in the perfect condition terminate, and originally constructed, each compound branchlet, but subsequently falling away have left but the naked stalks. This circumstance, as explained by Claparède and Lachmann, who unfortunately only succeeded in obtaining the species in such imperfect state, doubtless gave rise to Kützing's opinion of its fungoid character, he accepting the naked branching stalk as the *primary* portion destined to produce, as an aftergrowth,

* Bory, by the establishment of this transitional organic group, may be said to have completely anticipated Haeckel in his comparatively recent creation of a proposed kingdom of the Protista, already referred to at page 44.

the groups of monads or so-called "zoogonidia." This would necessarily be the case if *Anthophysa* was a plant; on the contrary, however, the stem here, and in all the true animal forms, is produced secondarily from the bodies of the animalcules, and in the present instance in a highly interesting manner. Both Dujardin and Cohn are among those who at an early date decided, on the grounds just stated, upon the animal nature of this organism. Still more recently this type has been made the subject of investigation by Professor H. James-Clark.* As in the case of *Monas* (*Oikomonas*), *Codosiga*, and other Flagellate types treated of in his memoir, that authority advocates for this animalcule the possession of a distinct mouth, and goes so far as to indicate in his accompanying figures the exact position of the supposed oral aperture, namely, on the anterior truncate edge immediately beneath the rostrum or projecting lip-like border, and at the base of the two flagella. There is no doubt that more frequently than otherwise the food-particles thrown back by the action of the flagella do impinge upon this anterior truncate border, and are thus engulfed somewhere near the point just indicated. Prolonged observation on the part of the author has nevertheless elicited that not unfrequently the food-particles strike against other portions of the surface of the body, and are then immediately entrapped by an outflowing film of sarcode in a manner similar to that recorded in this treatise of *Oikomonas*, *Spumella*, *Physomonas*, *Amphimonas*, and numerous other Pantostomata.

Although advancing so strong, but undoubtedly mistaken an opinion upon the food-assimilating function of *Anthophysa vegetans*, Professor Clark is altogether silent respecting the opposite and compensating function, of the rejection or evacuation of the digested refuse. Neither has that authority been altogether felicitous in his interpretation concerning the nature and development of the supporting pedicle, which, as presently shown, is intimately connected with the process of defecation. Upon this latter point he thus expresses himself: "As to the development of the stem, I think it quite certain that it grows out of the posterior end of the body. The best proof of this is that I have frequently found a monad nearly sessile upon a clear spot, and attached by a very short, faint, film-like thread. From this size upward, I have no difficulty in finding abundant examples as gradually increasing in diameter as they did in length; *this furnishing a pretty strong evidence that the stem grows under the influence of its own innate powers, and is not therefore a deposit emanating from the body of the monad*, except perhaps, as far as it may be nourished by a fluid circulating within its hollow core." Professor James-Clark was much mistaken in thus ascribing to the stem of *Anthophysa* an innate power of growth independent from that of the bodies of the monads. The function of getting rid of waste and digested particles and that of building up the pedicle are in fact co-ordinate; this supporting stem being almost entirely composed of the food-particles cast out from the parenchyma or endoplasm after the monads have extracted from them such nutritive qualities as they possessed on their first inception. We have here indeed a phenomenon precisely parallel in kind, though differing slightly in degree, from what has been already recorded on a previous page of *Oikomonas obliquus*, concerning which species it was shown, that the food-particles were, after the extraction of their nutritive properties, passed out at the posterior extremity of the body, and accumulated in a heap round the base of the pedicle.

The more minute structure and actual mode of the growth of the stem of *Anthophysa vegetans*, as ascertained by the author's recent investigations, may now be considered. Under ordinary conditions this pedicle or zoodendrium is somewhat flattened, tapering and narrowest at its fixed or proximal extremity, gradually increasing in diameter as it approaches its junction with the terminal mulberry-like group of monads. If the colony is an old one this pedicle is usually divided into three or four branches, the extremity of each branch bearing its monad cluster. The colour of the stem, where it has been formed some time, is a dark rusty brown changing into amber colour, and finally becoming quite diaphanous as it approaches

* 'Mem. Boston Soc. Nat. Hist.,' vol. i., part 3, 1868.

and is fused with the conjoined posterior extremities of the monad groups. In this region, moreover, the consistence of the pedicle is so soft and flexible that it allows the attached group of monads to gyrate or spin freely backwards and forwards upon its stalk in response to the active vibrations of the innumerable flagella. Not unfrequently, owing to diminution in quantity and quality of the building material used in the fabrication of the stem, it becomes incapable of further supporting these actively motile groups, and snapping through, sets them free in the form of those simply spheroidal clusters so closely resembling superficially the permanently free spheroidal colonies of *Uvella* or *Synura*, with which they were originally confounded. Examples of such free-floating clusters or "cœnobia," as delineated respectively by O. F. Müller and Friedrich Stein, are given at Pl. XVII. Fig. 15, and Pl. XVIII. Figs. 2, 4, and 5. The substance of the adult stem of *Anthophysa vegetans* is apparently at first sight horn-like and homogeneous, and similar to that out of which the loricæ and pedicles of many higher Infusoria are composed. Usually a nature akin to chitine is ascribed to this substance, but its affinity is probably much nearer to that of *keratose* or *keratine*, the basal substance of the skeletal framework of the fibrous or horny sponges. The comparatively firm consistence of the adult pedicles of the present species readily accounts for their long duration, they being frequently met with even after the monads have died away or become dispersed. Examined more minutely, it is found that the pedicle of *Anthophysa vegetans*, in place of being homogeneous, is, as shown in Pl. XVII. Figs. 16 to 18, striated longitudinally, the number of striæ increasing with the prolongation and corresponding greater diameter of the stem, but not themselves undergoing any alteration in their respective diameters.

By feeding a colony of these animalcules with pulverized carmine the significance of the stem with its mode of growth and striated structure became at once apparent. The administered pigment was so greedily ingested, that within a few minutes the body of each monad was gorged with brilliant particles, which regurgitated freely within the body-sarcode after the manner of the food-pellets in *Codosiga* or *Vorticella*. It was not long, however, before the discovery was made that there was little or no nutritive matter in this pigmentary substance, and its rejection thereupon commenced. This was effected entirely at the posterior extremity, or point of union with the pedicle, of each independent animalcule. In this species each member of the large spheroidal cluster radiates from the same terminal point of a single branchlet, and thus the separate contributions of rejected particles proceeding from each individual, become concentrated at their point of exit into one united stream. A change, however, now came over the aspect of the pedicle itself, for the particles of discarded material, instead of falling away as waste, and accumulating round the base of the pedicle as was observed of *Oikomonas obliquus*, were actually utilized as material out of which to build up and prolong it. The amber colour and striated appearance which had previously characterized this structure disappeared, and the pedicle now continued increasing rapidly in length, composed entirely of particles of carmine bound together by a small admixture of glutinous material passed from the monads' bodies. So rapidly and abundantly indeed were the carmine-particles received and discharged, that within half an hour the pedicle of one group had nearly doubled its former length, and continued growing at the same rate until a very abnormal and striking effect was produced. The general aspect of an example of *Anthophysa vegetans* with such an artificially constructed stem is illustrated at Pl. XVII. Fig. 18, and in which instance the whole of the pedicle from the point *a* represents the portion that was produced in the space of half an hour. In other instances the process of assimilating the carmine was carried on for a still longer interval, the result in such cases being that, missing its customary strength, the pedicle bent upon itself, forming a loose, flexible loop as shown at Fig. 19. Under ordinary conditions the growth of the pedicle is a much slower process, the pabulum out of which it is built not being usually so abundant, and consisting of more easily digested animal and vegetable particles, which weld together into a more compact and homogeneous mass. The stem-producing property of *Anthophysa* under such ordinary conditions may in fact be compared with that of some highly finished machine, into one end of which the raw and heterogeneous material is flung to issue at the opposite extremity a perfected and homogeneous fabric. On first passing away from the monad's body this stem is perfectly soft and glutinous, it gradually hardening and acquiring its dark brown hue with exposure to the water. It is only after this prolonged exposure, moreover, that the longitudinal striæ previously described make their appearance, such striæ again obviously representing the outlines of the individual contributions of each separate monad towards the common fabric, and these separate elements become fused with one another during their pristine soft and plastic state. The ordinary method of increase of the monad clusters of this species, namely by rapid longitudinal fission of the individual zooids, assists materially in demonstrating the opinion here expressed, as to the significance of the striæ, for as the stem grows longer and the monads continue to multiply in number the longitudinal striæ become also correspondingly more numerous. That there is a permanent hollow core in this structure, as has been maintained by James-Clark, is certainly not supported by the results of the author's investigations. That new-formed part of the stem near its point of junction with the terminal monad group, no doubt exhibits a firmer consistence exteriorly where it comes into direct contact with the water, but this distinction is only temporary and becomes entirely obliterated as the stem increases in age and strength.

Multiplication by longitudinal fission, as already indicated, represents an ordinary method of increase in these animalcules; a primary single monad dividing indefinitely, after the manner of *Codosiga* or *Epistylis*, until from the single individual which laid the foundation of the colony, one or more mulberry-like clusters are formed numbering respectively some fifty or sixty individual zooids. Now and then, these terminal clusters break away, and forming new attachments develop compound clusters similar to those from whence they originally sprang. Doubtless, however, there is another more complex method of increase manifested by this species, analogous to what has been already observed of numerous other Flagellata, obtained through the genetic union of two or more individual zooids, and followed by the production of innumerable independent germs or spores. Although up to the present time no direct evidence of such a sporular mode of reproduction is forthcoming, the following phenomena, observed by the author, may possibly serve as a clue towards the supply of this, as yet, missing link in the life-history of the species.

In the month of August 1871, the examination of a leaf of Myriophyllum led to the detection of an oval body adhering to it, closely resembling the egg of some free-swimming Rotiferæ, as represented at Pl. XVII. Fig. 20. Movements being in progress within this body, promising the early release of its contents, attention was specially concentrated upon it. Only a short interval had elapsed, however, before it became evident that the transparent shell contained innumerable independent organic particles in place of the single multicellular germ of an ordinary egg. As time progressed these separate particles began to exhibit violent ebullition-like movements as though endeavouring to break through the prison wall that encircled them. At the end of half an hour a rift suddenly appeared at one extremity, and a second inner investing membrane was protruded funnel-wise through the aperture, as shown at Fig. 21. The energetic or, so to say, excited motions of the imprisoned particles became now greatly augmented, till at length bursting in its turn (Fig. 22), this second inner capsule let loose into the surrounding water a countless swarm of minute, reniform, uniflagellate animalcules. These monadiform germs, which presented a remarkable resemblance to the somewhat similarly developed progeny of *Physomonas socialis*, and also to the adult form of the *Pleuromonas jaculans* of Perty, enjoyed their free roving condition for but a brief interval. Within a few minutes after their escape they became sluggish in their movements, and settling down on the surface of the glass slide withdrew their flagella and changed their shape from reniform to spherical, as shown at Fig. 25. In this quiescent state these spheroidal, and apparently encysted, bodies remained for the next twelve hours, when an accident occurred which interrupted the further investigation of their life-history in so direct a manner as had been intended. The damp growing-cell in which these organisms were confined, unfortunately became dry during an absence of more than a day's duration. Although everything contained in the cell was completely desiccated, abundant traces were left, nevertheless, of what had taken place previous to the evaporation of the water. At each spot which had been carefully noted as the point of attachment of the quiescent or encysted monads, was a minute, dark brown, striated, branching stem, corresponding in all ways with the characteristic pedicle of *Anthophysa vegetans*. The process of drying up had necessarily removed every trace of the animalcules whose presence would have still more satisfactorily established the connection between the monadiform products of the original egg-like cyst and the colonies of the species named; the evidence of the branching and striated stems was, however, so substantial as to leave little, if any, doubt of their relationship. How this original ovate cyst, assuming that it belonged to *Anthophysa vegetans*, was originally produced, remains to be determined. Judging from its comparatively large size it would appear to be most reasonable to surmise that it was formed by the coalescence of an entire colony or spheroidal terminal cluster of the flagelliferous monads, which after encystment broke up into abundant smaller uniflagellate locomotive germs, which made their escape under the conditions just related. A parallel fusion of numerous zooids succeeded by encystment and breaking up of their united masses into numerous spore-like bodies, is afforded in the life-history of the monad first described and figured by Messrs. Dallinger and Drysdale, as the "Hooked Monad," and which finds a place in this volume under the title of *Heteromita uncinata*. Phenomena closely identical are also presented in that mode of multiplication among the sponge-monads manifested by the production of the swarm-gemmules or so-called ciliated larvæ described in Chapter V.

Some slight additional testimony in favour of the above-suggested interpretation of the developmental phenomena of *Anthophysa vegetans* is afforded by the illustrations of this species given in Stein's recently published work. Among his excellent illustrations of this type—the more important of which are reproduced in Pl. XVIII. of this treatise—a representation is given (see Fig. 6) of a normally detached spheroidal cluster or "cœnobium," whose constituent monads have become separated from one another, and protrude from their posterior regions tail-like pseudopodal prolongations. At Figs. 7 and 8 of the same plate are represented similarly derived isolated monads that have assumed a conspicuously amœbiform contour. In some instances, as shown at Fig. 9, it would appear that these amœbiform zooids attached themselves separately and lay the foundation of new colonies, but it would seem also highly probable that under such condition they, in common with various other Flagellata, coalesce together and produce sporocysts similar to the one just described.

The highly distinctive longitudinally striate aspect of the branching stem of *Anthophysa vegetans* is not definitely indicated in any of Stein's figures, and it is further noteworthy that the example selected by him as illustrating the normal stock-form of this interesting species (see Pl. XVIII. Fig. 1) represents that lax and attenuate structural type indicating either the absence of congenial nutriment, or that the colony has outgrown its strength and lacks vital energy sufficient for the production of its customarily erect and comparatively massive zoodendrium. De Fromentel, in his 'Études sur les Microzoaires,' figures a like emaciated colony-stock. An almost precisely parallel deviation from a normally erect to a lax and decumbent growth-form, is afforded by the Peritrichous type, *Epistylis flavicans*, whose branched zoodendrium, while stiff and erect in its earlier and most robust condition, presents later on that loose and weakly structural form upon which Ehrenberg and other earlier authorities, regarding it as a distinct variety, have conferred the separate specific title of *Epistylis grandis*. In the original delineation of the species given by O. F. Müller, under the title of *Volvox vegetans*,* reproduced at Pl. XVII. Figs. 13 and 14, the more ordinary rigid and erect growth-form of the branching pedicle is represented. Brightwell, in his 'Infusorial Fauna of Norfolk,' 1848, figures this

* 'Animalcula Infusoria,' 1786.

species in an intermediate or semi-erect condition under Ehrenberg's name of *Epistylis vegetans*.

Anthophysa socialis, From. sp. PL. XVII. FIGS. 9–11.

Bodies broadly ovate, abruptly truncate anteriorly, attached in clusters of about eight zooids only to the extremity of a simple, thick, and evenly granular pedicle. Length of separate zooids 1–3000"; height of supporting pedicle 1–1000" to 1–750".

HAB.—Fresh water, on Confervæ.

The above specific title is adopted for the distinction of the flagellate organism imperfectly figured and described by De Fromentel * under the name of *Pycnobryon socialis*. Bütschli has already proposed to identify it with *Anthophysa vegetans*, but the more broadly ovate contour of the animalcules, which exhibit a perfectly straight instead of an obliquely truncate anterior border, added to the simple and coarsely granular character of the supporting pedicle, distinguish it in a marked manner from that species. The presence of the secondary and shorter flagellum characteristic of the present genus, was not recognized by De Fromentel; the magnification of 400 diameters only, employed by him in his examination of this and kindred Flagellata, being inadequate for its detection. The form figured by the same writer at pl. ix. fig. 11 of the work quoted, and referred with some doubt to the present type, is evidently a young colony of *Codosiga botrytis*. Bütschli's representation of *Anthophysa vegetans*, reproduced at Pl. XVII. Fig. 11, is apparently identical with the present animalcule and can certainly not be accepted as a typical example of the last-named species.

GENUS V. CEPHALOTHAMNIUM, Stein.

Animalcules obliquely pyriform, attached in groups to the extremities of an erect, rigid, hyaline and homogeneous, more or less extensively branching pedicle or zoodendrium; flagella two in number, one long and one short; endoplast and one or more contractile vesicles usually conspicuous. Inhabiting fresh water.

The representatives of this genus while corresponding, in the form and structure of the individual monads and their mode of groupment, with those of *Anthophysa*, are to be distinguished from them by the stiff, hyaline, and homogeneous composition of the supporting pedicle.

Cephalothamnium cæspitosa, S. K. sp.

PL. XVII. FIGS. 27–32, AND PL. XVIII. FIGS. 33–35.

Animalcules somewhat variable in shape, mostly irregularly and obliquely pyriform, attached in clusters of from two or three to as many as six or eight to the summit of a simple or sparsely divided pedicle; pedicle rarely exceeding the height of the individual animalcules. Length of separate bodies 1–5000".

HAB.—Fresh water, attached to a species of *Cyclops*.

This animalcule was first figured and described by the author under the title of *Anthophysa cæspitosa* in a communication made to the Linnean Society in June 1877, and has more recently received, at the hands of Stein, the name of *Cephalo-*

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* 'Microzoaires,' pp. 212 and 337, pl. ix. fig. 10, and xxvi. fig. 9.

thamnium cyclopum. While readily adopting Stein's proposed generic designation, the author's earlier conferred specific one is here retained. Superficially examined, the dense clusters of this specific type, as first met with, presented a considerable resemblance to the gregarious colonies of *Deltomonas cyclopum* described on a succeeding page. A nearer investigation, however, revealed the presence of the common supporting stem or pedicle. In no instance was this supporting pedicle found to exceed in height the length of a single animalcule's body, while in most cases it scarcely attained to one-half that altitude. While usually perfectly simple, the larger colony-stocks occasionally exhibit a rudimentary branching of the pedicle towards the summit, none so far met with by the author, however, presenting so distinct a development of secondary branches as is indicated in Stein's figure reproduced at Pl. XVIII.

Examined separately, the zooids of this species were found to present a considerable range of variation in their form and general aspect, their component sarcode exhibiting a more plastic or less firm consistence than in those of the Dendromonadidæ previously described. Here, too, for the first time among the representatives of this family group, examples were observed in which the flagella were entirely retracted, and short pseudopodium-like processes projected from either one portion or the general surface of the body. Phases of this amœbiform condition, as represented at Pl. XVII. Figs. 30 and 31, correspond in a remarkable manner with the analogous amœbiform condition of the collared monad *Codosiga botrytis* delineated at Pl. II. Fig. 25. This metamorphosed state is no doubt intimately connected with the process of reproduction. The somewhat abnormal process of multiplication by transverse fission, resulting in the product of a free-swimming zooid, was observed on one occasion, and is represented at Pl. XVII. Fig. 32. This species has been obtained by the writer attached to a species of *Cyclops* taken from ponds on Wandsworth Common.

Cephalothamnium cuneatum, S. K. PL. XVII. FIG. 12.

Bodies subtriangular or cuneiform, compressed, attached in clusters of about eight zooids to a slender, rectilinear, simple, or sparsely bifurcating pedicle. Length of bodies 1–2500″.

HAB.—Pond water, on a species of *Cyclops.*

Examples of this species have been met with on one occasion only on the Entomostracon mentioned, obtained from a pond near Acton. The most luxuriant specimen presented only the single bifurcation of the pedicle, as represented in the accompanying illustration. The larger size and more regular cuneiform contour of the animalcules, combined with the comparatively greater and more symmetrical development of the pedicle, distinguish this form from *A. cæspitosa* with which it is otherwise most nearly related.

Fam. VI. BIKŒCIDÆ, Stein.

Animalcules sedentary, ovate or pyriform, with a usually more or less projecting anterior lip-like prominence, solitary or colonially associated, secreting separate horny sheaths or loricæ, which are mostly stalked; flagella terminal, two in number, one long and one short; parenchyma transparent; no distinct oral aperture; endoplast and one or more contractile vesicles usually conspicuous; increasing by transverse subdivision and by the separation of the body into a mass of sporular elements. Inhabiting fresh and salt water.

The animalcules relegated to this family group closely coincide with those of the Dendromonadidæ last described, but are to be distinguished from them by their secretion of horny loricæ and normally transverse mode of fission; the relationship of these two groups is consequently closely parallel with that which subsists between the naked and loricate sections of the Vorticellidæ.

GENUS I. HEDRÆOPHYSA, S. K.

(Greek, *hedraios*, sessile; *physa*, bladder.)

Animalcules solitary, irregularly ovate, possessing a more or less conspicuous anterior lip-like prominence, inhabiting horny sheaths or loricæ, which are attached in a sessile manner, without an intermediate pedicle, to subaquatic objects; flagella two in number, unequal, one long and one short, originating close to each other near the centre of the anterior border.

The representatives of this genus differ from those of Bicosœca merely in the absence of a supporting pedicle to the lorica. A single species, inhabiting salt water, has as yet been observed.

Hedræophysa bulla, S. K. PL. XVIII. FIG. 24.

Lorica subglobose, bubble-like, anterior aperture of small dimensions; animalcule occupying the greater portion of the cavity of the lorica, attached in a sessile manner to its bottom; height of lorica 1–4000″.

HAB.—Salt water.

A single example only of this species has been so far met with, being then obtained by the author attached to Conferva from sea-water collected at St. Heliers, Jersey.

GENUS II. BICOSŒCA, James-Clark.

Animalcules solitary, more or less ovate, with a projecting anterior lip-like prominence, inhabiting simple, pedicellate, horny loricæ, to the bottom of which they are attached by a thread-like contractile ligament or peduncle; flagella two in number, unequal, one long and one short; an endoplast and one or more contractile vesicles usually conspicuous; no distinct oral aperture, food being incepted at all points of the periphery. Increasing by transverse fission and by the subdivision of the body into spores.

As first described by Professor H. James-Clark, the members of this genus were represented as possessing a single vibratile flagellum only. The existence of a comparatively minute secondary one has, however, been clearly demonstrated by the author on innumerable occasions, and in connection with a variety of specific types. The homologue of a secondary flagellum has been supposed by Professor Clark to exist in *B. lacustris* in the posterior eccentrically developed contractile ligament which fixes the animalcule to the bottom of its lorica, and which in such case he maintains favours the interpretation of *Bicosœca* as a thecated *Heteromita* or *Anisonema* permanently affixed in its sheath by the trailing or gubernaculate flagellum. That *Bicosœca* originates from a motile Heteromitous zooid is shown by the author in the following descriptions of *B. lacustris* and *B. poculum;* but the accompanying demonstration of the existence of two vibratile flagella, in addition to the contractile ligament, during the more normal sedentary conditions of these species, entirely negatives Professor Clark's hypothesis. In *Bicosœca pocillum*, more especially, the primary origin of the contractile pedicle as an altogether independent tail-like prolongation of the posterior region is clearly manifested. Stein* substitutes the title of Bikœca for this genus as more etymologically correct.

Bicosœca lacustris, J.-Clk. PL. XVIII. FIGS. 13–19.

Lorica elongate-ovate, widest posteriorly, a little over twice as long as broad, supported on a pedicle which nearly equals it in length; animalcule when extended projecting beyond the aperture of the lorica, produced anteriorly in the form of a projecting lip-like prominence, attached posteriorly to the bottom of the lorica by an eccentrically developed, thread-like, contractile ligament; flagella uneven, one long and one short, the longer one when retracted rolled spirally within the cavity of the lorica; contractile vesicles two or three in number, posteriorly situated; endoplast spherical, subcentral. Length of lorica 1–2500″.

HAB.—Pond water; abundant.

This species represents, undoubtedly, one of the most widely distributed members of the Flagellata, it having been met with by the author in more or less abundance on weeds from almost every sample of pond-water examined. The presence of the second and comparatively very short flagellum is difficult to determine without the employment of a high magnifying power of the microscope (800 diameters and upwards) and a careful manipulation of the illuminating agency. In the descriptions illustrative of this type, indeed, as originally given by H. James-Clark, or more subsequently by Stein or Bütschli, a single long flagellum only is reported to exist. The possession of a minute supplementary appendage has, however, been repeatedly corroborated, and more recently with the advantage of verification by an independent witness. Even where not distinctly visible, its presence is clearly indicated by the tremulous motion of the particles in the vicinity of the much attenuated lip-like prominence, and behind which process of the anterior region this smaller flagellum is frequently more or less completely concealed. The posterior and retractile thread-like ligament securing the animalcule to its lorica in this species is inserted eccentrically, and towards the ventral aspect—a circumstance, however, which is distinctly shown only when a lateral view, as indicated at Pl. XVIII. Fig. 19, is presented. On retreating into its lorica, this thread-like ligament or peduncle is folded tightly on itself, while the longer of the two flagella, as shown at Fig. 17, is thrown into an elegant spiral coil, reminding the observer of the spirally retracted proboscis of a butterfly. The ingestion of food-particles has been observed to take place indifferently at all points of the exposed anterior border, against which region they are cast by the vibrating motions of the long flagellum, the shorter appendage apparently assisting in making further secure the food-substances brought within reach by the longer one.

The most general method of reproduction exhibited by *Bicosœca lacustris*, in common with the other representatives of the same genus, is that of multiplication by transverse fission. Preceding such duplicative process, the body of the animalcule, growing to nearly twice its normal size, almost completely fills the cavity of the lorica; a transverse furrow then makes its way across the centre, increasing in depth until the anterior moiety becomes completely separated from the hinder one, and is liberated into the outer water. Within the course of a few minutes, the posterior portion, which is left attached to the contractile pedicle, develops two new flagella, and has assumed a contour in every way identical with that which the animalcule originally possessed. The detached anterior half issuing from the aperture of the lorica, immediately takes upon itself the form and habits of a free-swimming zooid, altogether unlike the parent, and most nearly resembling

* 'Infusionsthiere,' Abth. iii., 1878.

some representative of Dujardin's genus *Heteromita*. The anterior extremity of the body retains its pointed rostrum, and likewise the two flagella; but the function of these two organs becomes materially altered. Formerly the longer of the two flagella was apparently the most actively employed; this, however, is now left trailing in the rear, while the shorter one is advanced to the front, and, vigorously vibrating, constitutes the motive or propelling power. The movements of the animalcule during this free-swimming condition are, however, by no means regular, nor of long duration. After tumbling about in an aimless sort of manner for a little while—say half an hour—it meets with some surface suitable for attachment, and fixing itself to it, gradually develops a lorica, pedicle, and all other parts that characterize the parent form. In all such instances, where this interesting growth from a detached zooid has been observed, it is worthy of remark that the attachment was effected and the pedicle produced at that extremity which previously bore the flagella, these organs being absorbed and developed anew at the opposite or distal extremity. The peculiar aspect and movements of the free-swimming zooids of *Bicosœca lacustris* distinguish them readily from typical *Heteromitæ* or other independent forms, while their presence in the water affords a sure indication of the close vicinity of the adult sedentary animalcules from whence, by fission, they were originally derived. Not unfrequently *Bicosœca lacustris* has been observed by the author in a quiescent and apparently encysted state within its lorica; while still more recently an example has been met with—Pl. XVIII. Fig. 18—in which the former contents of the lorica were broken up into numerous spore-like bodies. Empty loricæ are of frequent occurrence, and are evidently of considerable consistence. Although such a phenomenon has not yet been observed, it is highly probable that the free-swimming monads liberated by the process of transverse fission, occasionally coalesce with one another, or with one of the fixed examples, and thus give rise to the sporular encystments, in a manner identical with what is now known to obtain among so many of the ordinary illoricate Flagellata. A first record of the occurrence of this species on this side of the Atlantic, embodying a figure illustrating the existence of two flagella—the second flagellum being there described as a shorter stylate appendage—was communicated by the author to the 'Monthly Microscopical Journal' for December 1871.

Bicosœca gracillipes, J.-Clk. Pl. XVIII. Figs. 21 and 22.

Lorica subcylindrical, slightly everted at the aperture, tapering towards its junction with the pedicle, about three and a half times as long as broad; pedicle twice the length of the lorica; enclosed animalcule elongate-oval, usually entirely enclosed within the cavity of the lorica; contractile vesicle subcentral. Length of lorica 1–2000″, of contained animalcule 1–4000″.

Hab.—Salt water.

This species was obtained by the author in September 1872, attached to seaweeds and Polyzoa collected at Bognor, Sussex. The example represented at Pl. XVIII. Fig. 22, differs from the more typical form of growth in the shorter comparative length of the pedicle which supports the lorica, and in the more exsert character of the contained zooid.

Bicosœca tenuis, S. K. Pl. XVIII. Fig. 23.

Lorica elongate-ovate or subfusiform, nearly three times as long as broad, tapering equally at each extremity; pedicle scarcely one-half the height of the lorica; animalcule with an attenuate anterior lip-like projection, slightly exsert anteriorly. Length of lorica 1–3000″ to 1–2500″.

Hab.—Salt water.

This species has been obtained on filamentous algæ and Sertularian zoophytes at St. Heliers, Jersey, and likewise at Bognor, Sussex. Both the lorica and contained animalcule, while presenting a considerable resemblance to the common fresh-water type *B. lacustris*, are to be distinguished from the same by their more attenuate contour. The development of this type from a naked *Physomonas*-like form has been observed, the subsequently produced lorica first appearing as a mere bubble-like film round the anterior margin of the animalcule's body.

Bicosœca pocillum, S. K. PL. XVIII. FIGS. 25–29.

Lorica cup-shaped or subcylindrical, rounded posteriorly, the anterior margin abruptly truncate, neither everted or constricted, varying in height from one and a half to two or three times its greatest breadth ; pedicle short, rarely half as high as the lorica ; animalcule subovate or calceolate, rounded posteriorly, the anterior margin excavate, produced on one side as a broad, flattened, lip-like process, occupying from one-third to one-half of the cavity of the lorica ; posterior retractile ligament equalling the body in length ; contractile vesicle posteriorly situated ; endoplast spherical, subcentral. Length of lorica 1–2500″ to 1–1500″, of contained animalcule 1–3250″.

HAB.—Salt water attached to the polyparies of hydroid zoophytes and polyzoa.

This species was obtained abundantly by the author at St. Heliers, Jersey, in the summer of the year 1878. It may be readily distinguished from all the preceding members of the genus by the rounded and subcalceolate contour of the animalcule and the plain cup-like or subcylindrical shape of the protective sheath. Multiplication by transverse fission was frequently observed, the free-swimming zooid produced by this process presenting a somewhat variable but highly distinctive form. In certain instances—Pl. XVIII. Fig. 27—the posterior region of the body was symmetrically rounded, as in the parent monad, but in others (Fig. 28) drawn out in an attenuated tail-like manner. The longer or primary flagellum under these free-swimming conditions was always extended in advance, causing by its undulations an even motion in a straightforward direction, while the shorter and secondary flagellum, about half the length of the primary one, was reflected ventrally, and trailed in the rear in a manner that imparted to the animalcule, as in the case of the similar motile zooid of *Bicosœca lacustris*, a close resemblance to the members of the genus *Heteromita*. Encountered in this free-swimming condition only, the animalcule would, indeed, without the slightest inconsistence, be referred to the last-named genus. The motile animalcules, after a brief nomadic existence, were observed to attach themselves, and to gradually develop, by exudation, their transparent loricæ. In the fixed condition immediately preceding the secretion of this protective structure, or in which the body had developed only its thread-like pedicle, as shown at Pl. XVIII. Fig. 29, the general form and structure correspond, to all appearances, with those of a typical representative of the genus *Physomonas*. The developmental history of this type is thus shown to exhibit three widely distinct phases, each of them being characteristic successively of the normal or adult condition of the three distinct Flagellate genera *Heteromita*, *Physomonas*, and finally *Bicosœca*. There is doubtless a still earlier and more simple monoflagellate condition resulting from the breaking-up of the parent body into spores, to be discovered. The ingestion of food at various parts of the periphery was frequently observed.

Examples of this species have been recently received by the author, in company with other marine Infusoria, from Mr. Thomas Bolton's microscopical studio.

GENUS III. STYLOBRYON, De Fromentel.

Animalcules social, inhabiting a compound polythecium, composed of separate horny loricæ united to one another, or to a common pedicle, through the medium of slender independent footstalks; bodies ovate with a projecting lip-like anterior border, affixed to the bottom of their loricæ by a contractile thread-like peduncle; flagella two in number, uneven, one long and one short, the former rolled spirally when retracted; parenchyma transparent and homogeneous. Increasing by transverse subdivision and by the resolution of the body into spores.

HAB.—Fresh water.

Stylobryon petiolatum, Duj. sp. PL. XXIII. FIGS. 17–30.

Component loricæ of polythecium wineglass-shaped, widest and slightly everted anteriorly, tapering towards and conically pointed at the posterior extremity, from one and a half to three times as long as broad; united to each other by pedicles which, while subequal in the same polythecium, vary in diverse colony-stocks from less than one-half to three or four times the length of a single lorica; pedicles produced for some little distance within the cavity of their associated loricæ, and forming bases of attachment for the enclosed zooids; animalcules plastic and changeable in shape, irregularly ovate, with one of the antero-lateral angles projecting in a lip-like manner, occupying about one-half of the cavity of the loricæ, united to it posteriorly by a contractile thread-like peduncle; flagella two in number, one long and one short, inserted at the base of the anterior lip-like prominence, the longer one coiled spirally when retracted; contractile vesicle single, posteriorly located; endoplast spherical, subcentral. Length of loricæ 1–800" to 1–500".

HAB.—Pond water, multiplying by transverse fission and by the subdivision of the entire body into spores.

This animalcule was first described by Dujardin under the title of *Dinobryon petiolatum*, the generic one here given being conferred upon it by De Fromentel, who figures and describes it in his 'Microzoaires' as *Stylobryon insignis*. There can further be but little doubt that the species figured by Stein in his recently published volume under the name of *Poteriodendron petiolatum* represents the same form, and this notwithstanding there are certain remarkable structural features accredited to it by this authority which, if fully substantiated, would necessitate its recognition as an entirely distinct organic type. According to Stein, the loricæ, while corresponding entirely in their contour and mode of union as defined in the above diagnosis, contain animalcules possessing one flagellum only, but which bear in the anterior region and to one side of the flagellum a supplementary membraniform expansion, resembling in a less conspicuously developed degree the funnel-shaped collar of the Choano-Flagellata. Having, however, had the opportunity of examining an extensive series of examples of the form now under discussion obtained from diverse localities, the author has arrived at the conclusion that so far as the presence of a collar-like structure is concerned, Stein has misinterpreted the actual facts of the case. In no instance could any such independent organ be detected; but in place of this it was observed that the anteriorly developed lip-like prominence occupied a conspicuous position, and might with ease be identified with the looked-for "collar." A reference to the plate illustrative of this type, in which at Figs. 27 and 28 are reproduced out of Stein's work two colony-stocks with their reputed collars, and at Figs. 17–23 delineations of aggregated colonies and isolated zooids in various aspects and conditions, as observed by the author, will at once make clear the ground of such identification. In Figs. 19 and 20 especially, where a front and profile view is given of an animalcule under the high magnifying power of 1500 diameters, it will be at once seen that the more attenuated sarcode substance entering into the composition of the anterior lip-like prominence necessarily presents in juxtaposition to the denser mass of the body proper the appearance of an independent hyaline organ. Such an aspect and correlated type of structure is by no means, however, restricted to the type now being considered, but is more or less prominent throughout all the members of both the present family and that of the preceding one of the *Dendromonadidæ.* The presence of the shorter of the two flagella, overlooked by Stein, is not easy to detect in living examples, but is shown distinctly in specimens killed with osmic acid.

As indicated in the figures given by the authority just quoted, the compound polythecium, built up of the more or less numerous separate and independent loricæ, exhibit a very considerable range of variation. Thus sometimes, as in Figs. 18 and 27, the loricæ may be so closely approximated that the pedicles as independent elements are almost completely subordinated, while in other cases, as at Figs. 17 and 28, these structures may equal or considerably exceed the length of the loricæ. The exceptionally long-stalked variety illustrated in the first of these two figures, was obtained by the author from a pond in the neighbourhood of Prestwich, Manchester, in November 1875; more ordinary examples of this species have been collected both in the vicinity of London and at St. Heliers, Jersey. An exceptionally fine specimen preserved with osmic acid, and obtained from one of the water-fowl ponds in the Zoological Gardens, Regent's Park, has been recently placed at the author's disposal by Mr. L. Dreyfus. The zoothecium embraces over one hundred loricæ, united by short pedicles as in the example figured at Pl. XXIII. Fig. 27. Among this group furthermore were included several loricæ in which the bodies of the animalcules had become divided up into sporular elements, these in some instances being entirely enclosed within and in others partly discharged from the apertures of the loricæ. Examples of such spore-bearing loricæ are represented at Figs. 24 and 25, as also isolated spores more highly magnified at Fig. 26.

Stylobryon (*Poteriodendron*) *petiolatum*, considered with the aid of the hitherto unrecorded structural details here submitted, must undoubtedly be regarded as a compound modification only of the form *Bicosœca lacustris*, previously described. It is a noteworthy circumstance, in this connection, that Stein himself, while advocating so distinct an interpretation of its structural features, admits it in his classification scheme to the same family group as *Bicosœca*, while Bütschli * figures and describes it—without indicating the presence of a second flagellum—as a probable compound example only of the last-named species.

While going to press, October 1880, the author has received luxuriant colony-stocks of this species from the neighbourhood of Dundee, through Mr. John Hood, in company with an interesting Melicertan, apparently new to science.

Stylobryon epistyloides, S. K. Pl. XVIII. Fig. 32.

Loricæ evenly ovate, about twice as long as broad, attached by short secondary peduncles, in social clusters of from two or three to six or eight zooids, to the summit of a simple, straight, rigid pedicle; anterior extremity of animalcules prolonged into a lip-like prominence, projecting slightly beyond the orifice of the loricæ. Length of loricæ 1–2000", of contained animalcules 1–3250". Hab.—Fresh water.

* "Beiträge zur Kenntniss der Flagellaten," 'Zeit. Wiss. Zool.,' Bd. xxx., 1878.

The colonies of this species closely resemble a number of zooids of *Bicosœca lacustris* grouped together at the extremity of a common rigid pedicle. This supporting stem is itself of variable dimensions, being sometimes only half as long as, but more often considerably exceeding in length the ovate loricæ. The compound groups of this species are apparently produced by the repeated longitudinal fission of a primary naked zooid of abnormal size, the formation and induration of the loricæ being accomplished subsequently. Examples of this type have been obtained from both Wandsworth Common and a pond near Acton. It was originally referred by the author to the genus *Dinobryon*, and is figured in connection with that generic title in the 'Popular Science Review' for April 1878.

Fam. VII. AMPHIMONADIDÆ, S. K.

Animalcules naked, free-swimming, or sedentary and adherent by a prolongation of the posterior extremity or by a distinctly developed caudal filament; flagella two in number, terminal, of equal size; no distinct oral aperture, food-substances being incepted at all points of the periphery.

The even development of the two flagella serves to distinguish the representatives of this family group from those of the Dendromonadidæ.

GENUS I. GONIOMONAS, Stein.

Animalcules free-swimming, persistent in shape, the anterior border obliquely truncate, having at the apex of the projecting angle two subequal and closely approximated flagella; multiplying by longitudinal fission.

HAB.—Fresh water.

This generic group is instituted by Stein * for the reception only of the *Monas truncata* of Fresenius.

Goniomonas truncata, Fres. sp. PL. XIV. FIGS. 31–33.

Body ovate, compressed, from one and a half to three times as long as broad, rounded posteriorly, the anterior border abruptly and obliquely truncate, with a sharply pointed and projecting anterior angle; flagella short, of uniform size, scarcely equalling the body in length, inserted at the apex of the projecting angle; parenchyma transparent, granular, enclosing near the anterior border a transversely placed, dark, band-like body; contractile vesicle situated on the shorter lateral border, a little behind the band-like body; endoplast located near the centre of the opposite or longer lateral border. Length 1–2500″ to 1–1000″. HAB.—Fresh water.

This species, synonymous with the *Monas truncata* of Fresenius, † has been recently encountered by both Bütschli and Stein, the former regarding it as a migrant member of the genus *Spumella*, to which he has provisionally relegated it, while the latter, as already mentioned, has instituted the present generic title for its reception. By both of these authorities has the anterior band-like body, first delineated by Fresenius, been observed, but is in either case evidently diversely

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* 'Infusionsthiere,' Abth. iii., 1878.

† "Beiträge zur Kenntniss Mikroskopischer Organismen," 'Abhandl. d. Senckenbergischen Naturforschenden Gesellschaft,' Frankfort, 1858.

interpreted. Bütschli remarks that under a high magnifying power it exhibits a granular formation, and is apparently homologous with the eye-like pigment-spot of *Euglena* and other Flagellata, while in Stein's figures, unfortunately accompanied by no descriptive text, the same initial (*b*) is set against it that is employed in a neighbouring form *Spumella guttula*—distinguished by the possession of a similar granular pigment-band—for the indication of a presumed oral furrow. The presence of ingested food-matter within the substance of the parenchyma is figured and alluded to by Professor Stein, and is probably incepted indifferently at all parts of the periphery. The movements of this type are reported by Bütschli to be rapid and uninterrupted; in some minute examples, however, recently examined by the author, the locomotion was observed to be weak, tremulous, and subject to constant interruption.

GENUS II. AMPHIMONAS, Dujardin.

Animalcules of spherical, ovate, or irregular outline, plastic and changeable in shape, attached posteriorly by a slender, non-contractile, thread-like filament: flagella two in number, equal in length and character; food incepted at any portion of the periphery; contractile vesicle and endoplast usually conspicuous.

Out of the three species of this genus enumerated by Dujardin, the one, *Amphimonas caudata*, is referable to the genus *Heteronema*, while the other two, *A. dispar* and *A. brachiata*, are exceedingly doubtful forms that might represent the motile condition of various biflagellate types. The two new species here introduced adapt themselves so well, however, to the broad characters of the genus as first established by Dujardin, that it seems desirable, with some slight amendment, to retain his generic title of *Amphimonas* for them in preference to constructing a new one, which would otherwise be necessary. As here characterized, the representatives of this genus correspond on the one hand with those of *Physomonas*, from which they are to be distinguished by their possession of two equal-sized flagellate appendages, and on the other with those of *Deltomonas*, which while possessing similar flagellate organs, attach themselves bodily to the chosen fulcrum of support without the intermedium of a filamentous pedicle. Perty, in referring a single form to the genus *Amphimonas* under the title of *A. exilis*, evidently associated with Dujardin's generic group an interpretation closely corresponding with the one here adopted. Diesing, in his 'Conspectus dispositionis familiarum et generum,' has merged the several species of *Hexamita* of Dujardin in the genus *Amphimonas*, though upon what grounds it is difficult to comprehend, the animalcules of that generic type being multiflagellate and, as hitherto recorded, free-swimming forms, presenting no resemblance whatever to the fixed biflagellate monads now under consideration.

Amphimonas globosa, S. K. PL. XIV. FIGS. 55–59.

Body subspherical, attached posteriorly by a slender, flexible, filamentous pedicle, equal in length to about three times its own diameter; flagella even, inserted close to one another in the centre of the anterior border, twice the length of the body, vibrated in an irregular undulating manner; parenchyma hyaline, vacuolar; contractile vesicles two in number, situated a little behind the median line; endoplast spherical, subcentral. Diameter of body 1–2000″. HAB.—Pond water with Myriophyllum.

The considerably larger size of this animalcule serves to distinguish it at once from *Physomonas socialis* with which, when first seen, it is perhaps liable to be confounded. On closer examination it is, morever, found to entirely want the emargination of the anterior border characteristic of that species, this region in the present form being perfectly smooth and even. Lastly, and more importantly, the characters afforded by the flagella separate it decisively from either the last-named or any superficially corresponding type. Neither of these organs, which are of equal length, are extended in that rigid arcuate manner characteristic of the single longer flagellate appendage of either *Physomonas*, *Spumella*, or *Oikomonas*, but are vigorously lashed and vibrated now on one side and then on the other, as in *Diplomita*, describing a maze of convolutions not easy for the eye to follow; the body of the animalcule meanwhile sways to and fro or floats up and down at the end of its flexible pedicle as light as a child's air-ball at the end of its restraining string. Food-particles, seized by the extremities of the extended flagella, are thrown back against the body, the thin yielding sarcode opening and spreading out to engulf them at whatever point upon which they may happen to impinge. An interesting example of food-ingestion, as observed by the author, will be found represented at Pl. XIV. Figs. 56–59. The ingested morsel, a large Bacillus, was first captured end-on, a transparent film of sarcode flowing out to invest it, the captured prey was then brought crosswise along the anterior border of the animalcule, and finally bent up and tucked away within the inner substance of the little creature's body. At Fig. 55*a* an example is delineated in the act of ingesting a minute particle on its lateral border. Spherical pedicellated encystments, corresponding closely with those described of *Physomonas communis*, but of larger size, have been observed in the neighbourhood of the present species, and apparently belonged to it.

Amphimonas divaricans, S. K. Pl. XIV. Fig. 66.

Body irregular in form, widest transversely, rounded posteriorly, the anterior margin abruptly and obliquely truncate, its two lateral angles unequally produced as conical prolongations; flagella corresponding in length and character, borne respectively by the apex of the two anterior angular extensions, equal in length to twice the diameter of the body; pedicle slender, straight, nearly equal to the flagella in length. Height of body 1–10,000", greatest width 1–8500". Hab.—Salt water.

This remarkably minute monad has as yet been met with on one occasion only, a group of two or three individuals being then found attached to conferva filaments from a jar of sea-water containing various polyzoa and hydroid zoophytes, obtained at St. Heliers, Jersey. The flagella, stationed at the termination of the conical anterior prolongations, one of which is produced to twice the height of the other, exhibited great activity, whirling round and round in a circular manner, and at the same time presenting a somewhat sinuous outline. The parenchyma was colourless and slightly granular, and a vacuolar space, which probably represented the contractile vesicle, being visible towards the posterior extremity. The exceedingly small dimensions of this form necessitated the employment of a magnifying power of no less than 2000 diameters for the satisfactory recognition of the external characters here recorded.

Amphimonas exilis, Perty.

Body conical or wedge-shaped, attenuate posteriorly, the anterior border truncate, sometimes emarginate; flagella long and slender, issuing close to one another from the centre of the anterior border, equal in size, twice the length of the body; parenchyma colourless, motion oscillating. Length of body 1–2180". Hab.—Stale marsh-water.

Perty detected on one occasion the presence of a posterior thread-like filament, and upon which slender evidence only the species is here provisionally retained in the genus *Amphimonas.*

GENUS III. DELTOMONAS, S. K.

(Greek Δ ; *monas.*)

Animalcules variable in form, subtriangular or wedge-shaped, attached by an attenuate prolongation of the posterior extremity of the body, which does not, however, assume the character of a distinct pedicle or caudal filament; flagella two in number, of equal length; no distinct oral aperture. Inhabiting fresh water.

The animalcules of this genus, while corresponding with those of *Amphimonas* in their fixed habits, and in the possession of two subequal anterior flagella, are to be distinguished from them by their direct mode of attachment, without the intermedium of a specially differentiated pedicle.

Deltomonas cyclopum, S. K. PL. XIV. FIGS. 60–65.

Body exceedingly plastic and variable in shape, most usually elongate-clavate, triangular, or wedge-shaped, somewhat compressed, widest and truncate anteriorly, tapering gradually towards the attached posterior extremity; flagella similar in size and character, equalling the body in length, springing from the lateral angles of the truncate anterior border; parenchyma colourless, granular; contractile vesicle conspicuous, situated a little in advance of the centre of the body; endoplast spherical, subcentral. Length of extended body 1–3000".

HAB.—Pond water. Multiplying mostly by longitudinal, rarely by transverse fission, and by the breaking-up of the body-mass into spores.

This Flagellate type was found in the month of January 1877, literally encrusting with its multitudes the carapace and limbs of specimens of a species of *Cyclops* taken from a horsepond in the neighbourhood of Ashby-de-la-Zouch. The various contours presented by different animalcules of the same colony are almost too numerous for description. Simply ovate, clavate, symmetrically or obliquely pyriform, are among a few of the leading variations from the typical triangular shape exhibited, these variations depending more or less on the state of development or extension of the individual zooids, as also upon the aspect in which they are presented to the view of the observer. The species increases rapidly by longitudinal fission, the first indication given of this process being the appearance of two flagella in place of one only at each of the anterior angles (see Pl. XIV. Fig. 63), this being speedily followed by the gradual cleavage through the centre, from above downwards, of the entire body-substance. The two zooids produced by this process of multiplication, although usually completely separated, remain near to one another on the same fulcrum of support, and in this way a single individual speedily produces an extensive and closely aggregated colony. Not unfrequently instances have been met with in which the units produced in this manner were collected in little clusters of four or more individuals, the bases of which, if not organically united, sprang apparently from the same point of attachment, as shown at Fig. 62. On more rare occasions the phenomenon of transverse fission was likewise witnessed, the divided anterior portion swimming off as a Heteromitous biflagellate monad destined either to lay the foundation of a new community in a more remote district, or not improbably to aid in compassing the still more rapid multiplication of the species by a genetic fusion with another individual, followed by the breaking-up of the united zooids into spore-like elements. That a sporular mode of increase does occur in connection with this form, was fully demonstrated by the discovery occasionally, among the others, of pyriform encysted individuals, in which the whole body-substance was divided into minute oval bodies as shown at Figs. 64 and 65, such metamorphosed animalcules evidently representing the characteristic sporocyst stage recorded of numerous other flagellate types described in this treatise.

Fam. VIII. SPONGOMONADIDÆ, Stein.

Animalcules symmetrically ovate; usually social, invariably secreting an external protective covering, which may take the form of horny loricæ, a gelatinous, more or less granular zoocytium, or an arborescent tubular zoothecium; flagella two in number, of equal length; no distinct oral aperture. Inhabiting fresh water.

The representatives of this family group are to be distinguished from those of the Dendromonadidæ or Bikœcidæ—with which their supporting or protective fabrics most nearly correspond—by the symmetry of their bodies and the equal development of the two flagella. The majority of forms included are remarkable for the considerable and often visibly conspicuous size attained by their compound colony-stocks.

Genus I. CLADOMONAS, Stein.

Animalcules ovate, with two anteriorly inserted, equal-sized flagella, living in social colonies, dividing by longitudinal fission, and building up a tubular and more or less regular, dichotomously branching zoothecium; the tubular branches not united to one another in a fasciculate manner, but remaining distinct throughout their length, and enclosing each at its distal end a single zooid; the basal end of each tubule sometimes separated from the preceding one by a distinct joint or dissepiment; zooids possessing no distinct oral aperture. Inhabiting fresh water.

The independence or non-fasciculate arrangement of the tubular branches of the zoothecium of this genus distinguishes it from that of *Rhipidodendron*, next described, with which it otherwise substantially corresponds. The form and structure of the enclosed animalcules are in both instances closely identical.

Cladomonas fruticulosa, Stein. Pl. XVIII. Figs. 11 and 12.

Zoothecium arborescent, erect, branching in the same plane, the separate ramifications short, rarely exceeding twice the length of the zooids, straight or flexuose; the bodies of the zooids evenly ovate, usually projecting for about half-way beyond the orifices of their respective tubules; flagella equal to or exceeding twice the length of the body; contractile vesicle conspicuous, subcentral. Length of bodies 1–3000″, height of zoothecium 1–300″. Hab.—Fresh water.

The two colonies of this species figured by Stein,* here reproduced, differ remarkably, the tubular ramuscules in one example being perfectly straight, and

* 'Infusionsthiere,' Abth. iii., 1878.

divaricating at an approximately uniform angle of 45°, while in the second and larger specimen these, while branching in the same plane, curve about in an altogether irregular manner. It is possible that this less regularly constructed tenement represents an instance in which the food supply had been less plentiful, the tubular fabric excreted losing through such a cause—as in the branching stalk of *Anthophysa vegetans*—its characteristic more erect and rigid bearing. In this comparatively irregular example, there would also appear to be an entire absence of the dissepiments or joint-like structure developed at each point of bifurcation in the more symmetrical and rigid form. The adult colonies of this species, according to Stein's figures, contain from but ten to fourteen zooids; the tubules, immediately succeeding the act of longitudinal fission of the enclosed zooids and preceding the further development and bifurcation of the ramuscule, necessarily enclose two animalcules.

Genus II. RHIPIDODENDRON, Stein.

Animalcules ovate, with two anteriorly inserted, attenuate and equal-sized vibratile flagella, living in social colonies, and building up a flabellate or dendriform aggregation or zoothecium of closely approximated granular tubules, the cavities of which are separately inhabited by a single zooid; contractile vesicle and endoplast conspicuous; no distinct oral aperture. Inhabiting fresh water.

Rhipidodendron splendidum, Stein. Pl. XVI. Figs. 1–3.

Aggregated tubules of the colony-stock forming an erect, compressed, flabelliform, profusely branching zoothecium; animalcules evenly ovate or elliptical, usually occupying the distal extremity of these tubules, their flagella only projecting into the surrounding water; flagella of equal size, about twice the length of the body; contractile vesicle and endoplast situated close to each other a little behind the centre of the body; parenchyma transparent, granular. Length of zooids 1–2000″, height of adult zoothecium 1–75″. Hab.—Fresh water.

The plate devoted by Professor Stein to the illustration of this most remarkable type* may be justly described as forming the gem of the entire series contained in his recently issued and important work. The innumerable members of the extensive colony-stock build up an aggregated structure that may be compared most appropriately with the similarly fan-shaped, tubular polyparies of the Cyclostomatous Polyzoon *Tubulipora flabellaris*. As suggested by Stein, it would seem just possible that the *Aporea ambigua*, described by J. W. Bailey in vol. ii. of the 'Smithsonian Contributions' for 1850 as a doubtful algoid or stalked infusorial product, is identical with this type; this earlier name, in the event of such identity being substantiated, will necessarily take precedence of Stein's. So far as it is possible to decide in the absence of full descriptive details, the ramifying tubular zoothecium of this interesting species would seem to be homologous with the solid branching pedicle or zoodendrium of *Anthophysa vegetans*, its tubular instead of solid character resulting through its secretion or excretion from the entire periphery of the individual animalcules, instead of from their posterior extremity only. As delineated by Stein, the consistence of this excreted zoothecium exhibits a distinct granular aspect, and is, in accordance with the accompanying explanation, of a rust-brown hue. In the larger example figured by this authority, and here reproduced, Pl. XVI. Fig. 1,

* 'Infusionsthiere,' Abth. iii. Taf. iv., 1878.

on a slightly reduced scale, there are no less than two hundred tubules bound together in the flabelliform zoothecium, about one-half of these only, however, being occupied by their minute fabricators.

Rhipidodendron Huxleyi, S. K. PL. XVI. FIGS. 4–9.

Aggregated tubules forming a spreading, bush-like, rust-brown, dichotomously branching, granular zoothecium, each separate branchlet of which is normally composed of four laterally united tubules; animalcules elongate-ovate, about twice as long as broad, scarcely projecting beyond the apertures of their respective tubules; flagella of equal size, twice the length of the body, inserted close to one another at the anterior extremity. Length of zooids 1–4000″, diameter of adult bush-like zoothecium 1–10″.

HAB.—Bog water.

This second species of the genus *Rhipidodendron* represents one of the latest acquisitions chronicled in this treatise, it having been collected by the author in September 1879 at Lustleigh Cleave, on the borders of Dartmoor, S. Devon; the same bog water yielding also the two new forms hereafter described under the titles of *Spongomonas sacculus* and *Monosiga longicollis.*

From the preceding type the present species may be at once distinguished by the attenuate form of growth of the zoothecium, only four tubules, as a rule, instead of a large and indefinite number, being bound up together in each separate ramuscule. The manner in which this more symmetrically branching zoothecium is constructed, is made apparent by reference to the diagrammatic illustration given at Pl. XVI. Fig. 8. As there shown, all four of the monads inhabiting the primitive four-chambered ramuscule divide by longitudinal fission simultaneously and abreast of one another, the result being the production of eight in place of the preceding four; the lateral pressure thus brought to bear within the comparatively confined space causes each equal moiety of four zooids to diverge slightly from the other, and these continuing independently the fabrication of their granular sheath, produce, at more or less regular intervals, the characteristic bifurcation of the entire mass. The absence of symmetrical subdivision of the zoothecium in *R. splendidum* is explained by the fact that the component tubules are congregated in rows two or three deep, the monads evidently not separating persistently in the same plane as obtains in the present type. The rust-brown, bush-like zoothecia of this species were produced abundantly, in close proximity to those of *Spongomonas sacculus*, on the sides of the bottle of water brought from the locality quoted, remaining so attached and forming conspicuous objects to the unaided vision for several weeks. Fragmentary branches of the zoothecia of a species identical with, or closely allied to, the present form, but exhibiting less regularity in the combination of the individual tubules and plan of bifurcation, have been recently received by the author from Mr. J. Levick, of Birmingham.

GENUS III. SPONGOMONAS, Stein.

Animalcules evenly ovate or spheroidal, provided with two equal-sized, anteriorly inserted, vibratile flagella; living in social colonies, and forming by excretion a common domicile, which takes the form of a variously modified gelatinous or semi-granular zoocytium, within which they remain constantly immersed, their flagella only protruding into the outer water; contractile vesicle and endoplast usually conspicuous; no distinct oral aperture. Inhabiting fresh water. Increasing by longitudinal fission and by the subdivision of the entire body into sporular elements.

This genus is founded by Stein * upon the *Phalansterium intestinum* of Cienkowski, two new and highly characteristic species being added. The desirability of separating this type from the monoflagellate *Phalansterium consociatum* of the last-named writer, had been recognized by the author previous to the publication of Stein's volume, and he had allotted to it in the manuscript of this work, then in the printer's hands, the new generic title of *Gleomonas*. The animalcules of *Spongomonas* correspond essentially in general form and structure with those of *Rhipidodendron* and *Cladomonas*, differing only in the character of the common supporting and protective element they collectively excrete, which here takes the form of a gelatinous and more or less granular zoocytium, closely analogous to the common slime-sheath produced by *Ophrydium* in the section of the Ciliata.

Spongomonas intestinalis, Cienk. sp. PL. XI. FIGS. 11–14.

Gelatinous zoocytium or common investing matrix presenting a slender, attenuate, more or less irregularly convolute, thread-like contour; contained animalcules ovate or subglobose; flagella similar in size and character, twice the length of the body, protruding for almost their entire length beyond the periphery of the zoocytium; contractile vesicle single, lateral; endoplast spherical, subcentral. Length of zooids 1–3000", diameter of thread-like matrix 1–250" to 1–125".

HAB.—Pond water with *Anthophysa* and *Dinobryon*.

As already stated, this species was primarily included by Cienkowski in his newly established genus, *Phalansterium*.† The more luxuriant colony-stocks may attain, according to this same authority, a length of as much as three centimetres, forming, under such circumstances, conspicuous objects to the unaided vision. These extensive colonies are produced by continuous fission and sporular subdivision from a single primary individual, accompanied by the secretion or exudation by each monad so produced, of mucus and rejectamenta, towards the building-up of the common gelatinous slime-sheath. The free ingestion of particles of indigo, at apparently no distinct oral aperture, is recorded by Cienkowski. The more explicit details of the form, structure, and mode of subdivision of the monads, supplied by Stein's recent illustrations, are reproduced in the accompanying plate. As there shown, a single zooid, by encystment and segmentation, becomes divided into two, four, or eight sporular elements.

Spongomonas discus, Stein. PL. XI. FIG. 10.

Zoocytium discoidal, flattened, gelatinous, and highly granular; animalcules subspheroidal; flagella two or three times the length of the body. Dimensions 1–3200". HAB.—Fresh water.

The zoothecium of this species corresponds closely in general form with that of *Phalansterium consociatum*, but does not exhibit the radiating or chambered subdivision of its structure characteristic of that type. Stein is somewhat uncertain which of these two represents the originally described *Monas consociata* of Fresenius, but the possession by each animalcule of a single flagellum only, is so clearly indicated in the figures given by that authority, as to leave but little doubt as to the correctness of Cienkowski's interpretation. Many individuals in the group figured by Stein, here reproduced, have withdrawn their flagella and become separated into

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* 'Infusionsthiere,' Abth. iii., 1878.

† L. Cienkowski, "Ueber Palmellaceen und einige Flagellaten," 'Archiv f. Mik. Anat.,' Bd. vi. Heft 4, 1870.

two or four macrospores within spheroidal cavities of the gelatinous zoothecium previously occupied by the parent zooids.

Spongomonas uvella, Stein. PL. XI. FIGS. 15 AND 16.

Animalcules ovate, nearly twice as long as broad, forming an erect, lobulate zoocytium, which tapers posteriorly into a short, slender, and almost stalk-like point of attachment; expanding distally into a variable number of closely associated ovate lobules, each of which is inhabited by a separate zooid; flagella rarely exceeding twice the length of the bodies, mostly less. Length 1–2100″, height of zoocytium 1–500″. HAB.—Fresh water.

The largest colony-stock of this species figured by Stein and here reproduced, contains about a dozen zooids only. No indication is given of spore-production, after the manner of the two preceding types.

Spongomonas sacculus, S. K. PL. XI. FIGS. 17–23.

Zoocytium granular, rust-brown colour, subglobose or sacculate, pendant, many individual zooids crowded within each saccular diverticulum of the common mass; the social colony-stock produced forming in its entirety a conspicuous object to the unaided vision; animalcules elongate-ovate, twice as long as broad; flagella about twice the length of the bodies; contractile vesicle lateral; endoplast ovate, central. Length of zooids 1–3250″, of adult saccular zoocytium 1–25″ to ½″. HAB.—Bog water.

This species was obtained by the author in September 1879, in bog water collected at Lustleigh Cleave, S. Devon, in company with *Rhipidodendron Huxleyi*. As first encountered it was passed over as mere flocculent inorganic debris adherent to the sides of the glass receptacle, and it was only by the accidental inclusion of a fragment with the examined specimens of the last-named type, that its presence and true nature were elicited. Once recognized, its existence in corresponding or even greater abundance than *Rhipidodendron* became apparent, and data of interest concerning its structural characteristics and rapidity of growth were placed on record. In this last connection, more especially, it was found, by taking diurnal measurements, that a colony-stock which on a given day presented in its total bulk the size only of a grain of millet-seed, or a diameter of 1–25″, might within three days so increase in calibre as to form a subpyriform pendulous sac, equalling or slightly exceeding the length of half an inch. From this point the zoocytium usually became disintegrated, and, falling away piecemeal, liberated the contained monads into the surrounding water under conditions favourable, no doubt, for the establishment of new colonies. A delineation of the contours of such a colony-stock, as observed at the commencement and termination of three consecutive days, is reproduced at Pl. XI. Figs. 18 and 19.

When examined with a high magnifying power, a conspicuous feature of the zoocytium of this type, shared, however, not only by the remaining members of this genus, but being in a less degree characteristic also of the more substantial zoothecia and zoocytia of *Rhipidodendron*, *Phalansterium*, and apparently *Cladomonas*, is manifested by the exceedingly regular distribution and even size of the granular particles distributed through its substance, and which add so materially to its consistence. In the present instance, these granular elements, taken separately, are of a roughly spheroidal shape, having a diameter of about one-tenth of the length of the associated monads, or the 1-30,000th of an inch, and exhibit by transmitted light a pale amber hue. So densely are these minute particles packed together within the transparent and mucilaginous element of the zoocytium, that they represent at least one-half of the total bulk of this structure, imparting to it, by their dense aggregation, the rich chestnut-brown or tawny hue characteristic of the entire organism, as seen even with the unassisted vision. The interpretation of the nature and origin of these minute coloured granules is undoubtedly to be found connected with the phenomena of excretion, and of which they are as much the direct product as is the branching stem or zoodendrium of *Anthophysa vegetans*, described in a previous page. In its more robust state of growth, the excreted elements in that species are welded together so as to produce one tolerably homogeneous, longitudinally striate stem; but in its more weakly condition, or when the food-material supplied is not sufficiently soluble, the excreted refuse is deposited and built into the substance of the stalk as two distinct elements, partly mucous and partly granular. It is this more abnormal condition, as seen in *Anthophysa*, that represents the normal one of *Spongomonas*, and apparently also that of the several previously-named Flagellate genera in which the mucilaginous and granular constituents are as persistently distinct. In *Rhipidodendron* and *Cladomonas*, however, the separate granular and mucilaginous elements, while plainly visible in the external wall of the zoothecium, are more closely amalgamated, and present an almost complete homogeneous consistence in the interior or lining layer of each tubule, the structure in its integrity thus acquiring that greater solidity which permits of its assumption of an erect dendritic contour.

The zooids of *Spongomonas sacculus* were observed to divide by transverse fission, the temporary retraction of the flagella and the lengthening and segmentation of the ovate endoplast constituting the preliminary act to such duplicative process. Sporular subdivision, as recorded of *S. intestinum*, has not as yet been detected. The distinction of this type from *Spongomonas uvella*, its apparent nearest ally, is manifested, independently of the comparatively colossal proportions it attains, by the crowded distribution of the monads within each lobe or saccular dilatation of the compound zoocytium, those in the last-named type occupying each a separately projecting chamber.

GENUS IV. DIPLOMITA, S. K.

(Greek, *diploos*, double; *mitos*, thread.)

Animalcules solitary, evenly ovate, attached by a thread-like retractile ligament to the bottom of a simple, pedicellate, horny lorica; flagella two in number, similar in length and character; the front margin not produced in a lip-like manner; a rudimentary eye-like pigment-spot often present in the anterior region; no distinct oral aperture. Inhabiting fresh water.

The as yet single known representative of this genus, while resembling *Bicosœca* in the form of the lorica and its mode of attachment within the same, exhibits in the character of the flagella and general features of the contained animalcule, so close a conformity to the zooids of *Spongomonas* and its allies, that it is here referred to the same family group.

Diplomita socialis, S. K. PL. XVIII. FIGS. 30 AND 31.

Lorica evenly ovate, about twice as long as broad, attached by a short pedicle; animalcules with two long terminal flagella of equal length, occupying a little more than one-half of the cavity of the lorica, slightly exsert from the aperture of this structure when extended; contractile vesicle posteriorly located; endoplast spherical, subcentral; parenchyma transparent, homogeneous; a minute, eye-like pigment-spot situated near the anterior extremity. Length of lorica 1-1675"; colour pale brown, or amber.

HAB.—Pond water.

The lorica in this species so closely resembles that of *Bicosœca lacustris*, that when empty, except for its larger size, it might be easily mistaken for it. The structure of the enclosed animalcule is, however, altogether distinct. In place of the one long and one short flagellum, there are here two long, equal-sized flagella, which lash the water vigorously in every direction, instead of being extended rigidly in an arcuate form with the extreme point alone vibrating, as obtains in the single long appendage of *Bicosœca*. There is likewise no distinct lip-like projection or rostrum, as in that type, the anterior border being evenly rounded. Where found, this animalcule usually occurs in considerable numbers, completely covering the filaments of *Confervæ* or other aquatic objects, as shown in Pl. XVIII. Fig. 31. The colour of the lorica in *Diplomita* is deeper than has as yet been observed in any other representative of the Pantostomatous group, presenting usually in adult examples a pale brown or amber hue. This circumstance may be cited as additional evidence in indication of its near affinity to the generic forms with which it is here correlated, but which in place of secreting separate loricæ, build up similarly coloured zoothecia or zoocytia. In all the examples so far examined, a bright spot, corresponding apparently with the so-called eye-speck of *Euglena*, *Dinobryon*, and other Flagellata, was conspicuous towards the anterior extremity. This type was first figured and briefly described by the author under the title of *Bicosœca socialis*, in the 'Monthly Microscopical Journal' for December 1871.

Fam. IX. HETEROMITIDÆ, S. K.

Animalcules naked, free-swimming or temporarily attached; flagella two in number, the more anterior appendage, "tractellum," locomotive and vibratile, the posterior one, "gubernaculum," usually trailing and adherent; no distinct oral aperture.

The representatives of this family correspond closely in their general form, habits, and character of the flagella with those of the Stomatode Anisonemidæ, but differ from them owing to the total absence of a distinct oral aperture, food-ingestion being accomplished at diverse points of the periphery. The appropriate titles of a "gubernaculum" and "tractellum," proposed respectively by Professors H. James-Clark and E. Ray Lankester for the distinction of the peculiar modified trailing flagellum and the ordinary vibratile appendage characteristic of the Heteromitidæ and other Flagellata, are here cordially adopted. A fuller reference to this subject is made in the account given hereafter of the family Anisonemidæ.

Genus I. HETEROMITA, Dujardin.

Animalcules free-swimming or temporarily attached, ovoid, globular, or elongate, plastic and changeable in shape, having no differentiated cuticular investment; flagella two in number, originating close to each other at the anterior or antero-ventral extremity of the body, the foremost, tractellum, directed in advance and constantly vibrated, the more posterior one, gubernaculum, usually trailing, or adherent by its distal extremity; food ingested at any portion of the periphery, possessing no distinct mouth. Inhabiting fresh and salt water, very abundant in animal and vegetable infusions.

Dujardin instituted this genus for the reception of those flagellate forms which, while agreeing with *Heteronema* and *Anisonema* in their external contour, are to be distinguished from them by the absence of a distinct cuticular investment. By many later writers this distinction has been considered insufficient for generic separation. A prolonged and careful investigation of numerous representatives of this genus has, however, enabled the author to point out a second and even more important correlative differentiation. Reference is here made to the ingestive functions, which in *Heteromita* correspond with those of *Oikomonas*, *Amphimonas*, *Physomonas*, and other Flagellata previously described, as manifested by the capacity to incept food at any portion of the periphery. Both *Anisonema* and *Heteronema* in this respect offer a much more highly advanced structural type, each of these possessing, as demonstrated by Bütschli and Stein, a distinct oral aperture and pharyngeal tract.

In Stein's recently published volume several species of *Heteromitæ* are referred to the genus *Bodo;* the last-named generic title, however, does not adapt itself to the forms included under the same denomination in this treatise, or as comprehended in it by other recent authorities.

The presumed resemblance between certain members of this genus and the so-called zoospores of the parasitic fungus *Peronospora infestans* will be found discussed in connection with the descriptive account of *Heteromita lens*.

Heteromita lens, Müller sp. PL. XV. FIGS. 1–17.

Body exceedingly soft and plastic, susceptible of considerable alteration of contour, usually subglobose, peach-shaped, or more or less ovate with a slightly narrower anterior extremity; flagella equal in size, very slender and flexible throughout, about twice the length of the body; endoplast spherical, subcentral; contractile vesicle posteriorly situated. Length 1–5000″ to 1–3250″.

HAB.—Vegetable infusions in both fresh and salt water.

This species, here identified with the *Monas lens* of Müller, occurs in vast abundance in hay infusions in both fresh and salt water, being usually, indeed, the first form to make its appearance in such artificial macerations. By continued and repeated examinations, the life-cycle and developmental manifestations of this type have been successfully traced, and are found to correspond broadly with those of the two species studied by Messrs. Dallinger and Drysdale, next described.

The results of the author's recent investigation of this form may be thus briefly summarized:—So soon as within twelve hours after placing the hay to macerate, the ordinary spring water used had become slightly discoloured, and on examination was found to contain, in addition to *Bacteria*, numerous excessively minute monadiform beings, spherical in shape, measuring the 1–20,000th part of an inch only in their diameter. These minute organisms, as shown at Pl. XV. Figs. 11–14, occurred singly or united in groups or short moniliform clusters, and propelled themselves through the water with an oscillating motion by the means of single, anteriorly developed, vibratile flagella. These motile organs necessarily required the most careful adjustment of the illuminating agency for their detection, and were often made manifest only by the movements of the particles in the surrounding water induced by their vibrations. At this early stage of their growth the monadiform units might, in their isolated condition, be identified with the *Monas punctum* or *pulvisculus* of Ehrenberg, or with any other of the simple globular forms of the genus *Monas*, that are so minute as to have received at the hands of their first discoverers no more definite description than that of mere moving points. The moniliform or aggregated clusters, on the other hand, delineated at Figs. 11, 12, and 14, so essentially and unmistakably correspond with the younger and more minute conditions of *Monas lens*, as depicted by O. F. Müller in Table i. fig. 11 of his 'Animalcula Infusoria' (1786), that the author has not the slightest hesitation in identifying them with his species. A closer investigation of fragments of the hay undergoing maceration revealed the presence of crowds of minute quiescent sporiform bodies identical in size with the motile units, and as which they were later on seen to detach themselves and swim away. These quiescent spores were found scattered more or less thickly over the entire surface of the hay, and were in many instances massed together in small symmetrical spheroidal heaps. The growth in the maceration of the motile monadiform units just described, proceeded so rapidly that within the course of only a few hours the entire field of the microscope, as supplied from the most minute dipping, was found crowded with adult zooids corresponding in form, size, and structure with the terms of the foregoing diagnosis.

In their most characteristic adult state the animalcules of *Heteromita lens* are normally subspherical or peach-shaped, as represented at Pl. XV. Fig. 1, but are subject to considerable individual variation. An ovoid form with a somewhat narrower anterior extremity (Fig. 2), on the symmetrical side, and an irregular, almost amœbiform contour (Fig. 3) on the unsymmetrical one, represent the most constant departures from the typical subspheroidal shape that have to be recorded. The greater portion of these monads were to be seen, as soon as the excitement ensuing upon their transference to the glass slide had subsided, temporarily attached, or as it were anchored, to the glass or vegetable debris through the medium of the hinder flagellum, or gubernaculum, and upon which the body oscillated, as though on a pendulum, through the constantly vibratory action of the anterior appendage. Many others were, however, swimming freely in the water, in some instances trailing their posterior or gubernaculate flagellum in the rear, and flourishing the anterior one in advance, while in others both flagella were directed anteriorly, their joint vibratory action assisting in the task of locomotion. These last-named examples, however, would appear to represent animalcules which had either passed or not yet arrived at their complete development. Division by longitudinal fission, as also the coalescence or fusion of the adult monads (Figs. 7 and 8), were frequently observed, likewise the subsequent encystment and breaking up of the intimately amalgamated zooids into minute spores corresponding precisely in form and size with those from which, as already shown, they originally sprang. In addition to this genetic mode of reproduction, multiplication by the simple encystment and splitting into four, eight, or sixteen segments or macrospores of the single zooids, was likewise authenticated, each such subdivided portion possessing two flagella, and, except for its more minute size, corresponding entirely with the parent animalcules at the time of its liberation into the surrounding water; the more conspicuous features of this reproductive process are represented at Figs. 15–17 of the same plate. Investigations pursued simultaneously with the vegetable material of a like nature macerated in sea-water instead of fresh, were attended by a similar first arrival of a monad perfectly agreeing in form and in its developmental cycle with the present species, excepting that the size was slightly smaller and the endoplasm apparently a little more dense and compact. This slight variation in size and consistence may be reasonably attributed to the higher specific gravity of the fluid medium employed. The *Heteromita granulum* of Dujardin, characterized by its spherical granulate body and two equal, slender flagella—diameter 1–2250″, hab. salt water—is probably identical with this marine variety of *H. lens*.

A feature of interest relating to the life-history of the present species that remains to be recorded, bears reference to the conduct of the animalcules under conditions inauspicious to their well-being, and which may be regarded as a modification of the process of diffluence. Thus if confined in quantities between the ordinary slide and cover-glass without a renewal of liquid medium, the oxygen apparently gets insufficient to support life comfortably, the movements of the animalcules grow weaker and more sluggish, and presently losing their capacity of fixing or anchoring themselves by their trailing flagellum, they float freely in the water, and are carried passively in whichever direction the capillary currents produced by the evaporation of the water may set in. Sometimes the normal spheroidal or ovate contour is retained for a considerable interval, but more usually the peripheral wall appears to entirely lose its customary more firm consistence, and the whole body-sarcode becomes projected in various directions, after the manner of ragged and irregularly developed pseudopodia. As the animalcule drifts helplessly along, these improvised pseudopodia often adhere tenaciously to the slide or other object, arresting its further progress, the aspect manifested under such conditions being represented at Pl. XV. Fig. 4. With a renewal of fresh oxygenated water the animalcules speedily reassume their pristine symmetry and activity, while by a further withholding of this important element complete dissolution soon terminates the scene. Additional details respecting the discovery of this species both in its adult and sporular conditions, in intimate connection with both hay and growing grass, are recorded at page 136 *et seq.*, of Chapter IV. (see also upper portion of Pl. XI.) devoted to the subject of Spontaneous Generation.

So remarkable a likeness subsists between the so-called biflagellate "zoospores" of the potato-fungus, *Peronospora infestans*, figured by Mr. Worthington Smith in the 'Monthly Microscopical Journal' for September 1876, and the typical adult zooids of *Hetromita lens* as here figured and described, that the author is unable to repress a suspicion that these presumed zoospores actually represent examples of the present cosmopolitan animalcule. Not only are the sizes of the bodies and the various shapes assumed absolutely identical, but even the presence of an endoplast and contractile vesicle, which occupy precisely similar relative positions, is clearly though unconsciously indicated in Mr. Smith's drawings. The abundant and almost invariable development of *H. lens* in connection with decaying foliage and other vegetable matters derived from well nigh every source, renders it not only possible but highly probable that the spores of these animalcules were imported with the potato leaves that formed the subject of Mr. Worthington Smith's investigation, freely developing side by side with the germs of the cryptogamic plant, and during their quiescent states so closely resembling them that their distinct nature and independent origin escaped detection.

Heteromita rostrata, S. K. Pl. XV. Figs. 18–28.

Body elongate-ovate, somewhat inflated posteriorly, the anterior extremity pointed and usually slightly recurved towards the ventral aspect; flagella equally slender, the anterior vibratile flagellum from one and a half to twice the length of the body, the posterior one, or gubernaculum, longer than the preceding, contracting, when the animalcule is attached, in a loose spiral coil; contractile vesicle mostly conspicuous, situated close to the anterior extremity; endoplast located near the opposite or posterior extremity. Length of body 1–3000″.

Hab.—Putrefying fish macerations.

The above title is here conferred upon the species figured and described by Messrs. Dallinger and Drysdale * under the name of the "Springing Monad," the springing action suggesting the name being caused by the rapid coiling and uncoiling of the longer anchoring or gubernaculate flagellum in its fixed condition. A similar leaping motion through the contraction of the gubernaculum being common to various other species of the genus *Heteromita*, the technical name here adopted has been conferred upon it more particularly with relation to the peculiar beak-like or rostrate contour of the anterior extremity of the body. The developmental and reproductive phenomena of this form as carefully followed out by its discoverers, correspond broadly with those of the many other monadiform animalcules they examined. Multiplication by the ordinary process of longitudinal fission represents the commonest and most conspicuous mode of increase, the two flagella, as shown at Pl. XV. Fig. 19, participating in the duplicative process. Certain animalcules, however, assume a spherical quiescent state and split obliquely or transversely into halves, each such divided portion swimming away in a form not distinguishable from the typical zooids. Further tracing these motile units, it was found that they did not attach themselves by their anchoring flagella, but wandered about until they came in contact with the ordinary sedentary monads, and with which they immediately coalesced. The ultimate result of this genetic fusion was the production of triangular encystments, which subsequently dehiscing at their three

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* 'Monthly Microscopical Journal,' Dec. 1873.

angles, liberated countless spores of infinitesimal dimensions. A space of ten hours was occupied in the attainment by these almost invisible spores of the typical adult form and size, these germinal products passing, in their onward growth, through a phase in which a single flagellum, and that the posterior or anchoring one, alone was visible. The illustrations given by Messrs. Dallinger and Drysdale of this interesting genetic reproductive process are reproduced at Pl. XV. Figs. 22–28. An adult monad, presenting the essential characteristics of the half-developed monoflagellate condition of *Heteromita rostrata*, recently discovered by the author in salt water, has been previously figured and described under the title of *Ancyromonas marina.*

Heteromita uncinata, S. K. Pl. XV. Figs. 29–41.

Body smooth, ovate, rounded posteriorly, narrower and slightly curved towards the ventral aspect anteriorly; anterior vibratile flagellum short, scarcely exceeding one-half of the length of the body, recurved or hooked at its extremity, posterior or trailing flagellum more than twice the length of the body; contractile vesicle conspicuous, situated near the narrower anterior end; endoplast at the opposite extremity. Length 1–4000″ to 1–3000″.

Hab.—Fish macerations in an advanced state of putrefaction.

The foregoing specific name is here proposed for the type figured and described by Messrs. Dallinger and Drysdale * under the title of the "Hooked Monad." Its developmental cycle, as successfully traced by these gentlemen, differs considerably in its details from that of the form last described. Transverse fission, preceded usually by the assumption of a semi-amœboid condition of the subdividing animalcule, constitutes the most simple mode of increase. The more important genetic mode of reproduction was found, however, to consist of the intimate amalgamation not only of two, but often of as many as four or even six individual zooids, the result of such fusion being the production of a larger or smaller spheroidal cyst, from which active monadiform germs of appreciable size, and in many instances already furnished with a single (the posterior) flagellum, were subsequently liberated. This monad is described as progressing rapidly through the water by a series of jerks or springs, which follow each other in constant succession, and are coincident with the movements of the hooked flagellum; no mention is made of its anchoring itself by the longer and trailing one, though this appendage is doubtless used for such a purpose. The so-called "snapping eyelid" alluded to by Messrs. Dallinger and Drysdale, undoubtedly represents the characteristic contractile vesicle, and in those instances where the anterior flagellum is described as having a knob or knot at its free extremity the animalcule is apparently engaged in withdrawing the organ into the substance of its body previous to the assumption of an amœboid condition and ultimate encystment.

The phenomenon of the compound coalescence or genetic union of a plurality of zooids, attested to by the authorities here quoted, in connection with *Heteromita uncinata*, is of especial interest, on account of the circumstance that a practically identical process of compound coalescence productive of sporular elements or their equivalents on a comparatively colossal scale obtains in the two groups of the Myxomycetes or Mycetozoa and the Spongida.

In neither of the two species of *Heteromita*, just described, and for whose discovery and life-history we are indebted to the painstaking researches of Messrs. Dallinger and Drysdale, has any intimation whatever been as yet given respecting their alimentary functions. Had a distinct oral orifice existed, or had the inception

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* 'Monthly Microscopical Journal,' Jan. 1874.

of solid food-particles at any point been directly observed, testimony to this effect would undoubtedly have been placed on record. Since, however, both in their illustrations and descriptive text all evidence of food-ingestion or of a food-ingesting aperture is conspicuous for its absence, there is substantial ground for premising that these lowly organized beings derive their sustenance after the manner of the Opalinidæ, by the direct imbibition, at all parts of their periphery, of the proteaceous nutritive fluids within which they are constantly immersed.

Heteromita ovata, Duj. Pl. XV. Figs. 65 and 66.

Body ovate, narrower anteriorly; surface smooth; endoplasm slightly granulate; anterior or terminative flagellum slender, two or three times longer than body, flexible throughout; posterior or anchoring flagellum four times the length of the body, and twice the thickness of the anterior one; contractile vesicle conspicuous, situated near the anterior extremity. Length of body 1–1000″ to 1–700″.

Hab.—River water with aquatic plants.

A form agreeing structurally with the terms of the foregoing diagnosis has been met with by the author in pond water, its increase by longitudinal fission, and the inception of food at various points of the periphery being also observed.

An animalcule presumed to be identical with this species but having a depressed lenticular contour with a plane ventral and convex dorsal surface, is figured by Stein under the name of *Bodo ovatus*, his drawings of it being represented in the accompanying plate. As there indicated, no less than three minute spheroidal contractile vesicles are stationed at the anterior extremity, the endoplast being located close behind them in the middle line. The two flagella as delineated by Stein are very slender and subequal in both length and thickness.

Heteromita globosa, Stein sp. Pl. XV. Figs. 61–64.

Body somewhat variable in shape, more usually subspheroidal or elliptical, surface coarsely granulate; flagella slender, subequal in length and thickness, two or three times the length of the body, inserted ventrally; contractile vesicle single, situated close to the centre of the right lateral border; endoplast spherical, located in the median line towards the anterior extremity. Length of body 1–2500″ to 1–1000″.

Hab.—Pond water.

This species is figured by Stein * in association with the title of *Bodo globosus*. An apparently identical form has been recently met with by the author in pond water from the neighbourhood of Birmingham, remitted by Mr. Levick. Numbers were crowded together within the carapace of a dead rotifer, *Noteus*, feasting upon its contents under conditions analogous to those reproduced from Stein's drawings at Pl. XV. Fig. 64, the pabulum in this instance being however the cell-contents of a fragment of *Œdogonium*. When thus collected within a small space, the distinction between the vibratile and trailing flagellum is not apparent, both appendages being deployed in advance and exhibiting an irregular undulatory motion. Except for their larger size and coarse granulation, the animalcules of this species coincide considerably in general form and proportions with those of *Heteromita lens*. The contractile vesicle, among other points of distinction, may be cited, however, as occupying a more anterior position.

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* 'Infusionsthiere,' Abth. iii., 1878.

Heteromita exigua, Perty.

Body oval or spheroidal, transparent; flagella about three times the length of the body, one projecting in front, the other trailing. Length 1–7200″ to 1–4800″.

HAB.—Turf water, in the Bernese Alps. Movements oscillating.

It is almost impossible to decide from the brief account given by Perty, whether this species is an independent form or only the young of another animalcule.

Heteromita pusilla, Perty.

Body elongate-ovate, subcylindrical, more or less constricted centrally, sometimes emarginate posteriorly; flagella from two to two and a half times the length of the body; endoplasm slightly granulate; movements oscillating. Length 1–3600″ to 1–2160″.

HAB.—Stagnant water with *Conferva.*

Heteromita amyli, Cienkowski sp.

Body elongate-fusiform, pointed at each extremity, seven or eight times as long as broad; flagella fine, subequal, not quite as long as the body. Length 1–600″. HAB.—Pond water with decaying *Nitella.*

This species, originally described by Cienkowski under the name of *Monas amyli,** must necessarily be separated from the genus *Monas* on account of its possessing two flagellate appendages. The comportment and proportions of these organs in accordance with that writer's drawings, correspond furthermore so closely with those of the ordinary representatives of the present genus, that it appears desirable to retain it in the same. The assumption of an amœboid phase accompanied by the extension of slender ray-like pseudopodia was witnessed, as also the fusion or coalescence of numerous animalcules into a single mass during their amœboid state after the manner of *Heteromita uncinata* previously described. The result of this conjugative process was the formation of a spheroidal cyst, the contents of which split up into innumerable fragments to be subsequently released as monadiform germs. The presence of a spherical endoplast and one or more contractile vesicles was noted during the amœboid phase. Excepting that this animalcule is not reported to possess the faculty of assuming a spirally twisted contour, its general form and proportions correspond closely with those of the *Heteromita* (*Spiromonas*) *angustata* of Dujardin hereafter described.

Heteromita sulcata, Mereschk.

Body somewhat variable in form, more or less oval or cylindrical, about twice as long as broad, the hinder extremity rounded or evenly truncate, the anterior border obliquely truncate; the dorsal surface traversed throughout by three or four parallel longitudinal furrows or striations; flagella slender, subequal in size, the posterior or trailing one slightly the longer, not twice the length of the body; contractile vesicle single, of large size, situated close to the insertion of the flagella. Dimensions unrecorded.

HAB.—Fresh water: Northern Russia (Mereschkowski †).

* "Beiträge zur Kenntniss der Monaden," 'Archiv für Mikroskopische Anatomie,' Bd. i., 1865.

† "Studien über Protozoen des Nordlichen Russland," 'Archiv für Mikroskopische Anatomie,' Bd. xvi., 1878.

Heteromita adunca, Mereschk. Pl. XV. Fig. 44.

Body oval, rounded posteriorly, sharply pointed and curved to one side anteriorly, nearly three times as long as broad; cuticular surface entirely smooth; endoplasm transparent, finely granular; flagella slender, inserted at the anterior extremity, the vibratile appendage slightly longer than the body, the trailing one exceeding twice that length; contractile vesicle conspicuous, situated in the anterior body-half. Length 1–4000″.

Hab.—Salt water from the White Sea; on the surface of infusions (Mereschkowski). Movements quick, tremulous, in a zigzag manner.

Heteromita cylindrica, Mereschk.

Body cylindrical, evenly rounded at both extremities, twice as long as broad; cuticular surface entirely smooth; endoplasm finely granulate; flagella slender, the anterior one equalling the body in length, the posterior one about twice as long; contractile vesicle single, subcentral, very large. Length 1–700″. Hab.—Salt water: White Sea (Mereschkowski).

Genus II. COLPONEMA, Stein.

Animalcules free-swimming, persistent in shape, irregularly ovate, the anterior extremity pointed and curved to one side, the ventral surface with a broad, subcentral, longitudinal groove or channel; flagella two in number, the one vibratile and the other trailing, the former inserted at the base of the anterior projection, and in front of the oral aperture, the latter produced from towards the centre of the ventral groove.

Colponema loxodes, Stein. Pl. XV. Figs. 45 and 46.

Body gibbously ovate or subsigmoidal, about twice as long as broad, the anterior extremity pointed, curved towards the left, the posterior extremity more bluntly pointed, sometimes straight and sometimes curved towards the right, thus giving the body a sigmoidal outline; ventral groove very wide in the anterior region, narrowing as it approaches the posterior termination; flagella slender, subequal, exceeding the body in length; endoplasm transparent, granular; contractile vesicle spherical, centrally located; endoplast indistinct. Length 1–900″. Hab.—Fresh water.

The figures of this singular form, as here reproduced, without descriptive details, are alone published by Stein in his recently issued volume. In the lateral flexure of the anterior region it somewhat resembles the *Heteromita adunca* of Mereschkowski.

Genus III. SPIROMONAS, Perty.

Animalcules free-swimming or temporarily attached, soft and plastic, flattened or compressed, twisted spirally on their long axis, bearing two anteriorly inserted subequal flagella, one of which is adherent at will. Inhabiting infusions and water with decomposing organic matter.

The genus *Spiromonas*, as comprehended in this treatise, includes the *Cyclidium distortum* of Dujardin and *Spiromonas volubilis* of Perty, to which is added a third very distinct species apparently identical with the *Heteromita angustata* of the first-named investigator, whose developmental phenomena have been recently traced by the author. The two previously mentioned forms have been regarded by some authorities as possibly representing transitional conditions only of *Monas lens*, but such an interpretation cannot be entertained in face of the data here recorded concerning the entire life of that species. The members of this genus, as originally described by Dujardin, are represented as having a single flagellum only, while Perty indicates the possession of no appendage whatever. The comparatively inferior quality of the optical appliances at the disposal of these earlier investigators, however, amply accounts for such an oversight.

Spiromonas distortum, Duj. sp. PL. XX. FIG. 23.

Body oval, compressed and nodular, with thickened tuberculate margins, twisted irregularly on its longitudinal axis in a single spire. Length 1-1000".

HAB.—Fresh water containing decomposing animal matter.

This species, which is described by Dujardin under the name of *Cyclidium distortum*, is represented as bearing a single long and slender flagellum at its anterior extremity, though probably a second one exists. The young zooids were observed by him to be simply discoidal, the spiral flexure being characteristic only of the adult animalcules.

Spiromonas volubilis, Perty.

Body leaf-like, compressed, rounded at both extremities, twisted longitudinally in a single spire; surface smooth, the margins not thickened or tuberculate. Length 1-1300".

HAB.—Stale water with decomposing matter in suspension.

Spiromonas angustata, Duj. sp. PL. XV. FIGS. 49-60.

Body elongate, linear, compressed, more or less pointed at the two extremities, five or six times as long as broad, twisted spirally or in a screw-like manner on its longitudinal axis; flagella slender, subequal, inserted close to each other at the apex of the anterior extremity, equalling the body in length, both directed forwards and vibratile when the animalcule is swimming, the inferior one sometimes used for the temporary attachment of the animalcule; contractile vesicle posteriorly located; endoplast inconspicuous. Length of body 1-2500".

HAB.—Vegetable infusions.

The animalcule as above characterized and here identified with the *Heteromita angustata* of Dujardin, was obtained abundantly by the author at St. Heliers, Jersey, in an infusion of hay with spring water at the end of three weeks' maceration. Although the elongate, screw-like form, with two or three spiral twists, represents the normal aspect of the adult individuals in their free-swimming state, a very considerable range of variation occurs among the units of a large series. This individual variation is dependent not only on the phase of development of the separate monads, but also on the condition of rest or activity that may at the time predominate. In common with *Spiromonas distortum*, the young of this species show no trace of the spiral convolutions which distinguish the adults, but are simply elongate and compressed; later on a single spiral flexure is developed, and it is not until the most mature and active natatory condition is arrived at that its characteristic highly convoluted contour is attained. In that intermediate phase in which the animalcules exhibit but one spiral twist, the body is comparatively short, about three times as long as broad, with rounded extremities, and presents a considerable resemblance to Perty's *Spiromonas volubilis*, last described. A prolonged investigation of this species elicited that it possesses a temporarily fixed as well as an active swimming stage, the animalcules at such time attaching themselves by the extremity of the posterior of the two flagella, and fishing in the surrounding water with the anterior one, after the manner of an ordinary *Heteromita* or *Anisonema*. It was further observed that under these conditions the spiral convolutions were relaxed, sometimes one only being represented, and in others disappearing altogether. On becoming detached and resuming the free-swimming state the spirally convolute contour is again adopted. At the end of a few hours almost the whole adult individuals of the colony under examination were seen to assume an amœboid phase, and to crawl actively over the surface of the glass by the aid of their pseudopodia. Some of these coming in contact with their fellows immediately fused or coalesced, forming subsequently spherical encystments which later on broke up into minute spore-like bodies. The single zooids likewise formed similar but smaller encystments, and dividing by multiple fission into two or four segments only, were subsequently liberated as units resembling the unconvolute earlier stages of the parent monads. The motion through the water of the adult animalcules is regular and even, consisting of progress in a straight line, the body turning on its long axis in a screw-like manner, both flagella actively vibrating in advance. In the younger examples the movements are eccentric and vacillating, the animalcules first advancing straight forward for a short distance, and then turning round and returning to the point from whence they started. Their motion in this respect somewhat resembles that of various species of *Vibrio* or *Spirillum*. The so-called *Bodo gracilis*, merely figured by Stein in his recently published volume, without a word of explanatory text, must undoubtedly be regarded as a synonym of this species.

GENUS IV. PHYLLOMITUS, Stein.

Animalcules free-swimming, variable in form, more or less ovate; flagella two in number, produced from the anterior extremity, unequal in length and united to one another throughout their basal portion; no distinct oral aperture.

The single species referred to this genus is figured without an accompanying description in Stein's recently issued volume, the present diagnosis of both that species and the present newly instituted generic group having to be framed from his delineations.

Phyllomitus undulans, Stein. PL. XV. FIGS. 47 AND 48.

Body elongate-ovate, variable in form, three or four times as long as broad; sometimes straight and rounded, and sometimes sharply pointed and recurved posteriorly; flagella united basally for a distance exceeding one-half of the length of the body, forming in this region a ligulate or strap-like prolongation, the shorter flagellum produced separately but a little distance beyond the distal termination of this ligulate prolongation, the longer one fine and undulating continued for a length exceeding that of the entire body; the anterior extremity of the ventral region immediately beneath the insertion of the flagella exhibiting an oval excavation; endoplast anteriorly situated; contractile vesicle not clearly indicated. Length 1–1200" to 1–914". HAB.—Fresh water.

The form of the body in this species accords closely with that of the *Tetramitus descissus* of Perty, it exhibiting a similar indifferently rounded or sharply pointed posterior conformation, and a corresponding excavation beneath the insertion of the flagella; the peculiar character of these last-named organs distinguishes it conspicuously from any representative of the Flagellata hitherto described. Although not indicating the existence of a well-defined contractile vesicle, Stein delineates in his several figures of this animalcule a vesicular-like structure near the posterior extremity, upon which, in the accompanying index, the title of an anal aperture is conferred.

Fam. X. TREPOMONADIDÆ, S. K.

Animalcules naked, free-swimming, entirely asymmetrical; flagella two in number, separately inserted; no distinct oral aperture.

GENUS I. TREPOMONAS, Dujardin.

Animalcules free-swimming, exceedingly unsymmetrical in shape, plastic and highly flexible; irregularly oval, from a dorsal aspect; thickened posteriorly, with two anterior, slender, recurved, wing-like lobes as seen in lateral view; sigmoidal with reversed and pointed extremities viewed apically; flagella two in number, alike in form and character, produced from the extremity of each of the lateral lobate processes; contractile vesicle and endoplast conspicuous; no distinct oral aperture; movements very rapid, gyratory. Inhabiting stagnant water with decomposing organic matter.

Trepomonas agilis, Duj. PL. XIX. FIGS. 1–14.

Body, from a dorsal view (Fig. 12), irregularly oval, broadish anteriorly, more slender and slightly curved posteriorly, with a longitudinal fold towards the left side; in lateral view (Fig. 10), somewhat tongue-shaped, thickest and rounded posteriorly, expanding anteriorly into two symmetrical, laminate, wing-like lobes, which are reflexed backwards to about the centre of the body and terminate each in a single long vibratile flagellum. Apical aspect (Fig. 11) broadly sigmoidal, with a thin hyaline border connecting the recurved points with the thicker body portion; the flagella continuous from the recurved points; endoplasm transparent, enclosing foreign granules; contractile vesicle postero-terminal; endoplast anteriorly situated. Length of body 1–1125".

HAB.—Marsh water with decaying vegetable substances.

The extraordinarily diverse aspects presented by this animalcule as seen from various points of view, taken together with its minute size and exceedingly active movements in the water, has hitherto presented an almost insurmountable obstacle to its accurate description and delineation. O. Bütschli,* making a careful investigation of this interesting type with the highest available magnifying power and the use of reagents has, however, clearly demonstrated its correct structure and contour, the foregoing diagnosis being framed from his excellent figures and description. The

* "Beiträge zur Kenntniss der Flagellaten," 'Zeit. Wiss. Zool.,' Band xxx. Heft 2, Jan. 1878.

researches of this author establish the accuracy of Dujardin's original anticipation that the animalcule possessed two flagella proceeding from the extremities of the recurved lobate processes, although by Perty, Fresenius, and more recently by De Fromentel, a single flagellate appendage only is reported. The figures given by these last-named authorities, representing this form as caliper-shaped or bifid posteriorly, with a single median anterior flagellum, is now shown to be an imperfect interpretation of the lateral view given at Pl. XIX. Fig. 10. By Diesing *Trepomonas agilis* is described as possessing a terminal oral aperture; but Bütschli, while noting the presence in the endoplasm of enclosed foreign particles, entirely failed to discover the existence of such a structure. Under these circumstances it seems desirable to refer this type, at all events provisionally, to the Pantostomatous section of the Flagellata, the food-particles observed being probably incepted at any point of the periphery. A circulation or cyclosis of the inner substance of the endoplasm is recorded of this form by Bütschli, and has been witnessed by the author, which corresponds broadly with that which obtains in the higher Ciliate type *Paramecium bursaria*. Two animalcules joined to one another posteriorly by a slender, filamentous extension of the body-sarcode, representing an advanced phase of the process of longitudinal fission, was observed on one occasion. The correspondence that subsists between the contour of this type, as seen in lateral aspect, Fig. 11, and the fission-stage of *Ancyromonas sigmoides* (see Pl. XIII. Figs. 51 and 52), is highly remarkable.

Stein, in his recently issued volume, gives a very exhaustive series of illustrations of the polymorphic contours presented by *Trepomonas agilis* under varying conditions of attitude or flexure, the more important of which are here reproduced. The young of this type are, in accordance with the same authority, provided with three or four long, slender flagella, presenting under such conditions the appearances delineated at Pl. XIX. Figs. 13 and 14.

Fam. XI. POLYTOMIDÆ, S. K.

Animalcules symmetrical, free-swimming or temporarily adherent, illoricate, but with a more indurated membraniform cuticular envelope; flagella terminal, two in number, of equal size; no distinct oral aperture; multiplying by endogenous subdivision.

Genus I. POLYTOMA, Ehrenberg.

Animalcules biflagellate, free-swimming or temporarily adherent, more or less ovate, persistent in shape, possessing a distinct investing membrane; flagella of equal length, projecting from the anterior extremity; contractile vesicles and endoplast conspicuous, inhabiting water containing decomposing animal matter. Increasing by endogenous multiple fission and by the production of macro- and micro-spores. No distinct oral aperture.

The type-form of this genus, the *Polytoma uvella* of Ehrenberg or *Monas uva* of Müller, is evidently identical with the so-called "biflagellate or acorn-monad" figured and described by Messrs. Dallinger and Drysdale in the 'Monthly Microscopical Journal' for December 1874. A considerable difference of opinion has existed as to whether *Polytoma*, as represented by this type, should be rightly referred to the animal or vegetable kingdom, the balance of evidence being now, however, entirely in favour of the first alternative. There is no secretion of chlorophyll within the endoplasm as in the ordinary phytozoa, and the investing membrane refuses to become blue under the action of iodine, as it would if composed of cellulose. Ehrenberg further reports that the animalcules will ingest coloured matter, such as indigo, and figures artificially fed examples in his work. This last circumstance, combined with the constant presence of conspicuously developed contractile vesicles, demonstrates the entire compliance of these organisms with the formula adopted at the commencement of this work for the distinction of all typical Infusoria.

Polytoma uvella, Ehr. PL. XV. FIGS. 67–78.

Body ovate or oblong, equally rounded at the two extremities, or slightly more pointed at the anterior one, invested by a delicate hyaline membranous cuticle ; flagella inserted close to one another at the anterior extremity, of equal size, exceeding the body in length, having apparently a small bead-like or fusiform inflation at their point of origin, such appearance being produced by a minute loop-like basal flexure; this basal region of the flagella; soft and adhesive, enabling the animalcules to attach themselves at will to foreign objects ; contractile vesicles two in number, anteriorly situated ; endoplast central, spherical; endoplasm of the posterior half of the body usually more coarsely granulate. Length of body 1–1200″ to 1–800″.

HAB.—Fish and other animal macerations.

In describing the form, as quoted overleaf, under the title of " the biflagellate or acorn-monad," Messrs. Dallinger and Drysdale appear to have been unaware of its identity with the *Polytoma uvella* of Ehrenberg, and of the results of Schneider's and Perty's investigations. These last-named authorities, while by no means supplying a complete and exhaustive account of its reproductive history, assist materially in the interpretation of certain phenomena, which have been left unexplained by our fellow countrymen. As first made known by Schneider, and since shown by Messrs. Dallinger and Drysdale, the animalcules increase rapidly by a process of multiple fission, caused by the first dividing into two, and then into four, eight, or even sixteen segment-masses of the entire protoplasmic mass enclosed within the external hyaline cuticular membrane, and quite independently of that structure. These divided portions assume the shape and aspect of the parent monad, the flagella often perforating and protruding through the cuticle of the latter, as shown at Pl. XV. Fig. 73. The organism now swims about with its contained young for a longer or less duration of time as an apparently compound organism.—It was this pseudo-compound phase, indeed, that Ehrenberg regarded as the normal one, and upon which he conferred its characteristic title of *Polytoma*. Subsequently, each of these subdivided portions breaking through the investing membrane of the parent monad, assumes an independent existence, leaving the latter as an empty and lifeless cyst. While the products of this multiple fission process may continue increasing in a similar manner for many generations and without the intervention of the coalescence or genetic union of two zooids, it has been shown by Messrs. Dallinger and Drysdale that there is yet another mode by which the perpetuation of the species is asexually accomplished. In certain examples under examination it was observed by these authorities that the posterior portion of the body was almost filled with granular masses of protoplasm, which conveyed to this region a roughened acorn-cup-like aspect as compared with the smooth and hyaline anterior portion; carefully watching them it was found that in the midst of their swiftly moving course these acorn-like zooids would suddenly discharge the entire contents of the posterior region as separate granular fragments into the surrounding water, as shown at Fig. 75. Each of these fragments thus liberated was amorphous in form, more or less agglomerated and perfectly transparent. Examined attentively with the aid of a magnification of 2500 diameters and upwards, minute dots were next seen to make their appearance in these granules, which increasing in size, exhibited active vibratory movements and were ultimately released as minute bacterium-like bodies. The growth of these liberated particles within a space of four or five hours to monads identical in size and structure with the parent form, was subsequently ascertained. A third or true genetic form of reproduction dependent on the intimate fusion or coalescence of two individuals followed by encystment and the breaking up of the amalgamated zooids into countless almost invisible spores (see Pl. XV. Figs. 77 and 78), as already described of *Monas Dallingeri*, *Cercomonas typicus*, and *Heteromita rostrata*, completes the life-cycle of this remarkable species as observed by these indefatigable investigators.

A few structural peculiarities of this type referred to by Messrs. Dallinger and Drysdale, demand brief notice. The so-called "snapping eye-spots" situated in the anterior region of this form, and reported to be present in many other monads examined by them, though they failed to determine their precise import and function, represent undoubtedly the characteristic contractile vesicles already recognized by Schneider and other earlier writers. Under certain conditions the two anterior flagella were further pronounced by these investigators to be replaced or supplemented by two knob-like structures, mounted on slender pedicles, and to which phase of the monad they therefore applied the title of the "clubbed condition." It was at first supposed that this condition was intimately connected with some special reproductive process, the question ultimately, however, being left undecided. Schneider, nevertheless, had previously maintained that the knob-like processes represented the flagella as withdrawn or shortened previous to encystment. Even under normal conditions the existence of fusiform or pear-shaped inflations of the bases of the flagella is recorded, these inflations being further interpreted as playing an important part in the function of natation, and as possessing apparently a muscular property. The swimming motions of *Polytoma* are described by Messrs. Dallinger and Drysdale as very graceful and swallow-like; the flagella being thrown out in the manner of a swimmer's arms and made to meet at the posterior end of the monad; these appendages can likewise, they report, be used in various other ways, producing a rolling-forward motion, a gyrating horizontal one, or even a longitudinal revolution.

Quite recently, January 1880, the author had the opportunity of examining living samples of *Polytoma uvella* as developed abundantly in animal macerations at the Biological Laboratory, South Kensington. The data thus independently derived have thrown an entirely unexpected light on the phenomena previously recorded, concerning the so-called knob-like or pyriform inflations at the base of the flagella, as observed by Schneider and Messrs. Dallinger and Drysdale. It has been definitely ascertained by both the examination of living monads and of examples killed with iodine and osmic acid, that what these authorities took for independent knob-like or fusiform developments are actually minute loop-like flexures of the basal region of the flagella, as shown in Figs. 67–69 of Plate XV. The substance of the flagella throughout this region is softer and more adhesive than in the remainder of their length, and it is by this loop-like flexure that the animalcules attach themselves to the glass or other neighbouring objects as first observed by Schneider, and may thus ride securely anchored, during the passage around them of even a considerably forcible current. It is certainly a very remarkable circumstance that this capacity of attaching themselves, so abundantly displayed in the specimens recently examined, should have entirely escaped the many hours' observation of Messrs. Dallinger and Drysdale, who have described them only as motile or free-swimming animalcules. In both the examples examined by the author on the occasion quoted, and still more recently, it was observed, indeed, that the attached condition is the more normal one, but few, unless purposely disturbed, exhibiting their natatory properties two minutes after their transfer to the field of the microscope. The existence of the loop-like flexures at the bases of the flagella, discovered by the author, explains readily the several apparently anomalous features concerning the type, noticed in the accounts given by previous investigators; thus the so-called "clubbed" condition of the animalcule, as reported by them, was repeatedly recognized, but was demonstrated to be the optical image, produced under high magnification, of the basal portion of the flagellum with its loop-like flexure only being in focus. Under slightly modified conditions, again, the loop-like flexures and the remaining length of the flagella being clearly visible, the divarication of this latter portion may be at such an angle that, as shown at Plate XV. Fig. 67, the basal flexure and terminal portion may appear to be separate structures, the former presenting an independent knob-like aspect. Lastly, where the distal lengths of the flagella and their basal flexures are both in focus, and apparently continuous with each other, these flexures may be coiled so closely beneath the anterior region of the animalcule's body, as to present the aspect of fusiform or pyriform inflations of the basal region of the flagella, as first interpreted by the two authorities here quoted. When the animalcules are treated with osmic acid or iodine, they roll over and over helplessly in the water, every portion of their organization being brought successively into focus, and the true significance of the previously imperfectly observed phenomena, as here explained, may easily be verified. Figs. 68 and 69 of the accompanying plate are delineated from examples submitted to this treatment. The two anterior so-called "snapping eye-like structures" reported by Messrs. Dallinger and Drysdale of this type, were immediately identified by the author with the normally developed and highly characteristic contractile vesicles.

Stein includes a long series of figures of this species in his recently published volume, the same, however, apparently containing but little that is new. One or more dark, granular, eye-like pigment-spots are shown in some, but not in all, of these figures, such spots being moreover located indifferently in separate animalcules at either the anterior or posterior extremity of the body. No indication of the characteristic loop-like flexure of the flagella or of the possession by the animalcules of a capacity to attach themselves, as here recorded, is given in Stein's figures or accompanying index.

The two forms described by Perty under the respective names of *Polytoma ocellata* and *P. virens*, cannot be regarded as otherwise than local or transitional variations of *P. uvella*. Diesing, nevertheless,* has proposed to institute a new generic and specific title, *Glenopolytoma typicum* for that variety, *P. ocellata*, in which a red pigment-spot is present at the anterior extremity.

Fam. XII. PSEUDOSPORIDÆ, S. K.

Animalcules naked, repent or natatory; flagella two in number, of even size; no distinct oral aperture.

GENUS I. PSEUDOSPORA, Cienkowski.

Animalcules free-swimming or repent, plastic and changeable in form, typically more or less ovate or globose; the anterior extremity bearing two long, equal-sized flagella; food incepted at any point of the periphery; endoplast and contractile vesicles conspicuous.

The *Pseudospora volvocis* only of Cienkowski is retained in the present genus, the two other forms, referred to it by that authority under the titles of *Pseudospora parasitica* and *P. nitellarum*, being in no way distinct from the ordinary members of the genus *Monas*, to which they are here referred. Food-particles would appear to be incepted at any point of the periphery, otherwise the features afforded by the plasticity of the body-sarcode and character of the flagella correspond considerably with those exhibited by the stomatode genus *Zygoselmis*.

Pseudospora volvocis, Cienk. PL. XV. FIGS. 42 AND 43.

Body ovate or globose, often amœbiform; flagella fine, equal in size, exceeding the body in length; contractile vesicles minute, three in number, scattered; endoplast spherical, subcentral. Length 1-1250".

HAB.—Fresh water, as a parasite of *Volvox globator*.

* 'Revision der Prothelminthen,' 1866.

According to Cienkowski * this species plunders the contents of *Volvox globator* in a manner somewhat identical with that pursued by *Colpodella pugnax* with relation to *Chlamydomonas pulvisculus*. Boring its way through the outer envelope of that protophyte, it creeps about on its inner surface, gradually devouring all the green cellular elements and daughter-cells. During the process it presents a semi-amœboid aspect, but retains the two long natatory flagella; under these auspices it would seem to exhibit more affinity with the genus *Mastigamœba*, and might therefore perhaps be appropriately relegated to the order of the Rhizo-Flagellata. Subsequently the flagella are completely withdrawn and the animalcule forms a double-walled encystment, the further development of which was not followed.

C.—PANTOSTOMATA-POLYMASTIGA

(Flagellate appendages three or more in number).

Fam. XIII. SPUMELLIDÆ, S. K.

Animalcules naked, free-swimming or attached; flagella terminal, three in number, unequal, one long and two short; no distinct oral aperture.

GENUS I. SPUMELLA, Cienkowski.

Animalcules minute, sometimes free-swimming but normally attached by a slender thread-like pedicle, more or less spherical or ovate in their sedentary state, but exceedingly plastic and changeable in shape in their free-swimming condition; flagelliferous system consisting of one long and two short rudimentary flagella which originate close to each another near the centre of the anterior border; endoplast and one or more contractile vesicles usually conspicuous; no distinct oral aperture, solid food-particles being incepted at all parts of the periphery. Inhabiting fresh and salt water, and abundant in infusions.

Those forms only are retained as representatives of the present genus that correspond structurally with the *Spumella vulgaris* of Cienkowski † (*Monas guttula* Ehr.), characterized by the possession of one long and two comparatively minute flagellate appendages. The monoflagellate types referred to it by O. Bütschli, under the titles of *Spumella termo* and *S. neglecta*, are necessarily relegated to the generic group *Oikomonas*, with whose representatives, as also with those of *Physomonas* and *Amphimonas*, except strict attention is paid to the character of the flagelliferous elements, the several species of *Spumella* are liable to be confounded.

Spumella guttula, Ehr. sp. PL. XIV. FIGS. 46–52.

Body perfectly globose in its sedentary condition, ovate, pyriform or elongate in its free-swimming state; flagellate appendages consisting of one long and two very short rudimentary flagella, the former extended rigidly and arcuately, the latter tremulous; endoplasm transparent, finely granulate, enclosing near the anterior border a short, straight, linear, pigmentary, or more densely granular band; contractile vesicle single, located near the

* "Beiträge zur Kenntniss der Monaden," 'Archiv f. Mikroskopische Anatomie,' Bd. i., 1865.

† "Ueber Palmellaceen und einige Flagellaten," 'Archiv f. Mikroskopische Anatomie,' Bd. ii., 1870.

centre of the lateral periphery; endoplast situated in the median line, towards the anterior extremity. Diameter of spheroidal zooids 1-2500″.

HAB.—Pond water.

Stein* proposes to identify this type with both the *Monas guttula* of Ehrenberg and the more recently introduced *Spumella vulgaris* of Cienkowski. It would seem just possible that the first-named identification is correct, but no mention is made by Ehrenberg of its most characteristic fixed existence and attachment by a special caudal filament, and which would undoubtedly, if recognized, have influenced that authority to relegate the animalcule to his caudate genus *Bodo*. Stein agrees with Cienkowski in allotting to this form the presence of two minute supplementary flagella at the base of the more conspicuous axial one; he further figures what he interprets to be the genetic union between a normal sedentary, and a minute motile zooid, the latter attaching itself to one side of the larger one, and becoming absorbed into its substance, the phenomena corresponding with those exhibited during the genetic union of the larger sedentary and minute migrant zooids of *Vorticella*, first discovered by this same authority and described later on. In specimens of this type, recently examined by the author, obtained in pond water containing *Acineta mystacina* and *Salpingœca gracilis*, the presence of the one long and two rudimentary flagella was fully certified, as also the existence of the linear furrow-like mark near the anterior border, interpreted by Stein and Cienkowski as representing a distinct oral aperture. That no such ingestive function can be assigned to it was however conclusively demonstrated through the witnessing on numerous occasions of the inception of solid food-particles at the most diverse regions of the periphery. As in the case of *Oikomonas*, *Amphimonas*, *Anthophysa*, and numerous other Pantostomatous Flagellata already described, such food-inception was manifested by the temporary rupture of the peripheral wall of the animalcule's body at whatever point against which the food-particle was thrown by the flagellum, accompanied by the simultaneous outflow of the softer inner sarcode which enveloped and secured the welcome morsel. Under such circumstances there can be but little doubt that this so-called oral furrow is, as in the case of *Goniomonas truncata*, as interpreted by Bütschli, a mere linear granular deposition corresponding morphologically with the red or other coloured pigment-spots common to *Euglena* and various ordinary Flagellata. Such a granular pigmentary interpretation entirely accords with the decision arrived at by the author in connection with the present species, after carefully submitting it to the highest available magnifying power. It would seem to be by no means improbable that Stein's representation of the presumed coalescence of a minute free-swimming zooid with a larger sedentary one, as here reproduced, Plate XIV. Fig. 49, might be more accurately interpreted as an example of the ingestion of a foreign food-particle at the lateral periphery.

Spumella vivipara, Ehr. sp. PL. XIV. FIGS. 34-36.

Body when attached usually obovate, widest and rounded anteriorly, tapering to a point at its posterior extremity; exceedingly plastic and changeable in shape, ovate, spheroidal, or elongate in its free-swimming state; one long axial and two short lateral flagella; endoplasm transparent, enclosing innumerable constantly vibrating refringent corpuscles; a short linear pigment-band or furrow-like mark situated close to the anterior border; pedicle short, scarcely equalling the body in length; contractile vesicle single, located near the centre of the lateral border; endoplast median, anteriorly situated. Length 1-1000″ to 1-620″.

HAB.—Fresh water and infusions.

* 'Infusionsthiere,' Abth. iii., 1878.

This species, originally described by Ehrenberg under the title of *Monas vivipara*, is distinguished more particularly by the presence of the innumerable moving corpuscles enclosed within the substance of the endoplasm, and which were mistaken by that authority for its living progeny. Stein, who has recently figured it in connection with the same name, has added the fuller details of the flagella, mode of attachment, and positions of the endoplast and contractile vesicle here recorded. The author has recently encountered an animalcule closely resembling the present form in hay infusions, it being of the same size and enclosing similar motile corpuscles within the endoplasm; the endoplast was, however, in these instances, situated to the rear of the contractile vesicle. The ingestion of food was observed on numerous occasions, a film of sarcode being thrown out at such times and enveloping the captured particle. This film was projected indifferently from various parts of the anterior border, and sometimes simultaneously from two separate portions of the periphery. In no instance could the linear pigment-band or so-called oral ledge or furrow, as indicated in Stein's drawings, be detected, and which circumstance, together with the variation in the position of the endoplast, favours the opinion that we have in this last-named instance a closely allied but specifically distinct variety.

Fam. XIV. TRIMASTIGIDÆ, S. K.

Animalcules naked, free-swimming or temporarily adherent; flagella three in number, equal or subequal, inserted close to one another; no distinct oral aperture.

GENUS I. CALLODICTYON, Carter.

Animalcules naked, entirely free-swimming, more or less ovate but plastic and somewhat variable in form; endoplasm highly vacuolar or cancellate, presenting a reticulate appearance; flagella three in number, similar in size and character, originating close to each other near the centre of the anterior border; no distinct oral aperture, all parts of the periphery being equally capable of incepting food-substances.

Callodictyon triciliatum, Carter. PL. XIX. FIGS. 16–19.

Body subpyriform, straight or slightly curved, from one and a half to twice as long as broad, widest anteriorly, tapering towards the posterior end, which is sometimes sharply and sometimes obtusely pointed and bifid at its extremity; flagella slender, equal in length to about one-half that of the body, inserted within a small depression in the centre of the anterior border; endoplasm transparent, divided up by innumerable equal-sized spherical vacuoles so as to present a reticulate or cellular aspect; endoplast spherical, anteriorly situated; no distinct contractile vacuole. Length 1–770″. HAB.—Fresh water with *Euglenæ:* Bombay (H. J. C.).

This singular animalcule is figured and described under the above title in Mr. Carter's account of the "Fresh- and Salt-water Rhizopoda of England and India," in the 'Annals of Natural History' for April 1865. Its plastic nature, and capacity of incepting food at any portion of its periphery, as in the case of Amœba, has induced this authority to refer the type to the section of the Rhizopoda, but it is very evident that its rightful position is among that newly instituted Pantostomatous division of the Infusoria Flagellata as delimited in this treatise. The voracity of this type, as evidenced by its discoverer, is very remarkable, organisms equal to or even exceeding itself in size being indiscriminately seized and pressed within the substance of its yielding reticulate body-sarcode. In one instance, Mr. Carter figures a large *Cremenula* thus incepted, while in another, Pl. XIX. Fig. 17, the animalcule has enclosed the central portion of a filament of *Oscillatoria*, the two ends of which are protruding from the opposite poles of the creature's body. Although the evenly vacuolar or reticulate character of the parenchyma or endoplasm of *Callodictyon* would appear to find no exact counterpart among the ordinary representatives of its class, a near approach in this respect obtains in *Noctiluca* and *Leptodiscus* among the Stomatode Flagellate forms, and in *Trachelius* and *Loxodes* among the Ciliata. Such an open vacuolar character of the parenchyma would seem to obviate the necessity for a contractile vesicle, the presence of which structure Mr. Carter was unable to detect.

GENUS II. TRICHOMONAS, Donné.

Animalcules free-swimming, soft and plastic, ovate or subfusiform, bearing at the anterior extremity two long subequal flagella, a third supplementary one depending from the posterior extremity; a toothed or lobate undulating membrane developed down one lateral border, which presents under insufficient magnifying power the aspect of a fringe of cilia; no distinct oral aperture. Habits endoparasitic.

The illustrations of *Trichomonas batrachorum* given by Stein in the third volume of his 'Infusionsthiere,' though unaccompanied by any descriptive text, have necessitated not only the formulation of a new generic diagnosis, but also the transfer of the genus from the monomastigate to the polymastigate section of the Flagellata. As originally described by Donné and embodied in the works of Dujardin and Perty, *Trichomonas* was represented as possessing a single anteriorly situated flagellum only, supplemented on one lateral border by a conspicuous fringe of cilia. As now shown by Stein, in the case at all events of the above-named species, there are no less than three flagellate appendages, while the presumed lateral fringe of cilia is found to be a delicate notched undulating membrane, closely resembling the membraniform border that constitutes the sole organ of locomotion in the genus *Trypanosoma*. An oral aperture, or rather the presumed position of such a structure, is indicated in one of Stein's figures, though by no means with sufficient distinctness to permit of the acceptance of the organism as an undoubted stomatode type. Such being the case, its provisional retention among the ordinary Pantostomata has been decided on.

Trichomonas batrachorum, Perty. PL. XIX. FIGS. 30–32.

Body subfusiform, widest centrally, pointed at each extremity, but most attenuate posteriorly, two or three times as long as broad; two long slender flagella produced from the apex of the anterior extremity, a similar single one apparently originating at a little distance from the posterior termination; a more or less conspicuous toothed or lobate undulating membrane developed down one lateral border, and a raised keel-like line down the opposite one; endoplast anteriorly located; contractile vesicle situated at a short distance from the posterior extremity. Length 1–2000″ to 1–640″.

HAB.—Intestinal canal of the common frog and toad.

The above diagnosis and accompanying illustrations of this species are drawn up and reproduced from the excellent figures of the type included in Stein's lately issued volume. In the absence of the forthcoming descriptive text, one or two points have to remain undecided, these relating chiefly to the character and number of the flagella. In one instance as many as three, but in all others only two of these appendages are produced from the anterior extremity. It is also somewhat difficult to decide whether the so-called posterior flagellum is actually developed from this region, or is merely a reflexed member of a single anteriorly inserted series.

Trichomonas vaginalis, Duj. PL. XIX. FIGS. 33 AND 34.

Body irregularly ovate, tuberculate, soft and plastic, and changeable in shape, often adherent by a gelatinous tail-like prolongation of the posterior extremity of the body; flagellum thicker at its base, fine and slender anteriorly, two or three times the length of the body, supplemented apparently by a lateral fringe of large and conspicuous cilia; endoplasm vacuolate. Length of body 1–2500″. HAB.—Vaginal mucus.

This species was first observed in decomposed human vaginal mucus by M. Donné, he communcating the circumstance to Dujardin. The zooids occurred in aggregated groups or as isolated individuals which readily adhered to the glass object-carrier, or other fulcrum of support, by a glutinous prolongation of the posterior extremity, their movements when so attached being oscillating. It has been suggested by some authorities that the objects thus observed by Donné were merely singly detached or agglomerated cells of ordinary ciliated epithelium; the possession, however, of a distinct flagellate appendage, as indicated in Dujardin's drawings, would seem, pending further investigation, to justify its provisional inclusion among the members of the present organic group. Neither the diagnosis here given of either this or of the succeeding species is to be accepted as complete, they being constructed from the very imperfect descriptions and figures placed on record by investigators who had not optical appliances suitable for their exhaustive examination. With such assistance it will probably be found that, as in *Trichomonas batrachorum*, the apparent lateral fringe of cilia is in reality an undulating membrane, and that the single flagellate appendage hitherto observed is supplemented by others of like kind.

Trichomonas limacis, Duj.

Body ovoid, smooth, pointed at each extremity; flagellum slender throughout, about twice the length of the body; a lateral fringe of cilia apparently extending from the base of the flagellum more than halfway to the posterior extremity; endoplasm vacuolar; movements active, rotating on its axis. Length of body 1–1650″.

HAB.—Intestinal tract of *Limax agrestris*.

GENUS III. DALLINGERIA, S. K.

(Nom. prop., *Dallinger.*)

Animalcules free-swimming, more or less ovate, persistent in form, having a single antero-terminal, and two oppositely placed lateral flagella, the latter adhesive at their distal extremities, permitting the zooid to temporarily anchor itself to any chosen spot after the manner of *Heteromita* and *Anisonema*. Endoplast conspicuous; no distinct oral aperture. Inhabiting animal macerations.

This new genus is established for the reception of the animalcule figured and described by the Rev. W. H. Dallinger, in a memoir published in the 'Proceedings of the Royal Society' for May 1878, as a "minute septic organism," no technical name being given nor any attempt being made to identify it with any previously described form. It being the only type, among the many so painstakingly investigated by Mr. Dallinger, in company usually with Dr. Drysdale, that represents both a new generic and specific form, the author derives much pleasure from bestowing upon it technical titles that shall serve to perpetuate their names in connection with this group of organisms.

As in the case of the numerous other monadiform beings referred to in this volume which have formed the subject of that authority's investigations, the entire life-cycle, as hereafter related, has been traced out. So far as can be at present determined, this special type would appear to exhibit a close affinity with the representatives of the genus *Heteromita*, from which, however, it is at once distinguished by the presence of two lateral instead of a single ventral anchoring filament. No reference being made to the existence of a distinct oral aperture or the presence of incepted food-granules, it must be provisionally assumed that the animalcule feeds by endosmosis, after the manner of the Opalinidæ, upon the nutritive fluids in which it takes up its residence.

Dallingeria Drysdali, S. K. PL. XIX. FIGS. 35–41.

Body elongate-ovate, about three times as long as broad, widest and rounded posteriorly, constricted centrally, the anterior region abruptly narrowed and neck-like; flagella subequal, long and slender, about twice the length of the body, the two lateral ones produced on each side immediately behind the narrower neck-like region; endoplast posteriorly located. Length of body 1–4000″. HAB.—Animal macerations.

The life-history of this species, as traced by the Rev. W. H. Dallinger, accords broadly with that of *Monas Dallingeri*, *Heteromita rostrata*, and other flagellate types upon which he and Dr. Drysdale conjointly have so successfully concentrated their attention. Multiplication by fission represents the normal and most common mode of increase. This process is preceded in the first instance by the splitting of the anterior flagellum (see Plate XIX. Fig. 37), the line of segmentation extending thence through the longitudinal axis of the body, including the subdivision of the endoplast, the missing lateral filament being reproduced by the attenuation of the sarcode film which lastly unites the eventually separated bodies. A period of from four to seven minutes is occupied in the completion of this act of fission, which may be repeated at intervals of three minutes for the duration of an hour. During the next two hours the same process proceeds at intervals of from seven to ten minutes, while after this, fission is more rare and sluggish and interrupted by irregular intervals varying from twenty to as much as forty minutes. The phenomenon of longitudinal fission may, in this manner, be continued, commencing with a newly developed individual, for a space of from five to seven hours, when death most usually ensues. Much more rarely, on an average of three cases out of nine, however, it was found that the monads at the end of about three hours of continuation of this cleavage process, underwent a complete metamorphosis. In these instances the two lateral flagella contracting, first assume a knotted or clubbed aspect, and the body, losing its normal ovoid form, becomes irregularly lobate around the margin and semi-amœboid. The two lateral flagella are ultimately entirely withdrawn, and the body, assuming a still more regularly ovate contour than it originally presented, being without the central constriction, progresses through the water as a simple monoflagellate organism, in all ways identical with the ordinary representatives of the genus *Monas*. The endoplast meanwhile increases largely in its proportions, and occupies a more posterior location, while, in addition, a belt-like granular zone makes its appearance, encircling the exact centre of the body, as shown at Pl. XIX. Fig. 38.

Swimming among the ordinary triflagellate members of the species the metamorphosed monads were observed to attach themselves to one of these, the two then swimming off and becoming by degrees completely fused with one another; all the flagella were now entirely retracted, the conjoined bodies exhibiting first an irregularly lobate or amœboid aspect, and finally a quiescent encysted state. The cysts thus formed, Fig. 39, were of an elongate-ovate or fusiform shape, and apparently devoid of all structure. After an interval of from three to five hours the cysts were seen to burst or collapse, releasing a cloud of exquisitely minute spores, hardly appreciable, and then only as the most minute specks, under a magnification of 5000 diameters. In five hours after their emission from the cyst the sporular elements grew to the size and contour of the parent form, the first traces of the characteristic lateral flagella having made their appearance as minute points at the end of the first two hours, before any movements had commenced, and while each individual appeared under the magnification quoted as but little more than a mere elongate speck. The habits of the animalcule as related by Mr. Dallinger are remarkable. When swimming it progresses through the water rapidly, in a direct line or in graceful curves, arresting, however, or reversing its course abruptly at any moment. On these occasions, one or both of the two lateral flagella are brought into action, and extended in an arm-like manner in place of remaining closely adpressed to the side with their free extremities trailing, as is more usual when a straight uninterrupted path is pursued. In all these movements the animalcule apparently exhibits a complete volitional control over the movements of these flagellate appendages and in the determination of its course.

The highly characteristic sedentary condition of the adult form remains to be described. Like *Heteromita*, *Anisonema*, and other Flagellata, this type, as already mentioned, temporarily anchors itself at will to any chosen spot, its moorings, however, being rendered doubly secure by the utilization, for this purpose, of the two lateral flagella in place of the single gubernaculate one employed by the foregoing forms. In this "anchored" condition the animalcule still exhibits vigorous movements, which are of a most remarkable character. In *Anisonema*, motion when at anchor consists, in its most actively motile state, of a swaying to and fro of the body only, after the manner of a pendulum. In *Dallingeria*, according to its discoverer, it takes the form of a rapid springing up and down, much as in *Heteromita rostrata*, the two adherent flagella being thrown, on the return of the body, into two spiral coils, which are once more relaxed by the upward spring. In the performance of these evolutions the body describes in the course of its descent the arc of a circle, striking with great rapidity and proportionate force, hammerwise, upon the point represented by the outstretched limit of reach of the anchoring flagella. It is further affirmed that this hammering action is always manifested in presence of decomposing organic matter, the blows being levelled against it with the apparent purpose of breaking up this material, and evidently contributing to or hastening such a result. Should the animalcule be found to possess an oral aperture, or other means of appropriating in a substantial form the fruits of its Vulcanic labours, this interpretation of its movements might be accepted, but in the absence of any such demonstration the author is scarcely prepared to regard its reported pulverizing accomplishments as other than fortuitous.*

Experiments, conducted with great skill and care by Mr. Dallinger, in order to

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* In the accompanying illustration the letters *a* and *b* of Fig. 35 denote the positions successively maintained by a zooid with relation to its base of attachment, through the coiling and uncoiling of the lateral flagella. By accident, the ruptured cyst discharging spores, Fig. 40, is placed at the point upon which the body of the animalcule would strike on the full extension of the spirally coiled appendage; repeated blows delivered in this fashion would doubtless have the effect of breaking the cyst and scattering the spores in the manner indicated. It might be suitably suggested as an alternative to the food-pulverizing interpretation arrived at by Mr. Dallinger, that the characteristic movements of these animalcules are intimately connected with such an artificial liberation and distribution of these spores.

ascertain the respective thermal death-points of the adult monad and its spores, elicited that the former succumbed at a fluid temperature of 142° Fahr., while the spores successfully resisted the very considerable one of 220° Fahr. of fluid heat, and the still higher one of 248° Fahr. if submitted to dry heat.

GENUS IV. TRIMASTIX, S. K.

(Greek, *treis*, three; *mastix*, lash.)

Animalcules naked, entirely free-swimming, more or less ovate or pyriform, with a laterally produced membranous border; flagella three in number, anteriorly inserted, one vibratile directed in advance, two reflected and trailing posteriorly; endoplast and contractile vesicle conspicuous; no distinct oral aperture.

Trimastix marina, S. K. PL. XIX. FIGS. 24–26.

Body subpyriform, rounded and inflated posteriorly, the pointed and attenuate anterior extremity curved slightly towards the ventral aspect; the lateral border produced on the right-hand side, extending from the anterior to the posterior extremity; flagella subequal in size and character, about twice the length of the body, the anteriorly directed flagellum vibratile throughout its length, one of the reflected ones free, the other retained towards its centre by the angle formed between the body-wall and lateral membrane, its length between this region and its point of insertion at the apical extremity constantly vibratile; contractile vesicle anteriorly located; endoplast spherical, adjacent to the posterior extremity. Length 1–1425″.

HAB.—Salt water with decaying vegetation.

This species was obtained by the author in November 1878, at St. Heliers, Jersey, in a vessel of sea-water containing *Fuci* in an advanced state of decomposition, a thick Bacterial pellicle in the gelatinous or "zooglœa" condition being present on the surface. While the general form, number, and disposition of the flagella correspond to some extent with those of *Dallingeria*, it differs conspicuously from that and all other types hitherto described in the development of the remarkable lateral border, and in the peculiar comportment of one of the posteriorly reflected flagella with relation to it. As first seen, it was premised that the anterior portion of this appendage was an independent undulating membrane, analogous to that possessed by *Trypanosoma* or *Trichomonas*, but its continuity with the portion produced beyond the posterior extremity was ultimately traced. The membranous lateral border, imparting to the animalcule a scroll-like aspect, or more correctly, perhaps, that of a convoluted shell, is of comparatively firm consistence, and was not observed to exhibit any variation in its contour. Although not represented in any previously known member of the Flagellata, a somewhat similar lateral membranous expansion occurs in the Holotrichous forms *Lembus* and *Proboscella*. It was supposed that the vibratile portion of the reflected flagellum might be connected with the office of conducting food-particles to a distinct oral aperture. No such orifice, however, was observed, nor the inception of food-substances at any part of the periphery.

Fam. XV. TETRAMITIDÆ, S. K.

Animalcules naked, entirely free-swimming; flagella usually four, rarely five, in number, inserted close to one another, near the centre of the anterior border; no distinct oral aperture.

GENUS I. TETRAMITUS, Perty.

Animalcules naked, free-swimming, plastic and changeable in form, usually more or less conical and tapering posteriorly, with a truncate anterior margin; flagella four in number, inserted close to each other at some point of the frontal border. No distinct oral aperture; contractile vesicle and endoplast conspicuous. HAB.—Stale water and organic infusions.

This genus was instituted by Perty, 'Kleinster Lebensformen,' 1852, for the reception of two closely allied forms, *Tetramitus rostratus* and *T. descissus.* By several authors, including more notably Diesing and Bütschli, it has been assumed that the genera *Pyramimonas* of Schmarda and *Chloraster* of Ehrenberg, include all the essential characteristics of the later one instituted by Perty, and which consequently possesses no claim for recognition. A reference to Schmarda's original figures and description of his type-form of the genus *Pyramimonas*, fortified by an intimate acquaintance with a closely-allied species, has fully satisfied the author, however, that the animalcules investigated and described by Perty represent an entirely distinct generic form, his title being consequently retained in this treatise. This decision, previously arrived at, has been entirely endorsed in Stein's recently published volume, and in which, indeed, all three genera, *Tetramitus*, *Chloraster*, and *Pyramimonas*, are admitted.

Tetramitus rostratus, Perty. PL. XIX. FIGS. 42–48.

Body soft and plastic, subpyriform, compressed, tapering and attenuate posteriorly, the frontal border abruptly truncate, with a small spout-like projection at its lower angle; a shallow groove extending from this point towards the posterior extremity; flagella subequal, slender and flexible throughout, exceeding the body in length, inserted into the small conical projection of the truncate frontal border; contractile vesicles two in number, situated close to each other near the base of the flagella; endoplast oval, central. Length of body 1–1000″ to 1–900″.

HAB.—Standing water and animal macerations.

This species, representing the *Tetramitus rostratus* of Perty and Fresenius, and the *Pyramimonas rostrata* of Diesing, is beyond doubt identical with the so-called "Calycine Monad," figured and described by Messrs. Dallinger and Drysdale in the 'Monthly Microscopical Journal' for May 1871. Its life-history, as elicited by the investigations of these authorities, coincides broadly with that of *Heteromita rostrata*, described on a previous page. Multiplication by longitudinal fission, accompanied by the temporary assumption of a softer semi-plastic state, represents the ordinary mode of increase, and has been already recorded by Perty. In this process the subdivision of the cone bearing the four flagella takes its share, the two newly developed zooids possessing at the time of separation only two flagellate appendages; these however subsequently divide rapidly in half, and thus secure to the animalcule its full complement. The more important phenomena of increase, through the genetic union of two animalcules followed by encystment and the breaking up of the amalgamated bodies into dust-like spores, was successfully traced through its various phases. In a space of nine hours the minute dust-like spores attained the characteristic aspect of the parent monads, and were simply slightly inferior to them in size. The individual zooids preparatory to and during the act of coalescence assume an altogether irregular and remarkable contour (see Pl. XIX. Figs. 44 and 45). The anterior portion bearing the four vibratile flagella alone retains its original outline, the whole posterior portion of the body protruding bluntly lobate pseudopodic processes by the aid of which it is enabled to creep about after the manner of an *Amœba*. Messrs. Dallinger and Drysdale further add that when in this amœboid condition they rapidly devour such living or dead Bacteria as they may chance to come across, ingesting them as *Amœbæ* do at any point of their periphery. The two rhythmically opening and closing so-called "eye-like spots" referred to by these same writers as being constantly present at the anterior extremity of the animalcules, evidently represent the contractile vesicles common to almost all members of the Flagellata. Perty and Fresenius indicate the existence of a single large vesicle only at its anterior end; but the two, as shown by Messrs. Dallinger and Drysdale, are situated so close to each other as to naturally appear as one only, unless an extremely high magnifying power is employed. Perty's description and illustrations of the process of longitudinal fission differ to a slight extent from that reported by Messrs. Dallinger and Drysdale, he having observed on various occasions that the four new flagella are developed before the partitioning into halves of the original animalcule, and which is thus provided for a short interval with eight of these appendages. The young of this species, as recently figured by Stein, possess a very attenuate contour, as shown at Pl. XIX. Figs. 47 and 48, more closely resembling in this respect the adult form of *Tetramitus descissus*.

Tetramitus descissus, Perty. Pl. XIX. Figs. 49 and 50.

Body elongate, slightly curved, conical or wedge-shaped, plastic and somewhat variable in form, the posterior extremity mostly tapering and pointed, sometimes obtusely rounded; the anterior half of the body obliquely truncate or excavate on its concave or ventral side; flagella subequal, slender, inserted close to one another at the anterior margin of the frontal excavation; contractile vesicle single, located near the posterior extremity; endoplast central, spherical. Length of body 1–1800". Hab.—Stagnant water with decomposing organic matter.

This animalcule, originally described by Perty under the above title, is apparently identical with the flagellate form recently investigated by O. Bütschli, and referred by him, while retaining Perty's specific name, to the genus *Pyramimonas*. There are nevertheless one or two points in Bütschli's account which do not exactly correspond with Perty's figures and description, though such differences as exist may be possibly attributable to mere local variation. Thus the flagella, while described by the earlier authority as being equal to or longer than the body, are represented by Bütschli as only half that length. The obliquely truncate anterior border bearing these flagella is likewise described and figured by the same authority as extending backwards on the ventral side to a much further distance than is shown by Perty.

These distinctions, if further substantiated, may necessitate the future introduction of two separate specific titles in place of the one here employed. The sarcode substance of this variety is apparently more plastic and liable to variations of outline, under normal conditions, than that of *Tetramitus rostratus*. No details have yet been recorded respecting the phenomena of reproduction. Representations of this species closely corresponding with those given by Bütschli are included in Stein's recently published volume.

Tetramitus sulcatus, Stein. Pl. XIX. Figs. 26 and 27.

Body obtusely pyriform or subcordate, widest and rounded anteriorly, tapering towards and bluntly pointed at the posterior extremity, about one and a half times as long as broad; a deep groove traversing the entire length of the centre of the ventral side and imparting to the posterior extremity, as seen from beneath, a bilobate contour; flagella four in number, of equal length, inserted close together in the centre of the anterior border; endoplast and contractile vesicle located side by side near the same anterior margin; parenchyma granular, soft and plastic. Length 1–700″.

HAB.—Fresh water.

The form of the body of this species, with its bilobate terminal extremity, accords closely with that of the *Callodictyon triciliatum* of Carter, the number and disposition of the flagella, and shape also of the body, excluding the median groove and posterior bifurcation, approaching that of *Tetraselmis.* In both of the last-named structural characters it differs considerably from the two preceding species, and would seem almost to lay claim to a separate generic title. In the figures only of this type included in Stein's recently published work, the enclosure within the body of solid food-particles is delineated, but no indication is given of a distinct oral aperture; probably, as in *Callodictyon*, these are incepted at any point of the periphery.

GENUS II. TETRASELMIS, Stein.

Animalcules free-swimming, solitary, contained within a transparent membranous lorica; four flagella of similar size and character inserted at the anterior extremity; endoplasm coloured green, usually enclosing an eye-like pigment-spot.

Tetraselmis cordiformis, Carter sp. PL. XIX. FIGS. 28 AND 29.

Lorica somewhat heart-shaped, widest and emarginate anteriorly, rounded and slightly narrower posteriorly; body of animalcule only partially or almost completely fitting the cavity of the lorica, coloured green throughout; flagella inserted close to each other in the centre of the anterior margin and thence protruded through the aperture of the lorica; eye-like pigment-spot situated near the centre of the lateral border; a large vacuolar dilatation lying immediately beneath the insertion of the flagella; contractile vesicles two in number, located one on each side of this area; endoplast located in the median line, a short distance to the rear of the contractile vesicles; the posterior region of the body often containing from one to three or more solid corpuscles of an apparently amylaceous nature. Length of lorica 1–933″. HAB.—Fresh water.

This species was first described by Mr. Carter * under the title of *Cryptoglena cordiformis*, and has been rightly recognized by Stein as representing an independent generic form. On one occasion Mr. Carter observed an example that had become encysted and broken up into a number of sporular bodies. The more complete diagnosis of the structural characters of the type here submitted is rendered with the aid of the illustrations of the species given by Professor Stein.

GENUS III. CHLORASTER, Ehrenberg.

Animalcules free-swimming, somewhat variable in form, subfusiform, angular, or prismatic; the anterior border bearing a central vibratile flagellum surrounded by four long, recurved, hair-like or setose flagellate appendages; endoplasm coloured green, frequently enclosing a red eye-like pigment; no distinct oral aperture. HAB.—Salt and fresh water.

* 'Annals of Natural History,' 1858.

The genus *Chloraster*, as here recognized, includes, in addition to the *Chloraster gyrans* of Ehrenberg, the *Pyramimonas* of Schmarda, and a third salt-water form recently obtained by the author in the Channel Islands. The close affinity of all three, and the undesirability of separating them into two generic groups, is made manifest on reference to the figures of both Ehrenberg's and Schmarda's types, as included in Stein's recently published work, and reproduced at Pl. XIX. As previously intimated, it has been proposed by Diesing and Bütschli to relegate the representatives of the genus *Tetramitus* also to that of *Chloraster*, or rather to *Pyramimonas* as defined by Schmarda, but it is evident from the comparatively complete data now made known concerning these respective groups that they exhibit nothing in common with each other, and cannot consistently be united.

Chloraster gyrans, Ehr. PL. XIX. FIGS. 21 AND 22.

Body subfusiform, widest centrally, pointed at each extremity, about twice as long as broad; the central region sometimes produced into four symmetrical lobate processes, which stand out at right angles to the long axis of the body; flagella five in number, of equal length, produced from the pointed anterior extremity; endoplasm green, enclosing anteriorly an eye-like pigment-speck. Length 1–632". HAB.—Fresh water.

The delineations of this type are reproduced from the figures given in Stein's recently published volume.*

Chloraster tetrarhynchus, Schmarda sp. PL. XIX. FIG. 20.

Body pyramidal or conical, truncate and widest anteriorly, the opposite extremity more or less pointed, longitudinally carinate down the central line at each of the four lateral angles; four long, recurved, setose flagella issuing from a papilla-like prominence in the centre of the anterior border, a long vibratile flagellum projecting from the centre of the reflected seta; colour green; movements swift, in a straight line or rotatory. Length 1–780" to 1–720". HAB.—Fresh water: near Vienna (Schmarda).

No indication is given by Schmarda, in either his drawings or description, of the central vibratile flagellum characteristic of both the preceding and the succeeding species; this organ is, however, so difficult to detect without the use of reagents and the most perfect magnifying glasses that it may have naturally escaped his attention. In some instances, as likewise in the case of *C. agilis*, the more normal quadrate contour of the body of the animalcule is exchanged for a rounded sub-conical or shortly fusiform outline. No coloured eye-like pigment-spot appears to be present in this type. Mr. Carter, in a manuscript note-book kindly placed at the author's disposal, has figured an organism with four radiating seta-like appendages at the anterior extremity, obtained by him from a well at Bombay, that is apparently closely allied to if not identical with this species. It having been collected in company with *Cladophora fracta*, Mr. Carter has suggested, in absence of further evidence, that the form may represent the motile zoospore-like elements of that algal; the appearance of both this and the following form, indeed, so closely approximates such reproductive structures, that but for the characteristic and evidently independent movements exhibited by *C. agilis*, circumstances would have apparently justified the relegation of this genus to the vegetable series.

In the accompanying figure given of this species, reproduced from Stein, there

* 'Infusionsthiere,' Abth. iii., 1878.

are no less than eight setose appendages delineated, representing apparently the number developed preparatory to the process of longitudinal fission.

Chloraster agilis, S. K. Pl. XIX. Fig. 15.

Body conical or subtriangular in profile, widest and truncate anteriorly, gradually tapering towards the posterior extremity, which is sometimes bluntly and sometimes sharply pointed; exhibiting in transverse view a quadrate outline with four symmetrically developed, projecting, keel-like angles; central vibratile flagellum slender, as long as the body, produced from a papilliform or pyramidal prominence that arises from the centre of the frontal border; four fine, flexible, setose flagella originating close to the base of the central flagellum, which they equal in length, and recurved towards the posterior extremity of the body; endoplasm pale transparent green, with a colourless central space, a faint red eye-like pigment-spot usually present near one of the angles of the anterior border. Length of body 1-2500". Hab.—Salt water.

This species, distinguishable from the preceding by its diminutive size and salt-water habitat, was obtained in some abundance in an infusion of hay in sea-water at St. Heliers, Jersey. It was first observed after the vegetable matter had been macerating for a space of about four weeks, and was probably imported originally with the water in the sporular condition. At first the author was disposed to identify it generically, if not specifically, with the *Plœotia vitrea* of Dujardin: his description of this form, however, in which it is described as possessing two flagella only, one of which is vibrated in advance and the other trailed behind and adherent at will, demonstrates the place of that species to be close to *Heteromita* or *Anisonema*, and nowhere near the present type. Like *Oxyrrhis*, this species exhibits a restless and active condition, in which it darts about too swiftly almost for the eye to follow, and a sedentary one, in which the body remains perfectly quiescent, and apparently angles for food with its extended vibratory flagellum. The four accessory, reflected, but flexible, hair-like setæ, although motionless during the quiescent state, are probably brought into active use in the natatory condition, it being difficult otherwise to account for the rapidity with which it, as it were, shoots along in a straight line from one resting-point to another.

The number of the setose flagella, as also the exact contour of the body, whether triangulate or quadrate, proved for a considerable while a difficult point to decide, but was finally settled by the addition to the water of dilute osmic acid, which at once killed the animalcules without altering their shape, and thus made clear the characters embodied in the foregoing diagnosis and accompanying figure. Neither the existence of a contractile vesicle, of a definite oral aperture, nor the inception of solid food, has as yet been determined in this species. The apparent control over their motions in the water exhibited by these little beings demands brief notice, and fully proves their claim for admission as representatives of the animal series. In a drop of water containing several examples of this species, it was noticed that if one animalcule in its swift nomadic career passed near another, possibly striking it with one of its extended setæ, the one so disturbed immediately started in pursuit, several often joining in the chase, and gambolling together in a manner corresponding with what is hereafter related of the Holotrichous Ciliate type *Cyclidium glaucoma*. In a similar manner it was also observed that they would congregate together in that part of the field most brilliantly illuminated by the aid of the achromatic condenser, when illuminated by artificial light. In addition to the faint red pigment-spot usually present at the anterior end, an oval, darkish-green, nucleus-like body was frequently noticed towards the posterior extremity.

Fam. XVI. HEXAMITIDÆ, S. K.

Animalcules naked, free-swimming or temporarily adherent; flagella six in number; no distinct oral aperture.

Genus I. HEXAMITA, Dujardin.

Animalcules naked, free-swimming or temporarily adherent; elongate-ovate or subfusiform, but more or less plastic and variable in shape; the posterior extremity bearing two long, flexible, adhesive, caudal flagella; four long vibratile flagella produced from the anterior border; endoplast and contractile vesicle usually conspicuous; no distinct oral aperture. Inhabiting stagnant water and the intestinal viscera of Amphibia. Increasing by longitudinal fission.

Up to a comparatively recent date much doubt prevailed respecting the existence of the hexaflagellate animalcules, imperfectly described and connected with the present generic title by Dujardin so long since as the year 1841.* Within the last few years, however, various specific types have been rediscovered and subjected to minute examination by Stein, Bütschli, and the present author, their place as highly remarkable representatives of the Infusoria Flagellata being through such investigation fully established. Among the data of note concerning the vital phenomena of these singular animalcules, recorded for the first time in this volume, may be mentioned their demonstrated capacity to lead a temporarily attached, in addition to a natatory existence, as described in association with the two specific types *H. intestinalis* and *H. inflata*. Although Stein has indicated in one of his drawings the position of a presumed oral aperture, no trace of any such distinct inceptive area has so far been detected by the author. Pending, consequently, the production of more decisive evidence in this direction, it has been decided to relegate the members of this generic group to the section of the Pantostomata.

Hexamita intestinalis, Duj. Pl. XIX. Figs. 60–62.

Body subfusiform, widest towards the anterior region, tapering and pointed posteriorly, two or three times as long as broad, frequently with one or two longitudinal dorsal sulci; all six flagellate appendages similar in size, equalling or exceeding the length of the body, the two posterior trailing flagella inserted close to each other at the pointed posterior extremity, the four anterior vibratile flagella originating in like manner from the anterior or apical extremity; contractile vesicle anteriorly located; endoplast spherical, subcentral. Length 1–2000″ to 1–1500″.

Hab.—Alimentary canal of Tritons and Batrachia.

This species is illustrated by a large series of figures in Stein's recently published volume, and has been obtained and examined in considerable abundance by the author from frogs dissected at Professor Huxley's biological laboratory, South Kensington, during the winter session of 1879 and 1880. In none of the illustrations given by the first-named authority is, however, any indication given of the characteristic habit manifested by the animalcules to attach themselves by their posterior flagella, as observed by the author of both this and the species next described. When

* F. Dujardin, 'Histoire des Zoophytes Infusoires,' Paris, 1841.

first transferred to the stage of the microscope, they, like *Polytoma*, usually rush wildly about the field, conveying the impression that they are entirely free-swimming. After a short interval, however, their movements get less excited, and they finally affix themselves to the glass slide, or any neighbouring organic debris, by their adherent posterior flagella, while the four anterior appendages are vibrated actively in the surrounding liquid medium, in the manner indicated at Pl. XIX. Fig. 61. The exact number, character, and point of insertion of the flagella may be readily substantiated during this attached condition, though with even greater facility on killing the little creatures by the application of a small drop of iodine or osmic acid. The extreme flexibility of these animalcules is frequently manifested in both their natatory and sedentary conditions, the body being frequently flexed to such an extent that the anterior and posterior extremities almost touch. In the figures of *Hexamita intestinalis*, recently published by Stein, two examples are represented as possessing a delicate, denticulate, frill-like membrane on each side of the anterior border, one of these, as represented at Pl. XIX. Fig. 62, exhibiting in addition numerous elongate papillose projections in the posterior region, which are pronounced in the index to be merely adherent Bacteria. No such frill-like border could be detected in any of the examples examined by the author, and it would seem highly probable that both this structure and the Bacteria-like appendages represent peculiarly modified pseudopodic expansions of the body-sarcode of the animalcule preparatory to the assumption of an encysted state. Similar slender papillose pseudopodia are shown in this volume to be emitted under like circumstances by the zooids of *Codosiga botrytis* and *Cephalothamnium cæspitosa.* The young of this species, according to Stein's figures, possess only two anteriorly inserted vibratile flagella, while the general contour of the body is more attenuate than that of the adults.

Among the numerous examples recently examined by the author, zooids were not unfrequently observed, in which the posterior region was distinctly cleft or bifurcated, after the manner of the succeeding species. This circumstance, added to the fact of the identity of the habitats of the free-swimming *H. inflata* and the Amphibia that harbour *H. intestinalis*, not unnaturally raises a doubt as to whether these two presumed distinct types may not ultimately prove to be free-swimming, and endoparasitic phases of the same specific form.

Hexamita inflata, Duj. PL. XIX. FIGS. 56–59.

Body oblong or subquadrangular, emarginate or bifid posteriorly, plastic and changeable in form, varying from one and a half to two or three times as long as broad, the two caudal trailing flagella produced as tail-like prolongations of each limb of the posterior bifurcation, the four anterior vibratile flagella originating close to one another in the centre of the anterior border; contractile vesicle anteriorly located; endoplast subcentral. Length 1–2500″ to 1–1200″.

HAB.—Pond water with decomposing organic matter and in vegetable infusions.

Independently of its distinct habitat, this species is to be distinguished from the preceding form by its broader contour and the conspicuous emargination of the posterior region. It has recently been figured by both Stein and Bütschli, and has also been obtained by the author from both marsh-water and from an infusion of decaying flowers, its companions in each instance being *Trepomonas agilis*, and in the latter one also *Vorticella infusionum.* Like *Hexamita intestinalis*, it has been frequently observed to affix itself by the two caudal flagella, the anterior appendages being meanwhile deployed and vibrated actively in the surrounding water, with the apparent object of drawing suitable food-particles within reach of the body. The animalcules under this temporarily affixed condition were found on several occasions to exhibit a remarkable peculiarity of deportment, which, though subsequently observed, has not as yet been recorded of the preceding type. The adhesion in these instances was effected only by the extreme distal terminations of the caudal flagella, and the animalcule, extended to its full length at their extremity, rotated rapidly backwards and forwards on its long axis. The two caudal flagella were thus alternately twisted upon each other in converse directions, while the four anterior appendages performed, in unison with this reversible gyratory motion, graceful and devious curves around the creature's body; the aspect of an animalcule engaged in such active exercise is represented at Pl. XIX. Fig. 59. As already suggested by the author in an article on "Parasitic Infusoria," contributed to the 'Popular Science Review' for October 1880, it would seem highly probable that the form described by Professor Leidy under the title of *Trichonympha agilis*—referred provisionally in this treatise to the Holotrichous order of the Ciliata—represents some species of *Hexamita*, imperfectly observed by him under the conditions just related. The simile invoked by this authority in connection with *Trichonympha*, that of ballet-dancers having long cords suspended from their shoulders, which whirled around them in mazy undulations as they danced, by no means inaptly represents the characteristic aspect of the members of the present genus during their attached gyratory phase of existence here recorded.

The adhesive character of the caudal flagella of *Hexamita* is often manifested by the animalcules picking up flocculent matter or other debris with these appendages, and dragging it with them as they swim through the water. This phenomenon is indicated in the delineation by Stein, without explanatory notes, reproduced at Fig. 58 of the plate just quoted, and has been frequently witnessed by the author. In addition to its more ordinary sedentary condition, the present type has also been observed by the author to creep and bore its way through the gelatinous zooglœa-scum collected on the surface of vegetable infusions, the body at such times assuming the most protean contours, and closely resembling that of an *Amœba*. *Hexamita inflata* is figured by Bütschli as having six vibratile flagella, in addition to the caudal pair, inserted at remote distances upon the lateral periphery. This representation of their disposition is apparently derived from an error of interpretation, otherwise, if eight flagella in all were actually present, the example had evidently developmented a supplementary pair, preparatory to the process of longitudinal subdivision. Such an octoflagellate example, reproduced from Stein's volume, is delineated at Pl. XIX. Fig. 57; but in this case the supplementary pair is developed at the posterior extremity, which has become doubly emarginate or quadrifid.

Hexamita rostrata, Stein. Pl. XIX. Fig. 55.

Body fusiform, broad and inflated centrally, with a conical or rostrate anterior prolongation, and a still longer and attenuate caudal termination, the total length about equal to twice the central breadth; flagella long, slender, and of equal size, the four anterior ones inserted close to each other at the apex of the anterior prolongation, the two posterior appendages similarly approximated at the end of the caudal extension; contractile vesicle posteriorly situated; endoplast not indicated. Length 1-640".

Hab.—Unrecorded.

This species is shown by Stein's figures to correspond closely with *H. intestinalis*, but may be distinguished from the same by the distinct prolongations of the anterior and posterior regions of the body. In general contour, as delineated by Stein, this type may be said to correspond singularly with that of the apterous insect *Lepisma*, the proportions and locations of the two sets of flagella agreeing in a remarkable manner with the antennary and caudal filaments of that arthropod.

Hexamita nodulosa, Duj.

Body oblong, with three or four longitudinal nodular rows, the two lateral of which are extended posteriorly, imparting to this region a bifurcate aspect; caudal flagella produced from the posterior bifurcations; vibratile flagella four in number, long and slender, projecting from the anterior margin. Length 1–2000″ to 1–1500″.

HAB.—Pond water with decomposing animal matter.

This species, as yet observed only by Dujardin, is most probably, as suggested by Bütschli, a variety merely of *H. inflata*.

Fam. XVII. LOPHOMONADIDÆ, S. K.

Animalcules naked, solitary, and free-swimming, bearing a tuft of flagella at the anterior extremity; no distinct oral aperture.

GENUS I. LOPHOMONAS, Stein.

Animalcules free-swimming, somewhat plastic and varying in form, spherical, ovate, or fusiform, bearing at the anterior extremity a crescent-shaped fascicle of long, slender flagella; endoplast sometimes distinct; contractile vesicle not yet recognized; inhabiting the intestinal tract of various Insecta.

This genus was first instituted by Stein, in the year 1860,* for the reception of a singular form obtained by him from the intestinal canal of the common cockroach, *Blatta* (*Periplaneta*) *orientalis*. The same type has been since met with under similar conditions by O. Bütschli, who has further described a second well-marked species. The tuft-like fascicle of flagella at the anterior extremity, forming the leading characteristic of the members of this genus, consists of so thick an aggregation of these vibratile appendages, as to convey to the individual zooids the aspect almost of certain Ciliata, such as *Strombidium*.

Lophomonas blattarum, Stein. PL. XIX. FIGS. 52–54.

Body somewhat variable in form, ovate or subspherical, surface smooth; the frontal margin slightly narrowed, abruptly truncate; flagella issuing in a dense brush-like tuft from the frontal border, the central ones longest, directed straight forward, equal to or exceeding the length of the body, the lateral ones shorter, gradually diminishing in size, reflected outwards; an indistinct vesicular space posteriorly located; endoplast spherical, situated in the median line near the anterior extremity. Length of body 1–825″.

HAB.—Intestine of the common cockroach, *Blatta* (*Periplaneta*) *orientalis*.

The accounts given by Stein and Bütschli of this animalcule, while agreeing in general details with one another, differ slightly in some minor points. Stein, for instance, has described the examples examined by him as of a rounded subspherical shape, whereas those forming the subject of Bütschli's investigations were, for the most part, of elongate-oval form; the rounder outline being chiefly associated

* 'Sitz. der könig... böhm. Ges. Wiss.'

with younger individuals. This slight disparity of contour, Bütschli suggests, may be possibly accounted for by the fact that Stein turned his examples into pure water, a medium which, proving uncongenial to their habits, may have resulted in their assumption of a more contracted shape. Using himself a solution of the white of egg, he preserved the animalcules in a healthy and normal state for a space of twenty-four hours and upwards. The presence of food-particles within the substance of the endoplasm has been observed by both of the authorities quoted, Stein further reporting the possession of a narrow, crescentic oral aperture at the anterior extremity. The existence of such a structure is, however, not confirmed by the investigation of Bütschli. The food-particles ingested are usually collected together in the posterior half of the body, leaving the anterior moiety clear and transparent; the expulsion of effete matter at the posterior extremity was on one occasion witnessed by Bütschli. Not unfrequently this investigator observed that the body-plasma of the posterior end was drawn out in a tail-like manner; his illustration given of this phenomenon being at the same time connected with one of the rounder or younger individuals, would seem to indicate that in this earlier stage the sarcode of the body presents that greater amount of viscosity or ductility which is common to the young, and in some instances to the adults also, of the more simple monadine types. The first step towards the process of increase by fission has been observed, but not the complete act. In one of these suspected instances there was an appearance as of fine cilia at the posterior extremity of the body. The movements of the flagella-fascicle of this animalcule are somewhat complex, the central bundle of straight and longer ones undulating together rhythmically, while the shorter and reflected lateral ones vibrate independently.

Lophomonas striata, Bütschli. PL. XIX. FIG. 51.

Body variable in shape, mostly subfusiform, with an attenuate and pointed posterior extremity, but sometimes ovate and rounded in this region; anterior border abruptly and somewhat obliquely truncate; flagella-fascicle brush-like, similar to that of *L. blattarum*, but somewhat shorter in proportion to the length of the body; the entire external surface distinctly and obliquely striate; contractile vesicle and endoplast not yet observed. Length 1–800″.

HAB.—Intestine of *Blatta* (*Periplaneta*) *orientalis*.

Although the characters of this animalcule appear sufficiently distinct for separate specific recognition, Bütschli entertains some doubt whether it may not ultimately be found to represent a transitional condition only of *L. blattarum*. The two, while tenanting the same specific host, were, however, usually found inhabiting separate individuals, and did the present form represent a developmental phase only of the other, it would scarcely have escaped Stein's notice. The substance of the parenchyma in this type or variety would appear to be much more homogeneous than in the form last described. A clear vacuolar space was on one occasion noticed near the anterior extremity, but no trace of an endoplast or nucleus could be detected.

Leydig has briefly referred, in his anatomical description of the mole-cricket, *Gryllotalpa*, to a globose animalcule bearing a lateral tuft of undulating hairs, that inhabits the intestinal tract of that insect. As remarked by Bütschli, it is highly probable that this organism represents another species of *Lophomonas*, as also that this genus has numerous other representatives distributed among the Orthopterous order of the Insecta.

Fam. XVIII. CATALLACTIDÆ, S. K.

Animalcules coherent in social clusters, their anterior and exposed border clothed with long vibratile flagella; no distinct oral aperture.

GENUS I. MAGOSPHÆRA, Haeckel.

Animalcules free-swimming, united in social clusters, joined to each other centrally by an inward extension of their prolonged posterior extremities, the anterior or exposed margin of each animalcule clothed with long vibratile flagella; endoplast and contractile vesicle conspicuous, increasing by the subdivision into sporular elements of a single encysted zooid. Inhabiting salt water.

Professor Haeckel * has proposed to create a special and independent class of his sub-kingdom of the Protista, which he denominates the Catallacta, for the reception of the as yet single known type bearing the above generic title, discovered by himself on the coast of Norway. It is evident, however, that the structure, life history, and developmental features of this organism, as reported by himself, accord so closely with those of all the ordinary representatives of the Infusoria Flagellata, as recorded in this volume, that any such complete isolation of this particular type is altogether artificial and uncalled for. Individually examined, the zooids of *Magosphæra* correspond remarkably with those of the endoparasitic type *Lophomonas*, last described, and if encountered separately under like conditions would undoubtedly be relegated to the same multiflagellate genus. Their coherence in spheroidal clusters, again, and maintenance of a free-swimming existence, find precise parallels in such genera as *Synura*, *Syncrypta*, and *Uroglena*, while the ultimate assumption by the zooids of an amœboid phase and subdivision into sporular elements are common to the majority, if not to the entire section of the Pantostomatous Flagellata. Mostly, among the ordinary Flagellata, the resultants of such a process of multiple fission or sporular subdivision become scattered asunder throughout the surrounding water; a like more or less permanent coherence of the subdivisional derivatives is nevertheless maintained by the three last-named genera, and, with certain modifications, recurs in those motile reproductive products of the sponges, the "swarm-gemmules" or so-called "ciliated larvæ," discussed at length in Chapter V., and which are there shown to consist similarly of ovate or sub-spheroidal aggregations of flagellate animalcules. The only essential distinction manifested by the several types just quoted consists of the fact that in these latter the constituent zooids of the spheroidal or ovate masses are monoflagellate or biflagellate, while in those of the present generic group they are polyflagellate. While thus reluctantly compelled to ignore Professor Haeckel's claim on behalf of *Magosphæra* of a title carrying with it the comprehensive significance he would attach to it, his denomination of the same, slightly modified so as to reduce its import to that only of a family name, is here preserved.

Magosphæra planula, Haeckel. PL. I. FIGS. 12–17.

Bodies pyriform, forming spheroidal clusters, united to each other centrally by an attenuate inward prolongation of their posterior extremities, the interstices between being filled in by a common gelatinous matrix or zoocytium, the anterior margin truncate flattened, the antero-lateral borders polyhedral through mutual pressure; flagella equalling one-half of the length of the body, developed from the entire exposed anterior surface; endoplast spherical, situated in the median line towards the anterior extremity; contractile vesicle single, subcentral. Diameter of adult sphere-masses 1–320″.

HAB.—Salt water, Norwegian coast.

* "Die Catallacten, eine neue Protistengruppe," 'Jenaische Zeitschrift,' Bd. vi., 1870.

The development of this interesting form, as reported by Haeckel, may be thus summarized. The earliest or initial condition is represented by a single spherical, egg-like body, containing a large central nucleus or endoplast and enclosed nucleolus or endoplastule immersed within structureless transparent protoplasm, and surrounded by a denser investing membrane, as shown at Pl. I. Fig. 16; the nucleus divides by fission into two equal halves, accompanied by a similar segmentation of the circumjacent protoplasm, each section of which now envelops a single nucleus. By a repetition of this process, similar to that of ordinary yolk-cleavage, four, eight, sixteen, and finally thirty-two nucleated cleavage-spheres or daughter-cells are produced, and the segmentation is completed. The thirty-two bodies resulting from this segmentation begin now to exhibit amœboid movements within the investing pellicle, and emit from their surface small, irregular pseudopodic processes; these gradually become longer and thinner, ultimately presenting the form of attenuate vibratile flagella. United in a single spherical mass these bodies rotate slowly within their membranous prison, which at length bursts asunder, leaving the compound colony to swim away freely in the surrounding water, under the characteristic adult aspect detailed in the foregoing diagnosis, and delineated at Pl. I. Fig. 12. Sooner or later this compound body falls to pieces, the individual zooids assume an amœboid form (Fig. 15), and it is believed become encysted and once more repeat the cycle. During their active aggregated life the zooids ingest food apparently at any part of their exposed anterior border, there being no distinct oral aperture, and likewise during their amœboid condition through any portion of their periphery.

Apart from the true affinities and significance of *Magosphæra* previously discussed, the singular resemblance in general form, size, and plan of ciliation of the separate zooids to the constituent elements of ciliated epithelium will at once suggest itself to the practical physiologist. A coherent spherule of such epithelial cells indeed, excepting for the absence of the contractile vesicles, would be indistinguishable from a colony-stock of *Magosphæra planula*, as originally described and delineated by Professor Haeckel.

Order V. CHOANO-FLAGELLATA, S. K.

OR *FLAGELLATA-DISCOSTOMATA.*

Animalcules exceedingly minute, highly polymorphic and variable in form, usually exhibiting in their most normal and characteristic phase a symmetrically ovate, pyriform, or clavate outline; a single long, lash-like flagellum produced from the centre of the anterior border, the base of which is embraced by a delicate, hyaline, extensile and retractile, collar-like expansion of the body-sarcode; the collar in its extended condition infundibuliform or wineglass-shaped, when contracted subcylindrical or conical, exhibiting in its expanded state a distinct circulating current or cyclosis of its finely granular substance; ingestive area discoidal, food-substances being brought in contact with the expanded collar through the vibratory action of the flagellum, first carried up the outside and then down the inside of this structure with the circulating sarcode current, and finally received into the substance of the body anywhere within the circular area circumscribed by its base; fæcal or waste products discharged at any point within the same discoidal space; a distinct spheroidal endoplast with a contained endoplastule and two or more contractile vesicles usually conspicuous.

Inhabiting salt and fresh water. Increasing by longitudinal or transverse fission and by encystment and subdivision of the entire body into sporular elements.

Section I. DISCOSTOMATA-GYMNOZOIDA.

Collared monads free-swimming or sedentary, loricate or illoricate, solitary or colonially associated, never in the latter instance completely immersed or hidden within special chambers in a common gelatinous matrix or cytoblastema, but either entirely naked or with their distal regions freely exposed to the surrounding water.

The extensive and remarkably beautiful series of Flagellate organisms comprehended under the present sectional title may be said to represent the fruits of the most recent microscopic research. The immunity from discovery and taxonomy which they have for so long previously enjoyed is undoubtedly due to their excessive minuteness, the largest individual zooid in the entire group not exceeding in length the 1–1000th part of an English inch, while in the majority of instances the much smaller calibre of the 1–3000th" obtains. The rapid progress made by opticians, however, within the last few years, in the production, at a moderate cost, of object-glasses of high magnifying power, has placed in the hands of the histologist the key to an entirely new organic world, and of which the present group furnishes, perhaps, a not altogether inappropriate illustration.

The earliest intelligible record given concerning the existence of the series of minute organisms here referred to the newly established order of the Choano-Flagellata, and distinguished in all instances by their possession of the delicate, collar-like organ which encloses with its base the single terminal flagellum, must undoubtedly be associated with the name of the late Professor H. James-Clark, of the Agricultural College of Pennsylvania, U.S.A., who in June 1866 communicated to the Boston Society of Natural History a detailed account, with copious illustrations, of four American forms discovered by himself as inhabitants partly of salt and partly of fresh water. Previous to this date such authorities as Ehrenberg and Stein had certainly figured and described one or two species of the genus *Codosiga* as minute varieties or early growths of representatives of the Peritrichous genus *Epistylis*, while Fresenius had gone so far as to recognize in the form now known as *Codosiga botrytis* the flagelliferous character of the component zooids, and also the possession by them of a truncate hyaline projection of the anterior border that may be readily identified at the present day with the distinct collar-like organ that characterizes all members of this group. Prior even to the time of Ehrenberg a record of the existence of these minute Flagellate organisms is to be met with, some members of the genera, *Monosiga* or *Salpingœca* being in all probability represented by the so-called "squamulæ adhærentes" figured by O. F. Müller, and even referred to by Leeuwenhoek as being found attached to the pedicles of *Vorticella* (*Carchesium*) *polypinum* and *V.* (*Epistylis*) *anastatica.* The names of those who have to be accredited with the confirmation and further extension of the comparatively recent discoveries of Professor Clark are as yet but few in number. The pleasant experience of being the first upon this side of the Atlantic to recognize types belonging to the same category, partly identical with and partly differing from those made known by that authority, and to generally substantiate that interpretation of their structure which he had first submitted, fell to the lot of the present author.

A notice of such discovery, with illustrations and brief diagnoses of the several forms observed, was communicated to the meeting of the Royal Microscopical Society held on November 1st, 1871, and was published in the following, December, number of the 'Monthly Microscopical Journal.' From that date forward the author's attention has been more especially concentrated upon this highly interesting organic group, the result of such investigation being the registration of over three-quarters out of the total number of fifty or more species now known to science, and described in this treatise. The greater number of this series were already known to the author in the year 1877, and formed the subject of a communication, accompanied by an extensive set of plates, read in abstract at the meeting of the Linnæan Society on June 21st, 1877. While, however, it was subsequently decided to reserve all complete textual and illustrative details for primary publication in the present manual, a general summary of the contents of this communication was given in three articles published respectively in the 'Annals and Magazine of Natural History' for January and August 1878, and in the 'Popular Science Review' for April of the same year. As an accompaniment to the article in this last-named periodical, entitled "A New Field for the Microscopist," were produced furthermore two plates containing upon a reduced scale delineations, with their technical names attached, of all the newly discovered species embraced in the larger communication made to the Linnæan Society, so as to secure for them a priority of nomenclature pending the appearance of the present treatise. Since the publication of these several papers a recognition of the collared monads has been accomplished by the German authorities, Professors F. Stein and O. Bütschli, the former more especially in his 'Infusionsthiere,' Bd. iii. Heft 1, produced in November 1878, containing illustrations, of which the textual descriptions yet await publication, of some half a dozen varieties distinct from those first discovered by Professor Clark, or included in the author's earlier communication of the year 1871. Bütschli's observations were confined to three or four specific forms identical with types previously examined by Professor Clark or the author. Still later, M. Charles Robin, in the 'Journal de l'Anatomie et de la Physiologie' for November 1879, has placed on record the results of his investigation of the single type *Codosiga botrytis*, bringing to a conclusion the enumeration of the literature concerning this highly interesting group of the Flagellata so far accumulated. By no one of these several authorities, however, has there as yet been produced any attempt at a full interpretation of the remarkable and important functional properties pertaining to the delicate funnel-shaped sarcode expansion or "collar" common to all the members of this organic series. By both Professor Clark and Bütschli it has been maintained that an oral aperture is present, the former indicating its position as within the area circumscribed by the collar, and at the base of the flagellum, while Bütschli, in the case of *Codosiga botrytis*, has somewhat more vaguely defined it as appertaining to special vacuolar areas developed at different points of the periphery external to the base of the expanded collar. The intimate correlation of this last-named structure with the process of food-inception, appears to have altogether escaped recognition by these investigators.

What the precise import of the "collar" is, and in what manner it is connected with the ingestive functions, had been ascertained by the present author so far back as the year 1871, and is indirectly referred to in the paper then communicated to the Royal Microscopical Society, already quoted. Full details, with explanatory illustrations, were, however, reserved for comprehension in the more exhaustive account of this remarkable group of animalcules produced six years later, and were also extensively set forth, with accompanying figures, in the two articles bearing upon this subject, published in the months of January and April 1878. A slightly amended quotation *in extenso* from the later of these two publications, in conjunction with the coloured frontispiece of this manual, may be advantageously produced on the present occasion in illustration of the structural and functional properties and peculiarities of the organ now under consideration :—"Specifically, this delicate hyaline organ, the 'collar,' is of such extreme tenuity, that its true form and nature can be demonstrated only by a very careful adjustment of the achromatic condenser or other accessory illuminating apparatus employed, and is even then exhibited to greater advantage by supplying the animalcule under examination with artificial food, such as carmine or indigo. Under the conditions last mentioned, it will be found that the collar consists of a transparent infundibuliform film of sarcode that may be protruded from and withdrawn at will into the general substance of the monad's body, in the same manner as the sarcode prolongations or pseudopodia of an *Amœba* or other Rhizopod. As in the pseudopodia of certain Rhizopods, such as the Foraminifera, it will moreover be found that, notwithstanding the extreme tenuity of the sarcode film, a circulation of its substance is being constantly maintained, flowing upwards on the outside, over the distal edge or rim, and downwards on the inner surface, at the base of which it again comes in contact and merges with the protoplasmic substance of the body. This wineglass-like film of sarcode doubtless acts as an efficient branchial or respiratory organ, but such by no means represents its most important function. In conjunction with the centrally enclosed flagellum it constitutes a most admirably contrived trap or snare for the capture and retention of the animalcule's food. Whirling round with inconceivable rapidity, the last-named organ, the flagellum, creates a strong centrifugal current in the water, setting in from behind towards the direction of its own apex, and bringing with it all such tiny organic particles as do not possess sufficient weight or power to stem its tide.* But for the outstretched collar, these would simply hurry with the stream past the monad's body and out of reach. Not for them, however, so easy a passing of the rapids! In the midst of their swift career they strike against the almost impalpable film of sarcode of which the organ is composed, and to this they adhere as tenaciously as a snared bird to a lime-daubed twig or an incautious fly to a spider's web. Then slowly, almost imperceptibly, the captive atoms are carried along with the circulating current of the collar's substance up the outside and down the inside until, on reaching the base of its inner surface, they are engulfed within the sarcode substance of the monad's body. The food-particles after ingestion are gradually accumulated into spherical agglomerations, and then regurgitated through the body under conditions nearly identical with those exhibited by such a higher infusorial type as *Vorticella.* The indigestible residua are eventually liberated from the area, limited by the base of the collar, within which they primarily gained access."

The highly characteristic aspect of an animalcule that has fed upon and become gorged with carmine particles in the manner previously suggested, is delineated in the frontispiece of this treatise, which represents an animalcule of *Monosiga gracilis* S. K., viewed with the enormous magnification of 8000 diameters, as obtained by a $\frac{1}{50}$-inch object-glass and C ocular, supplied to the author by Messrs. Powell and Lealand. The arrows placed in various positions serve to indicate the direction of the current induced by the active rotation of the flagellum, and also the course described by the carmine particles after striking upon and becoming adherent to the extended collar. Even where the magnifying power employed is not sufficient to exhibit the cyclosis of the collar substance, the addition of carmine or indigo, in a granular form, to the water containing the animalcules is highly advantageous, since the particles having a tendency to accumulate upon the distal rim of the structure, as shown in the frontispiece, define its contour with an amount of perspicuity obtainable under no ordinary conditions. Most usually, in point of fact, as seen even with adequate magnification, this highly important organ, the collar, is visible only in the optically denser regions represented by the two lateral peripheries, taking the apparent shape then of two linear or setaceous appendages projecting one on either side of the centrally located flagellum. As such apparently simply linear or setose structures, the lateral peripheries of the characteristic collar have indeed been delineated by both earlier and more modern investigators. Examples of monads having their true structure thus only partially revealed, are abundantly furnished by the illustrations reproduced from the authorities referred to, given at Plate II. Figs. 12, 16, 19, 20, and 21, Pl. V. Figs. 32 and 33, and Pl. VI. Fig. 11. The figure last quoted is of especial interest, since it represents a form included by Mr. Carter

* This seemingly anomalous direction of the current induced by the motion of the flagellum may be simply and practically illustrated and explained by inserting a stick through a ring and giving them a swift rotatory action, the free or distal end being made to describe the larger circle. Although the stick may be elevated perpendicularly, the ring will travel from the base to its apex, thus demonstrating the centrifugal nature of the force engendered. Such a more abnormal rotatory flagellum will act as a "*pulsellum*" (see p. 416), driving the body, if detached, backwards through the water. In all ordinary Flagellata the motions of the flagellum are simply undulatory, producing currents in an opposite direction, or towards its base of attachment, and the appendage acting as a "*tractellum*" drags the body after it, if detached, in a straightforward course.

in his note-book so long ago as the year 1857, under the designation of an "animalcule with ear-like processes," and which has been since recognized by him as a species closely allied to the *Salpingœca amphoridium* of Professor H. James-Clark.

The more exact morphological significance of that special organ, the "collar," remains to be discussed. Having due regard to the circulatory currents or cyclosis manifested by the sarcode substance of which it is composed, there can scarcely be room for doubt that this structure finds its precise homologue in the pseudopodia of the Foraminiferous group of the Rhizopoda, and in which a similar circulation or cyclosis of the constituent sarcode is exhibited. Its extreme mobility and plasticity, allowing it at will to be contracted from a widely expanding infundibular contour to a subcylindrical or truncate conical outline, as first recognized by Clark, and shown in many of the accompanying illustrations, or further to be withdrawn entirely into the substance of the body, is of itself indicative of a close relationship with the group just designated. The collar may, in fact, be most appropriately compared in this connection to a funnel-shaped aggregation of the single anteriorly protruded pseudopodic fascicle of some Monothalamous Foraminifer such as *Lagena* or *Miliola*, or it may be supposed that such a type has developed a single subcylindrical anterior pseudopodium, whose substance has become hollowed out centrally, so as to produce a tubular or infundibuliform contour. In either case the central flagellum may be regarded as a supplementary appendage, whose presence alone secures the group of the Choano-Flagellata from being placed among, or closely adjacent to, such typical Rhizopoda.

Comparatively small as is the number of species that have so far been referred to this Discostomatous or collared Flagellate section, the multiplicity of forms presented by them is truly remarkable. Still more noteworthy, however, in this connection, is the extraordinary similarity that subsists between these various modifications and conditions of growth, as here exhibited, and those found to obtain among the more highly organized Peritrichous group of the Vorticellidæ. Like these latter, the great majority of its members pass a sedentary existence, and are similarly distinguished under such conditions for their solitary, or social and dendritic habits of growth, for their secretion and occupation of distinct horny loricæ, or for their colonial aggregation within a common gelatinous matrix or zoocytium. Compared in detail with one another, the isolated representatives of the genus *Monosiga* may aptly be likened to those of *Vorticella* or *Rhabdostyla*, *Codosiga* to *Epistylis* or *Opercularia*, *Salpingœca* to *Vaginicola* or *Cothurnia*, while in *Phalansterium* and *Protospongia* the conditions presented find their precise parallel in *Ophrydium*. It would seem by no means unreasonable, indeed, to regard these diversely modified Flagellata as the lineal ancestors or archetypes of the Peritrichous series, and it has been already suggested by Gruber * that the funnel-shaped collar of the present Flagellate series finds its morphological counterpart in the delicate transparent membrane lying within the peristome of many ordinary Vorticellidæ, and which seen in profile presents the aspect of a setose appendage. A still closer approximation is, however, undoubtedly found in E. Ray Lankester's anomalous genus *Torquatella*, where an extensile and contractile collar-like membrane takes the place of the normal circular fringe of cilia. As demonstrated in various instances in the course of this treatise, the primitive condition of the adoral fringe or wreath of cilia is that of a simple membranous band or expansion; and accepting the phenomena thus exhibited by the life-history of the zooid or individual as in all probability indicative of the developmental cycle or phylogeny of the group or order, it may be consistently inferred that the Peritrichous series originated from a stock or phylum in which the now highly specialized adoral ciliary wreath was represented by a simple infundibuliform membranous expansion. While the genus *Torquatella* affords substantial evidence in favour of this interpretation, still more important testimony in the same direction is perhaps yielded by the two Cilio-flagellate types *Stephanomonas* and *Asthmatos*. Both of these, while possessing an anteriorly located

* 'Zeitschrift für Wissenschaftliche Zoologie,' Bd. xxxi., 1879.

circular fringe of cilia, are furnished in addition with a long terminal flagellum, the relationship maintained between these diversely modified appendages being identical with that subsisting between the collar and its centrally enclosed flagellum in the flagellate group now under discussion. If, indeed, future investigation were to reveal that the initial condition of the ciliary wreath in these two generic types took, as in other cases, the form of a simple membranous expansion, these animalcules, during such earlier epoch of their existence, would be altogether indistinguishable from the representatives of the ordinary Choano-Flagellata. In *Asthmatos* it is further noteworthy that the cilia comprising the adoral wreath are of an unstable and fugitive nature, being capable of protrusion and retraction after the manner of pseudopodia within the substance of the body-sarcode. This particular attribute of the appendages in question may be also cited as substantially supporting the affinity here inferred, a similar but even more conspicuously pronounced Rhizopodal attribute being exhibited by the morphologically corresponding or homologous appendage possessed by the collared monads.

As already briefly related at page 80, the animalcules belonging to this highly interesting Flagellate order are remarkable for their pale glaucous green or fluorescent hue, such colour assisting materially in the recognition of their presence even when the magnifying power employed is insufficient for the detection of their characteristic collar, with its enclosed flagellum.

The leading demarcations of the family and generic groups of the independent or Gymnozoidal section of the collared Flagellata or Discostomata adopted in this volume are set forth in the accompanying Table.

FAMILIES AND GENERA OF CHOANO-FLAGELLATA.

SECTION I. DISCOSTOMATA-GYMNOZOIDA.

FAMILY.			GENUS.
I. CODONOSIGIDÆ. Animalcules naked, secreting neither a lorica nor a gelatinous syncytium.	Attached	Solitary, stalked or sessile ..	1. *Monosiga.*
		United socially on a common pedicle	2. *Codosiga.*
	Free-swimming	United in stellate clusters ..	3. *Astrosiga.*
		United in chain-like series ..	4. *Desmarella.*
II. SALPINGŒCIDÆ. Animalcules secreting horny loricæ.	Lorica solitary	Sedentary	5. *Salpingœca.*
		Free-swimming	6. *Lagenœca.*
	Loricæ united socially and forming a branching polythecium		7. *Polyœca.*
III. PHALANSTERIIDÆ. Animalcules secreting a gelatinous zoocytium; forming extensive social colonies.	Collar rudimentary		8. *Phalansterium.*
	Collar well developed		9. *Protospongia.*

Fam. I. CODONOSIGIDÆ, S. K.

Animalcules free-swimming or attached, solitary or socially united, entirely naked, secreting neither independent loricæ nor gelatinous zoocytia ; collar well developed, encircling the base of the single terminal flagellum ; contractile vesicles two or three in number, posteriorly located ; endoplast spherical, subcentral.

GENUS I. MONOSIGA, S. K.

(Greek, *monos*, solitary ; *siga*, silence.)

Animalcules solitary, illoricate, of ovate or spheroidal contour, but somewhat plastic and changeable in shape, sessile or attached through the medium of a simple rigid pedicle ; bearing anteriorly a well-developed membranous collar and single centrally enclosed flagellum; contractile vesicles two or three in number, posteriorly located; endoplast spheroidal, subcentral. Inhabiting salt and fresh water. Increasing by transverse fission, and by the breaking up of the entire body-mass into sporular elements.

This newly established generic group comprehends the simplest known representatives of the Choano-Flagellate order. All its members, while agreeing essentially in structure with the isolated zooids of the previously discovered genera *Codosiga* and *Salpingœca*, are to be distinguished from the former by their eminently solitary mode of growth, and from that of *Salpingœca* by the entire absence of a protective sheath or lorica. With relation to the compound type *Codosiga*, *Monosiga* may be said to occupy a position similar to that which subsists between the solitary Peritrichous genus *Vorticella* and the compound forms *Carchesium* and *Epistylis*. In all the species here enumerated it has been observed that the body-sarcode is of much softer and more plastic consistence than obtains in either *Codosiga* or most other generic representatives of the same order; owing to this circumstance it is found that while each specific type preserves a more normally maintained characteristic form, the separate zooids are subject to considerable individual variation. A like plasticity, developed, however, to a more extensive degree, is especially distinctive of the aggregated collared monads of all sponge-stocks, and which, examined in their isolated condition as shown at Pl. VIII. Figs. 2–7, 10, 18, and 20, might easily be mistaken for members of the present genus. A distinctive feature pertaining to the developmental phenomena of *Monosiga* as compared with *Codosiga*, is afforded by their transverse in place of longitudinal plan of subdivision; the anteriorly produced resultant of such process of segmentation swims off as a simple collarless uniflagellate monad, and forms an independent attachment.

A.—Pedicle absent, rudimentary, or non-persistent.

Monosiga angustata, S. K. Pl. II. Figs. 31 and 32.

Body very attenuate, clavate or subcylindrical, about four times as long as broad, attached by its more slender posterior extremity, without the intermedium of a pedicle; endoplast spherical, subcentral; contractile vesicles two in number, posteriorly located. Length of body 1–2500″.

Hab.—Fresh water, solitary.

Only two or three examples of this elegant little animalcule have been as yet observed, being then discovered attached to examples of a species of *Cyclops* obtained from a pond on Wandsworth Common. The earlier condition of this type, prior to the development of the characteristic collar, represented at Pl. II. Fig. 32, is remarkable for its conspicuous resemblance to the undeveloped and elongate collarless monads of a motile sponge-gemmule, as illustrated in various figures of Pl. IX.

Monosiga consociatum, S. K. Pl. IV. Figs. 19–21.

Body ovate or pyriform, widest posteriorly, about one and a half times as long as broad, attached sessilely or through the intermedium of a short rudimentary pedicle; endoplast spherical, subcentral; contractile vesicles two in number, posteriorly located. Length of body 1–4000″ to 1–3500″.

Hab.—Fresh water, gregarious.

The zooids of this species are not unlike those of the persistently stalked marine *M. ovata*, but are of even more plastic consistence. Although a short pedicle was occasionally observed, the majority of examples were fixed directly to the water-weed without any such intermedium. This diverse character of the mode of attachment of the individual zooids finds its parallel in the loricated type *Salpingœca amphoridium*, where also a short pedicle may or may not be developed. A colony of this species was first discovered attached to decaying leaves of *Valisneria* from a fresh-water aquarium, and has been subsequently met with clustered in a similar social manner upon the carapace of a species of *Cyclops* taken from a mill-pond in St. Peter's Valley, Jersey.

At Figs. 20 and 21 of Pl. IV. two zooids are represented which, having withdrawn their collars and flagella, have assumed a semi-amœbiform contour, while the endoplasm has become highly vacuolar.

Monosiga Steinii, S. K. Pl. IV. Fig. 12.

Body elongate-ovate or subfusiform, widest centrally, tapering evenly towards each extremity, about twice as long as broad, attached immediately by its pointed posterior termination to the chosen fulcrum of support; collar nearly equalling the body in height; contractile vesicle single, posteriorly situated; endoplast inconspicuous. Length of body 1–1600″.

Hab.—Fresh water, attached to the pedicle of *Vorticella convallaria.*

Some half a dozen zooids of this species are figured by Stein * as doubtful phases of *Codosiga botrytis*, attached to the contractile stalk of a single example of the Vorticellidan above named. The even fusiform contour of the body, and entire absence of a pedicle, serve to distinguish this type from *M. brevipes*, which it otherwise most nearly resembles. A species apparently identical with this form has been recently observed by the author attached to the branching pedicle of *Epistylis plicatilis*.

Monosiga fusiformis, S. K. Pl. IV. Fig. 17.

Body elongate-fusiform, widest centrally, tapering and attenuate at each extremity, about three times as long as broad, fixed by the posterior extremity without any intermediate pedicle; contractile vesicles two in number, posteriorly located; endoplast subcentral. Length 1–2500″.

Hab.—Pond water, gregarious.

Examples of this species were found congregated upon the carapace and ovisacs of a species of *Cyclops* obtained from one of the water-fowl ponds in the Zoological Gardens, Regent's Park, in May 1879. Its more attenuate contour and crowded habit of growth distinguish it from *Monosiga Steinii.*

B.—Pedicle conspicuously and persistently developed.

Monosiga gracilis, S. K. Pl. II. Fig. 3, and Frontispiece.

Body elongate-ovate, broadest anteriorly, attenuate posteriorly, about two and a half times as long as broad, seated on a pedicle of from three to four times the length of the body, distal extremity of the pedicle retaining its original plastic state for a length nearly equalling that of the body. Length 1–4000″. Hab.—Salt water.

This species was obtained by the author in November 1875, attached to the stems of hydroid zoophytes and sea-weeds from the Manchester Aquarium, and also

* 'Infusionsthiere,' Abth. iii., 1878.

growing on similar organisms taken direct from the sea at Bognor, Sussex, in September 1872. In the examples derived from the last-named locality, the bodies of the animalcules presented a somewhat more rounded outline than those obtained at Manchester, both, however, agreeing in that essential plastic character of the distal region of the pedicle referred to in the foregoing diagnosis. The elegant wineglass-shaped collar in this type attains a greater comparative altitude than has been observed of any other member of this group, its total height not unfrequently equalling twice that of the body. It is at the same time of such extreme tenuity as to be scarcely visible throughout its entire length without recourse to the artificial feeding process described in the introductory remarks upon the group (see p. 326). Such feeding process at once shows up the outline of the hyaline organ with marvellous distinctness, and may be advantageously adopted in all cases where the contour of this structure is difficult to determine. An example of this species has been selected for the illustration given, in the frontispiece, of the ingestive phenomena exhibited by the animalcules of this order, the characteristic collar being somewhat foreshortened for want of space.

Monosiga ovata, S. K. Pl. II. Figs. 33–35.

Body subject to considerable variation in its proportions, normally inversely egg-shaped or obovate, broadest posteriorly, seated upon a rigid pedicle of a length equal or subequal to that of the body. Length of body 1–5000″ to 1–3500″. Hab.—Salt water.

The normal contour of the body of this species closely resembles that of *Monosiga gracilis* with the proportions reversed, e. g. the broader region being the end next to the pedicle instead of the one forming the free or distal extremity. The pedicle is also proportionally much shorter and rigid throughout its entire length. Representatives of this species frequently occur in which the form of the body differs considerably from the above and typical state, the outline then assumed being considerably more elongate and almost subcylindrical. These elongate zooids, as shown at Pl. II. Fig. 35, are sometimes slightly constricted towards the centre, and point probably to a phase preparatory to multiplication by transverse fission. The examples supplying this description were found, in company with *Monosiga gracilis*, attached to filamentous marine algæ collected at Bognor, Sussex, in September 1872.

Monosiga globosa, S. K. Pl. II. Figs. 4–6.

Body subspheroidal, attached to a very long, straight, and slender pedicle, whose total length equals four or five times that of the diameter of the body. Dimensions of body 1–4000″. Hab.—Fresh water.

The globular contour of the body and, in fully developed zooids, the great proportional length of the supporting pedicle, distinguish this type from any of the various species here described. Propagation by transverse fission, or by the separating off from the anterior extremity of monoflagellate free-swimming gemmules, has been frequently observed; the zooid so liberated, after passing a short nomadic existence, attaches itself by its posterior extremity, and developing a pedicle and collar, grows to the parent form. Such a separated monadiform zooid, with its primitively attached state, is represented at Pl. II. Figs. 5 and 6.

Monosiga brevipes, S. K. Pl. II. Figs. 7–9.

Body in its more normal state symmetrically ovate or elliptical, the posterior and anterior extremities being equally and obtusely pointed;

pedicle rigid and very short, not exceeding half the length of the body. Length of body 1–3000″ to 1–2500″. HAB.—Fresh water.

The zooids of this species have been encountered by the author abundantly attached to the pedicles of the higher Infusorial types, *Vorticella nebulifera*, *V. campanula*, *Epistylis flavicans*, and *Carchesium polypinum*. They not improbably represent the so-called "squamulæ adhærentes" referred to at page 325, first met with under similar conditions by O. F. Müller. As in *Monosiga ovata*, the form of the body is subject to considerable variations of contour. Pl. II. Fig. 8 thus illustrates an example in which the anterior extremity is so considerably prolonged as to impart to the animalcule a flask-like or bottle-shaped outline, while on other occasions, as at Fig. 9, the two apices may be so retracted as to produce an almost spheroidal shape. The pedicle, though short, is always distinctly developed, a circumstance which serves to distinguish this type from *Monosiga Steinii*.

Monosiga longicollis, S. K. PL. IV. FIG. 18.

Body flask-shaped, rounded and widest posteriorly, produced anteriorly in an attenuate neck-like manner, rather over twice as long as broad; pedicle short, one-quarter the length of the body. Length of body 1–2500″.

HAB.—Bog water, gregarious.

This type, which exhibits persistently a flask-shaped contour closely corresponding with that occasionally presented by *Monosiga brevipes*, was discovered by the author in September 1879, attached in social groups to the branching zoothecium of *Rhipidodendron Huxleyi*, previously described.

GENUS II. CODOSIGA, James-Clark.

Animalcules illoricate, spherical or ovate, attached socially to the terminations of a simple or variously branching, fixed and rigid pedicle or zoodendrium; collar well developed, enclosing the single terminal flagellum; contractile vesicles conspicuous, two or more in number, posteriorly located; endoplast anterior or subcentral; multiplying by longitudinal fission and by encystment and subdivision into spores. Inhabiting salt and fresh water.

To the single fresh-water representative of this genus, the *Codosiga pulcherrima* of Professor H. James-Clark, since identified with the imperfectly observed *Epistylis botrytis* of Ehrenberg, nine well-marked additional forms have been added by the author. Some of these inhabit salt and some fresh water, while all are readily distinguishable from each other by the form of growth of the supporting stem, or by the varying contours of the individual zooids. The branching colony-stocks of *Codosiga*, viewed with an insufficient amount of magnification, correspond so closely in their general mode of growth with those of *Epistylis*, that many of them encountered without a knowledge of their true nature, by both earlier and comparatively recent investigators, have been regarded as either immature or exceedingly minute species of that genus. Stein has preferred in his lately published work to alter the designation of this generic group from *Codosiga* to *Codonosiga*, upon the ground that the etymology of the first title as introduced by Professor Clark is not perfectly correct. Adhering, however, to the recommendations of the British Association,* to the effect that all scientific titles must be regarded simply as proper names, without regard to their strict etymological construction, and that when once conferred it is desirable that they should be permanently retained, Stein's proposed alteration has not been adopted in this manual.

* 'Rules of Zoological Nomenclature,' ed. 1878.

Codosiga botrytis, Ehr. sp. Pl. II. Figs. 22–29, and Pl. IV. Figs. 6–10.

Bodies smooth and transparent, symmetrically ovate, more attenuate posteriorly, about one and a half times as long as broad; from two or three to as many as twenty or more zooids, attached to the extremity of a straight, slender, simple, rigid pedicle, whose height equals four or five times the length of the body; their junction with this structure effected through the medium of a slender flexible extension of the posterior region, which frequently presents the aspect of a distinct secondary footstalk; contractile vesicles two or three in number, posteriorly located; endoplast spherical, situated in the median line in advance of the centre of the body. Length of body, exclusive of the collar, 1–2500″ to 1–2000″, the collar when extended equalling the body in height. Hab.—Fresh water, gregarious.

It being now universally admitted that this species—first described in an intelligible and exhaustive form by the late Professor H. James-Clark, under the name of *Codosiga pulcherrima*—is identical with the *Epistylis botrytis* of Ehrenberg, and *Anthophysa solitaria* of Bory and Fresenius, the specific title conferred upon it by the earliest of these several investigators must necessarily take precedence of the otherwise eminently suitable one proposed by the American authority. Among the numerous specific forms of the genus *Codosiga* enumerated in this volume, the present type represents the one most generally distributed. Since first meeting with it in the neighbourhood of London in the year 1871, it has been obtained by the author from innumerable stations throughout the country. Where once found, it is, moreover, usually abundant, being eminently sociable in its habits, and not unfrequently, as shown at Pl. II. Fig. 29, covering with a miniature forest-like growth the thread-like filaments of various aquatic Confervæ; the finely divided leaves of *Myriophyllum spicatum* form likewise a favourable fulcrum of support for this most elegant little species. At first sight it would appear that each separate ovate zooid springs immediately from the rigid pedicle, but a closer examination shows that each of these possesses a short, independent footstalk, which is, moreover, flexible and endowed with the vitality of the body proper. This fact may be clearly demonstrated by the observation of animalcules undergoing the process of longitudinal fission, and at which times it will be seen that the short flexible footstalk shares in the subdivision. As shown at Fig. 24, both the flagellum and the membranous collar participate in the longitudinal subdivision of the zooid, the latter structure during the process being conically contracted.

During the author's earlier acquaintance with this animalcule examples were frequently met with in which the entire surface of the body bristled with slender rod-like projections, which were at first regarded as foreign bacterium-like organisms accidentally entangled in the peripheral sarcode. Later on, however, it was determined that these structures were organically connected with the animalcule's body. It was then thought that the individuals exhibiting this peculiarity belonged to a separate species, and they were consequently figured and briefly described in the 'Monthly Microscopical Journal' for December 1871, under the title of *Codosiga echinata*. It has since been ascertained by the author that this supposed specific variety is an amœbiform condition of *C. botrytis* previous to its passing into an encysted state; the short rod-like processes corresponding indeed with the retractile pseudopodia temporarily developed under like circumstances by *Salpingœca amphoridium*, or other ordinary Flagellata. Sometimes, as shown at Pl. II. Fig. 26, these rod-like radiating pseudopodia are developed while the collar is fully expanded, but more often both this structure and the flagellum are entirely withdrawn into the substance of the body, which then presents the aspect delineated at Fig. 25. Upon this amœboid phase ensues an encysted condition in which the entire cuticular surface becomes indurated, and the enclosed endosarc breaks up into a number of spore-like bodies, as shown at Fig. 27. It is not improbable that previous to this encysting process, conjugation with other free-swimming animalcules is effected; but such a genetic union has not up to the present time been witnessed by the author, but is reported by Stein.

Bütschli, who has recently examined this form,* is disposed to maintain that food is ingested outside the membranous collar, through vesicular extensions that may be developed at any point close to its base. This interpretation, however, together with the original separate mouth theory advanced by Professor Clark, becomes quite untenable when set side by side with the evidence recently adduced relative to the nature and function of the collar, and as explained at length in the introductory notice of this group. Although normally only two spherical contractile vesicles, as represented by Bütschli, are to be observed in the posterior extremity of the body, as many as three are not unfrequently to be found, though, as explained by Professor Clark, this is more usual in examples about to increase by longitudinal fission. The systole and diastole of each of these vesicles, as observed by the author, occupy a duration of 60‴; Professor Clark, however, gives only half this time. The adherent bacteria interpretation, now abandoned, but formerly connected by the author with the echinate or amœboid state of this animalcule, is adopted independently by Bütschli in the publication quoted. Stein likewise figures an example in his recently issued volume, with a similar bacterial explanation, and also an instance in which the genetic union of a smaller free-swimming zooid with a solitary sedentary one is apparently in process of accomplishment. In both of these last-named instances, reproduced at Pl. IV. Figs. 9 and 10, it would seem probable, however, that the types figured are referable to the solitary genus *Monosiga* rather than to the colonially associated one now under consideration. Attention may be especially directed to the remarkable similarity that subsists between a luxuriant and subspheroidal colony-stock of *Codosiga botrytis*, as reproduced from Stein's work, at Pl. IV. Fig 6, and the subspheroidal or rosette-shaped gemmules, consisting of similar closely aggregated collared monads, developed by the sponge *Halisarca lobularis*, delineated at Pl. IX. Fig. 20. The addition of a pedicle is alone required in this latter instance to render the two monad aggregates indistinguishable.

Dr. Charles Robin has very recently † figured a supposed variety of *Codosiga botrytis* in which the characteristic collar is replaced by four rigid cirrhate processes. It is quite evident, however, that this presumed distinct variety represents merely that modified condition common to all members of the Choano-Flagellata, and specially referred to and illustrated in the description given of *Salpingœca amphoridium*, in which, the collar being withdrawn, simple pseudopodic extensions take its place. There can further be but little doubt that the form obtained from the Victoria Docks, figured and described by the author of this treatise in the 'Monthly Microscopical Journal' for May 1869, under the title of *Acineta socialis*, and compared at the time with the *Epistylis botrytis* of Ehrenberg, is identical with a similarly modified condition of the present species. Polymorphic tentacle-like processes approximating more closely to the pseudopodia of an ordinary Rhizopod than to the characteristic appendages of a true *Acineta*, were distinctly observed, and their presence accepted as rendering the relegation of the type to the order of the Suctoria entirely provisional.

Codosiga umbellata, Tatem sp. PL. IV. FIGS. 1–5.

Bodies gibbously ovate, rather over twice as long as broad, clustered in groups of from four to eight individual zooids at the terminations of a rigid tripartite, bi-tripartite, or occasionally quadripartite branching pedicle or zoodendrium. Length of bodies 1–1250″. Total length of branching pedicle

* 'Zeitschrift für Wissenschaftliche Zoologie,' Bd. xxx., Heft 2, 1878.

† 'Journal de l'Anatomie et Physiologie,' Nov. and Dec. 1879.

eight or ten to twenty times that of the body of a single zooid. Contractile vesicles and endoplast as in *C. botrytis.* HAB.—Fresh water.

This species, first figured and briefly described by the author under the above title in the 'Monthly Microscopical Journal' for December 1871, represents, both as regards the dimensions of the individual zooids and the size and proportion of the branching pedicle, the largest, and at the same time one of the most symmetrically developed members of this notably elegant genus so far discovered. An adult colony, inclusive of the branching pedicle, not unfrequently attains a total height of as much as the 1-62nd part of an English inch, and is therefore easily recognized with a comparatively low power of the microscope. It is almost beyond doubt a variety of this species that is figured and described by Mr. Tatem in the 'Transactions of the Royal Microscopical Society' for the year 1868, as a new type of *Epistylis*, and which he proposes to distinguish by the title of *Epistylis umbellatus.* The magnification of 300 diameters only, employed by Mr. Tatem, was not sufficient to enable him to recognize the hyaline collar and flagellum surmounting the distal extremity of each animalcule's body, but that he did not prove the existence of true cilia is equally apparent on reference to his figures, where in place of the continuous ciliary wreath characteristic of the ordinary Epistylids, a mere suspicion only of such structure is indicated at the two antero-lateral margins, and which may be easily identified with the imperfectly seen outline in profile of the transparent infundibulate collar. The dimensions, again, of the individual animalcules and branching pedicle of Mr. Tatem's supposed *Epistylis* accord so closely with those of the species now under discussion, that there can be but little uncertainty as to the near, if not absolute, identity of the two forms, and on this account Mr. Tatem's proposed specific title is here retained, and his own name associated with the nomenclature of the species. The method in which the symmetrically branched pedicle of *Codosiga umbellata* is produced is not very readily comprehended. The example figured by Mr. Tatem would seem to afford an instance of a quadripartite branching variety, but the tripartite one is the more prevalent. It might have been anticipated that this quadripartite type would have been the most frequent as the resultant of a single zooid twice divided by longitudinal fission, the four individuals thus produced then making a new start afterwards to repeat the process. The figure supplied by Mr. Tatem in fact shows four individuals at the extremity of each of the sixteen branchlets of the pedicle, a circumstance which exactly bears out such an interpretation. In all cases examined by the author, however, the pedicle was either tripartite or bi-tripartite (see Pl. IV. Figs. 1 and 3), the termination of each branchlet bearing, moreover, a considerable number of collared zooids. The foregoing explanation is therefore altogether inapplicable in these instances, and it remains an open question whether this distinct order of growth is not possibly indicative of a separate specific organization. Not having, however, as yet met with the quadripartite form figured by Mr. Tatem, and thus obtained an opportunity of instituting the necessary comparisons, the testimony so far elicited is here accepted in favour of their specific identity, and they are here distinguished as varietal forms only of *Codosiga umbellata.* In the more frequent tripartite and bi-tripartite pedicle of this specific type, it might in another direction be not inappropriately suggested that we find foreshadowed the same potential energy that produces in connection with the essentially similar collar-bearing monads of certain calcareous and siliceous sponge-forms their characteristic tripartite or bi-tripartite spicula. In addition to obtaining examples of *Codosiga umbellata* from various localities near London, the author has also received it growing upon *Anacharis* from the neighbourhood of Stourbridge, Worcestershire, in company with *Opercularia nutans* and other Infusorial forms remitted by Mr. Thomas Bolton.

Various altogether irregular stock-forms of this species are figured by Stein in his recently published volume, one of the more prominent of these being reproduced at Pl. IV. Fig. 5. That authority has further conferred upon the present species the distinct generic name of *Codonocladium*, with reference evidently to the branched character of the supporting pedicle. The transition, however, from the forms in which the zooids are almost, but not quite, sessilely attached to the summit of the primary stalk, as in *C. botrytis*, to those in which the latter structure is conspicuously branched, as in *C. umbellata*, and as shown by such types as *C. pyriformis*, *C. grossulariata*, and *C. candelabrum*, hitherto unknown to Stein, is however so gradual that an independent generic title in the present instance cannot be consistently maintained.

In examples of *Codosiga umbellata* examined by the author while going to press —November 1880, received from Mr. John Hood, of Dundee—a phenomenon has been observed not previously recorded of any other representative of the present Flagellate order. These having been submitted to somewhat undue pressure, threw out around their bodies a hyaline film of sarcode, which imparted to them the aspect of being enclosed within independent sheaths or loricæ, ultimately retracting both their collars and flagella. This pressure being removed, the bodies resumed their accustomed shape and the flagella and collars were again extended. In the delineations of *Codosiga botrytis* given by O. Bütschli, one abnormal example, figured and described as possessing a delicate viscid case, apparently represents a closely parallel condition of metamorphosis.

Codosiga allioides, S. K. Pl. II. Figs. 1 and 2.

Animalcules as in *C. botrytis*, but associated upon a multicapitate pedicle or zoodendrium, the main stem developing from one point as many as ten secondary branches of equal length, at the extremities of which the animalcules are grouped in subsessile social clusters; contractile vesicles and endoplast conspicuous. Length of bodies 1–1650″. Secondary stalks six or seven times, and primary stalk over twelve times the length of the supported zooids. Hab.—Fresh water.

The umbellate zoodendrium of this variety exhibits a plan of ramification that corresponds substantially with the floral umbel of the genus *Allium* and its allies among vegetable types, and upon which account the present specific title has been adopted. In another direction this species may be said to present the appearance of a number of colony-stocks of *Codosiga botrytis*, united at the bases of their respective pedicles to one common main rachis. In the single example that has yet been met with, there were no less than ten of these branches bearing each from three to six or seven animalcules. The length of each secondary stalk was rather longer in proportion than the single one of *C. botrytis*, while the main rachis measured a little over twice the length of the secondary ones. A corresponding diversity in size also subsists between the individual zooids of this type and those of *C. botrytis*, the latter being considerably smaller. The single specimen here figured and described was found growing on *Nitella* taken from a pond in the neighbourhood of London, supplied to the author by Mr. William Gay, F.R.M.S. From *Codosiga umbellata*, with the irregular growth-form of which, as reproduced from Stein's work at Pl. IV. Fig. 5, it to some extent agrees, the present species may be readily distinguished by the lax and undulating instead of rigid and rectilinear character of the supporting pedicle.

Codosiga cymosa, S. K. Pl. III. Figs. 3–7.

Zooids symmetrically ovate, stationed separately, upon short independent footstalks, at the extremities of a cymose or corymbiform, profusely branching pedicle or zoodendrium. Length of bodies 1–5000″, of main rachis 1–500″ to 1–250″. Hab.—Salt water.

The number of animalcules included in a single colony-stock of *Codosiga cymosa* exceeds that of any other species of the genus yet discovered, the luxuriantly branching pedicle not unfrequently supporting, as shown in the accompanying plate, as many as, or more than, one hundred individual zooids. With the exception of *C. pyriformis*, it is further the only example, out of the nine known species of the genus, that has been found in salt water, though doubtless future investigation will reveal the existence of many additional forms. The species as here figured and described was met with in November 1875, attached in great abundance to the empty cells of Polyzoa and Sertularian zoophytes, taken from the marine tanks of the Manchester Aquarium, at that time in the author's charge. As these zoophytes were in the first instance derived from various remote localities, it is not possible to fix the exact station on the British coast-line from whence they were originally imported. The branching pedicle or zoodendrium of *Codosiga cymosa* varies considerably in different colonies; where a large number of zooids are present the characteristic *corymboid* type is predominant, and the colony-stock as a whole considerably resembles in external contour the corymbiform flower-spike or panicle of the sea-lavender (*Statice limonium*). Pl. III. Fig. 7, represents an abnormal growth of this species in which the complete colony-stock presents in the arrangement of its constituent zooids an aspect highly suggestive in miniature of the zoarium of the polyzoic genera *Aulopora* or *Hippothoa*. This growth-form is produced by the abnormal mode of gemmation. Usually the tree-like colony is formed by the irregular dichotomous branching of the pedicle, the primary animalcules at the base of these branches becoming obliterated or losing their individuality by their onward growth. In this instance, however, each new bud, in taking its origin from the base of its predecessor, has left the preceding one intact, while at the same time the gemmation is much more sparse, and the pedicle to each individual is unusually prolonged. As shown at Fig. 4, it mostly happens that all the animalcules composing one large colony-stock, are so disposed as to face in the same direction, a formula of growth remarkable for its symmetry and elegance. At Pl. III. Fig. 6*a* will be found delineated a zooid in which the collar is retracted and the body, after throwing around it a hardened cyst-like investment, has divided itself into two equal parts. This no doubt represents the initial stage of a further breaking up of the entire body into sporular elements. As shown at Fig. 5*a*, there appears to be a tendency in this species to occasionally produce zooids of abnormal size. This phenomenon is probably also connected with the function of reproduction, and is suggestive of the like development, for reproductive purposes, of animalcules of abnormal size, which obtains in the genus *Zoothamnium*, among the higher Peritrichous Infusoria.

Codosiga grossularia, S. K. Pl. II. Figs. 10 and 11.

Zooids subspheroidal, attached in small clusters, through the intermedium of short independent pedicles, to a simple or sparsely branching main rachis. Length and diameter of bodies of animalcules 1–2500″; height of main rachis five or six to ten times the length of the supported zooids, secondary branchlets not equalling or but slightly exceeding their diameter.

Hab.—Fresh water.

This species may be easily recognized by the globose form of the bodies of the separate zooids, all the remaining representatives of the genus hitherto met with exhibiting a more or less ovate outline. The main stem remains undivided for a considerable distance, and is sinuous, as in *C. alloides*. The secondary subdivisions of the pedicle rarely exceed in length the diameter of a single animalcule, and being given off in close proximity to one another, impart to the complete colony-stock a considerable resemblance to a small bunch of currants. This species is of rare occurrence, two or three isolated examples only having been so far met with. At Plate II. Fig. 11 a colony-stock of three zooids only is represented, which are protruding digitiform pseudopodia from their lateral peripheries in a manner corresponding to that which has been previously recorded of *C. botrytis*. The examples furnishing this description were obtained by the author from a pond in the North London district supplied from the New River Waterworks.

Codosiga candelabrum, S. K. PL. III. FIGS. 8 AND 9.

Zooids elongate, gibbously ovate, from two and a half to three times as long as broad, forming small erect clusters and attached by secondary footstalks of their own altitude to the extremity of a pedicle of almost twice that height. Length of bodies 1-2000".

HAB.—Fresh water, on Entomostraca.

This type was obtained in March 1876, from the fresh-water dykes in the neighbourhood of Great Yarmouth, Norfolk, all the specimens then examined being found attached to the ovisacs and limb-joints of a species of *Cyclops*. In form and size the individual zooids correspond closely with those of *Codosiga umbellata*, the shortness of the primary pedicle, the length of the secondary ones, and the erect position maintained by the animalcules with relation to their supporting stem, distinguish it at once, however, from either the adults or from a young colony of that species, for which it might possibly at first sight be mistaken. Except for the small number of animalcules included in one colony-stock, four being the greatest number that has been yet observed, this species in miniature recalls to mind the higher Infusoria *Epistylis digitalis*, or *E. anastatica*, found growing with it on the same Entomostracon.

Codosiga pyriformis, S. K. PL. II. FIG. 14.

Zooids subpyriform, attached in small clusters by distinct rigid footstalks, which equal their own bodies in length, to the apex of a long, simple, and slightly sinuous primary pedicle. Length of bodies 1-4000".

HAB.—Salt water.

This type closely approaches the cosmopolitan fresh-water species *C. botrytis*, previously described. In addition, however, to its salt-water habitat and the broader contour of the animalcules, it may be readily distinguished from that species by the more attenuate and less rigid growth of the primary pedicle, by the greater length of the secondary ones, and the in general more erect position assumed by the individual zooids; this latter feature is a necessary accompaniment of the comparatively rigid consistence of the short secondary pedicles which immediately support the animalcules. It would seem to be not altogether improbable that the so-called variety of *Codosiga botrytis* recently figured and described by C. Robin, characterized by similarly developed secondary footstalks, represents the type now under consideration. This supposition receives substantial support from the circumstance that, although no habitat is recorded, the majority of accompanying infusorial types described by him are essentially inhabitants of salt water.

The examples of *Codosiga pyriformis* examined by the author were obtained growing abundantly on the deserted polyparies of Hydroid zoophytes and Polyzoa received from Brighton.

Codosiga furcata, S. K. PL. II. FIGS. 15-19.

Zooids shortly and obtusely ovate, attached singly or in pairs by footstalks of about their own length to a short and irregular, furcately branching pedicle. Length of bodies 1-3300", height of primary pedicle rarely exceeding that of a single zooid. HAB.—Fresh water.

This species may be readily distinguished from all the preceding forms by the character of the pedicle which commences branching at a short distance only from its origin. So far but a single colony of two animalcules has been met with by the author, but there can be little doubt that it is identical with that uncertain form figured by Stein in his 'Die Infusionsthiere auf ihre Entwickelunggeschichte,' 1854, as probably the young condition of one of the branching Vorticellidæ, or rather as an Acineta-phase, which he at that time believed preceded the perfect ciliated state of those more highly organized Infusoria. The magnifying power employed by Stein revealed only the two lateral margins of the transparent collar, which thus resembled the semi-withdrawn suctorial fascicles of various typical *Acinetæ*.

As many as ten zooids are comprised by Stein in the largest colony-stock he illustrates. The single specimen encountered by the author was obtained from a pond near South Norwood, London, in June 1877.

Codosiga Steinii, S. K. Pl. II. Fig. 20.

Zooids evenly ovate, stationed singly, or during the process of subdivision in pairs, at the extremities of a slender, dichotomously branching pedicle or zoodendrium. Length of bodies 1–3000″; primary, secondary and succeeding subdivisions of the pedicle mostly equalling about twice the length of the supported zooids. Hab.—Fresh water.

The above specific title is conferred upon the animalcule figured by Stein in 'Wiegman's Archives,' Taf. ii. fig. 36, 1849, as the probable young of *Epistylis nutans*;* these figures indicating, however, by the presence of the setum-like process on each side of the anterior border, the possession of an imperfectly observed but characteristic collar. In the illustrations of this form referred to and here reproduced, as many as fourteen zooids, in various processes of development, are represented upon the branching colony. The interspace between the basal attachment and first division of the pedicle, as also those between its subsequent ramifications, vary from the same to that of about twice the length of the body of the separate zooids; this more extended proportionate distance maintained between the ramifications of the pedicle readily distinguishes the species from *Codosiga furcata*, with which the contour of this structural element most closely coincides.

Codosiga assimilis, S. K. Pl. II. Fig. 21.

Zooids few in number, ovate or subpyriform, stationed singly at the extremities of a branching pedicle, the main rachis of which, equal to about four times the length of the zooids' bodies, is straight and simple, dividing then in a dichotomous manner, and forming short ramifications not exceeding the length of the animalcule's body. Length of these latter 1–1800″. Hab.—Fresh water.

This type is likewise figured by Stein, in company with the two preceding forms, as a probable early condition of *Epistylis nutans*, the mode of growth of the pedicle, and proportionately larger size of the animalcules, indicating, however, its specific distinctness. Pritchard, in reproducing Stein's figure, has proposed to identify it with the *Epistylis* (*Codosiga*) *botrytis* of Ehrenberg, but the compound ramification of the distal region of the pedicle demonstrates its non-correspondence with that simply pedicellate type. In this last named feature the pedicle of *Codosiga assimilis* agrees more closely with that of *C. grossularia*, while the contour of the zooids nearly resembles that of the marine *Codosiga pyriformis*. These latter are at the same time of considerably larger dimensions than those of either of the last-named varieties.

By accident, the illustration of this species has been included in the index to Pl. II. as a second example of *C. Steinii*.

* See also Pritchard's 'Infusoria,' pl. xxvii. fig. 22.

Genus III. ASTROSIGA, S. K.

(Greek, *astron*, star; *siga*, silence.)

Animalcules naked, free-swimming, united by their posterior extremities so as to form compound stellate or subspheroidal clusters; anterior region bearing a single long terminal flagellum, whose base is encircled by a well-developed, extensile and contractile, hyaline collar.

Astrosiga disjuncta, From sp. Pl. II. Figs. 12 and 13.

Zooids fusiform, tapering posteriorly, and there united to one another by the attenuated and almost pedicle-like elongations of the body-substance of this region. Length of zooids 1–1600″. Hab.—Fresh water.

The new generic title conferred upon this species has been established by the author for the reception of the form figured and described by De Fromentel * as a species of *Uvella.* In his description, which is most meagre, and also in his illustration, each unit is represented as bearing three short flagella, which, from their position and direction, it is evident represent a central flagellate appendage and the two lateral margins of the hyaline infundibulate collar of a typical collared animalcule, as seen under inadequate magnification. The figure given by De Fromentel is reproduced at Pl. II. Fig. 12, as also another representation, Fig. 13, slightly enlarged from this, with the anterior margin of the collar, which escaped that authority's notice, alone filled in. The example figured represents a stellæform colony composed of five zooids only, but doubtless much larger ones exist. Taken collectively, the colony-stocks of this specific type present a close resemblance to the monad-clusters of *Codosiga botrytis* separated from their common footstalk and floating freely in the water after the manner of the detached monad aggregates or "cœnobia" of *Anthophysa vegetans.* The more attenuate contour of the constituent monads of *Astrosiga* at the same time precludes the inference that might otherwise be arrived at, that it represents a detached colony of the first-named species.

Genus IV. DESMARELLA, S. K.

(Dim. of Greek *desmos*, chain.)

Animalcules naked, free-swimming, forming compound colonies, and united to one another by their lateral surfaces, without the intermedium of a pedicle or other supplementary element. Flagellum single, terminal, its base encircled by a well-developed, extensile and contractile, hyaline collar.

This and the preceding genus constitute the only free-swimming compound colony forms of the Choano-Flagellate order as yet discovered, though further investigation will probably lead to the recognition of as large a number of varieties as are here shown to obtain among the sedentary species.

Desmarella moniliformis, S. K. Pl. II. Fig. 30.

Zooids symmetrically ovoid, arranged in single chain-like series, each colony-stock containing from two to as many as eight individual units; endoplast spherical, subcentral; contractile vesicles two or more in number, posteriorly located. Length of individual zooids 1–4000″.

Hab.—Salt water.

* 'Études sur les Microzoaires,' Paris, 1876.

Examples of this specific type have been obtained in considerable abundance both in sea-water from the fish-house at the Zoological Gardens, Regent's Park, during the month of April 1877, and since then in water from the open sea at St. Heliers, Jersey. Propelled by the rapid motion of their flagella, the floating colonies of this species pass through the water with such rapidity that it is difficult to retain them in the field of view when a high power of the microscope is being used, and it is only when naturally at rest, or the animalcules become entangled among surrounding substances, that their true structure can be satisfactorily determined. The mode of growth of this type seems to indicate that the moniliform colony is produced by the successive longitudinal fission of the primary individuals, though the process has not yet been directly observed. In the larger colonies the perfect chain of animalcules usually assumes a rounded crescentic outline. The individual zooids appear to possess a more indurated cuticular surface than is met with in any other representative of this group, and up to the present time no trace of a plastic or amœboid condition has been detected. The contractile vesicles are, as with the more ordinary members of this order, posteriorly located. The remarkable resemblance that subsists between a colony of this specific form and the portion of a single segment of the collar-bearing zooids of the "ampullaceous sacs" of certain sponge-forms will be made apparent on comparing the illustration given of this species with Pl. IX. Fig. 2 representing such an isolated fragment of the ampullaceous sac of the spiculeless sponge *Halisarca Dujardinii.*

Small colonies of this species, consisting of from two to four laterally united zooids only, have been quite recently, November 1880, detected by the author in sea-water remitted with living Polyzoa by Mr. Thomas Bolton from the Aston Aquarium, Birmingham.

Desmarella phalanx, Stein sp.

Zooids resembling those of *Desmarella moniliformis,* forming similar floating chain-like colonies, but inhabiting fresh water.

This species is figured by Stein* under the designation of *Codonodesmus phalanx.* While its fresh-water habitat renders it probable that the form is specifically distinct from the type last described, there can be no doubt as to their generic identity. Since, however, the title introduced by the author has been already made use of in connection with illustrations and textual reference on two occasions prior to the appearance of Stein's volume,† such previously proposed one necessarily takes the precedence. In one of the chain-like colony-stocks of the present type, figured by Stein, no less than eleven zooids are laterally united, while in another, consisting of eight animalcules, the group is in process of division into two smaller aggregates of four units each. Stein apparently entertains doubts as to whether this species represents a permanent and independent stock-form, he having connected with the generic and specific titles introduced by him a provisional significance only.

Fam. II. SALPINGŒCIDÆ, S. K.

Animalcules secreting and inhabiting independent or socially united protective sheaths or loricæ, which are either free-floating or attached, in a sessile manner or through the medium of a distinct pedicle, to aquatic objects; flagellum single, terminal, encircled laterally by a well-developed membranous collar; contractile vesicles usually two or more in number, posteriorly located; endoplast subcentral. Inhabiting salt and fresh water.

* 'Infusionsthiere,' Abth. iii., November 1878.
† 'Popular Science Review,' April 1878, and 'Ann. Nat. Hist.,' August 1878.

Genus I. SALPINGŒCA, James-Clark.

Animalcules solitary, plastic and variable in form, secreting and inhabiting a fixed, chitinous, transparent sheath or lorica; the lorica either sessile or mounted on a more or less distinctly developed pedicle; mostly freely movable within and not attached permanently to the lorica, but sometimes united to it posteriorly through the intermedium of a pedicle-like extension of the body-sarcode, or through the medium of several pseudopodic prolongations; contractile vesicles conspicuous, two or more in number. Inhabiting salt and fresh water. Increasing usually by transverse, rarely by longitudinal fission and by subdivision into spores.

The animalcules of this genus correspond in form and aspect with those of *Codosiga* and *Monosiga*, indicating in the great plasticity of their sarcode, as also in their isolated mode of growth, their more close affinity with the latter. The diversely shaped and elegant transparent loricæ secreted and inhabited by the numerous members of the genus *Salpingœca*, readily distinguish them from those of the preceding groups. Pursuing that comparison between these lowly organized types and the higher infusorial forms which has been previously instituted, *Salpingœca* may be said to exhibit a relationship towards *Monosiga* analogous to that which subsists between the loricated genera *Cothurnia* or *Vaginicola* and the simple illoricate genus *Vorticella.* Professor James-Clark, who first established the present generic group, introduced three forms as claimants for admission to it. All of these have been met with by the author in British waters, while upwards of twenty forms new to science are here added to them. The process of alimentation in *Salpingœca* corresponds exactly with what has been described of *Codosiga* or *Monosiga*, there being no distinct mouth as at first presumed by Professor Clark, but the inceptive or oral area being common to the whole region enclosed by the membranous collar, and the ingested food-particles being captured with the assistance of this structure. Propagation by transverse fission, as in *Monosiga*, as also by the breaking up of the body into sporular elements, has been satisfactorily determined in connection with several specific types.

A.—Pedicle absent, rudimentary, or exceptionally developed.

Salpingœca amphoridium, J.-Clk. Pl. V. Figs. 1–9.

Lorica sessile, flask-shaped, rounded at the base, produced anteriorly into a long, narrow neck, aperture of the neck slightly everted; contained zooid adapting itself to the shape of the lorica, inflated posteriorly and developed anteriorly into a slender neck-like portion; contractile vesicles three or four in number, posteriorly located; endoplast spherical, subcentral. Length of lorica, including the neck, 1–3350″ to 1–2500″; diameter of the expanded base 1–4000″.

Hab.—Fresh water, attached gregariously to Confervæ and other aquatic plants.

Var. *a.*—Same as the above, but the lorica mounted on a very short and rudimentary pedicle.

This animalcule appears to be the most abundant and widely distributed representative of the collar-bearing Flagellate order so far discovered. First introduced to the notice of the scientific world by Professor H. James-Clark,* it has been met with by the author in incredible numbers coating the filaments of various confervoid algæ and other water plants taken from numerous widely separated localities. A tolerable idea of the gregarious habits of this Flagellate animalcule, as manifested under favourable conditions, may be gained by reference to Pl. V. Fig. 1, representing the portion only of a colony attached to a single cell of one of the filamentous algæ viewed with a magnifying power of about 600 diameters. The lorica, which throughout *Salpingœca* and the three succeeding genera furnishes as a rule the only safe and reliable means of arriving at a satisfactory diagnosis of the species, is in this particular instance strongly suggestive of a Florence flask, or the more familiar caraffe that forms the necessary adjunct of the domestic toilet-table. With these it likewise vies in its crystalline transparency, which thus freely permits a clear and uninterrupted view of its living occupant.

The contained zooid itself, whose hardened exudation has built up its crystal cell, closely corresponds with that of a *Codosiga* or *Monosiga*, but exhibits a still greater amount of plasticity and tendency to alter its shape than has been observed in either of those two genera. The animalcule, which after secreting its lorica lies entirely free within it, occupies in its normal condition about one-half of its cavity, as represented at Pl. V. Fig. 2, the film-like collar and flagellate appendage projecting beyond the distal expansion of the neck of the lorica. It frequently happens, however, that the sarcode body occupies a considerably larger portion than one-half of the cavity of its lorica, and it is under these conditions that the animalcule usually exhibits its most characteristic polymorphic properties. At such times the hyaline collar disappears, having been altogether withdrawn into the substance of the body; the flagellum is soon retracted in a similar manner, and the whole animalcule thus becomes to all appearance one homogeneous mass of protoplasm. On arriving at this stage, or even before the absorption of the flagellum, however, this little speck of sarcode, apparently cramped and confined by the walls of its domicile, has commenced to protrude or bubble over, as it were, from the orifice of the lorica, the sarcode thus projected exhibiting remarkably diverse contours. Figs. 5 to 7 of the plate representing this species serve to illustrate the more typical modifications that may be assumed under the above conditions by the extended sarcode. Fig. 5, for instance, represents a phase in which, the collar being retracted, the flagellum still remains intact, and projects from a lobe-like extension of the excurrent sarcode. At Fig. 7 the flagellum is entirely withdrawn, and the mass of protruding sarcode, greatly increased in bulk, is separated into numerous digitate prolongations, imparting to the animalcule a general aspect strongly suggestive of an example of the loricated Rhizopod *Difflugia*, with its pseudopodia extended, and of which genus, had it been only encountered in this stage, it might have been consistently accepted as a minute species. Fig. 6 represents a third variety of the many-protean forms assumed by this animalcule, and in which the projecting sarcode is split up into innumerable fine divisions after the manner of the pseudopodia of the genus *Gromia*. We have in this instance, probably, a phase exhibiting an abnormal disintegration of the hyaline collar previous to its complete absorption, and corresponding in kind, though exceeding it in degree, to that one reported by C. Robin of *Codosiga botrytis*, in which, as already related, the collar was replaced by four processes resembling setæ. The import of the foregoing singular modification of the sarcode of *Salpingœca amphoridium* does not however culminate in its mimetic resemblance to certain ordinary Rhizopods. There is undoubtedly correlated with this phenomenon one of the most important phases of the animalcule's reproductive functions. It has indeed been ascertained by repeated observation on the part of the present author, that the redundant mass of sarcode extruded from the interior of the lorica under the various forms described, is ultimately severed from the parent mass, and after a short lease of liberty reattaches itself and becomes developed into a collared zooid resembling that from whence it sprang. The parent animalcule, after this budding or practically transverse fission process, diminished considerably in size, assumes its

* 'Memoirs of the Boston Society of Natural History,' vol. i., 1868.

pristine contour, and developing a new hyaline collar and flagellum, is not to be distinguished from the ordinary zooids with which it is associated. That portion of the sarcode which is extruded and breaks away in the manner just described, is found in the case of the species now under discussion, to uniformly assume a persistent and highly characteristic shape. This, as shown at Pl. V. Figs. 8 and 9, may be compared to that of a minute, stellate, free-swimming Amœba corresponding closely with the type described by Dujardin under the title of *Amœba radiosa*, but of much smaller comparative proportions and with shorter pseudopodia. In close proximity to the larger colonies of this species, minute, floating, stellate, amœboid zooids, identical in form with those whose detachment has been actually observed, are almost invariably met with, these at the same time retaining a marked resemblance to the phase assumed by the sarcode when issuing from the lorica as shown at Fig. 7, allowing for that slight contraction and general pulling together of its substance which ensue upon its detachment from the parent mass.

Professor James-Clark, in his original account of this species, attributes to it a distinct oral and anal aperture, lying somewhere near the base of the flagellum. This interpretation of its alimentary apparatus has, however, as in the case of all other members of the Choano-Flagellata, to be finitely dismissed. Carmine, when administered, was intercepted and ingested under circumstances and in a manner absolutely identical with what has been already described at page 326 of *Monosiga gracilis*, while digested particles were observed to pass out in a similar manner from any part of the area confined by the base of the hyaline collar. Professor Clark further describes the flagellum as usually assuming a rigid and arcuate deportment; this aspect, however, is only the optical impression imparted at first sight through its exceedingly rapid revolution, an explanation which is satisfactorily confirmed by introducing carmine and watching the course of the currents produced in the manner already detailed. The duration of time occupied between the systole and diastole of each of the three or four conspicuous contractile vesicles situated at the lower extremity of this animalcule's body, average, in accordance with the author's observations, from thirty to fifty seconds. The duration of time between the expansion and contraction of these special vesicles, appears to differ considerably among allied members of the same genus, and furnishes probably a supplementary character for specific diagnosis.

While inspecting the manuscript note-books kindly placed at the author's disposal by Mr. Carter, a drawing has been noticed which beyond doubt represents several examples of a species closely allied to the present one, though, so far as can be judged from the comparatively low power of magnification employed in their delineation, the necks of the loricæ would appear, proportionately, to be considerably shorter. The drawing quoted, indicating by the short diverging lines at the apex of each lorica the presence of the characteristic collar and central flagellum, is with Mr. Carter's permission reproduced at Pl. III. Fig. 1. Beyond the registration of their having been obtained from fresh water at Bombay in the year 1855, no written details are preserved. The *Chytridium ampullaceum* of Braun * presents a remarkable superficial resemblance in both form and habits of growth to the minute Flagellate type now under discussion. No trace, however, of the flagellum or collar-like appendage, as distinctly marked in the preceding instance, is exhibited in the illustrations quoted, but merely a short conical projection beyond the orifice of the flask-shaped lorica, somewhat resembling a minute pseudopodic protrusion, but which may at the same time be the conical operculum of a genuine *Chytridium*. Stein, in his recently published volume,† appears inclined to identify the present form with Braun's type, and at the same time associates with the title of *Salpingœca amphoridium* an elongate form altogether distinct from the one originally figured and described by Professor H. James-Clark. Upon this more elongate type the author has consequently conferred in this volume the new name of *Salpingœca Steinii*. None of the various polymorphic phases of the present species, as here figured and described, appear to have been noted by Professor Stein.

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* 'Abhl. Berl. Akad.,' Taf. v. figs. 24–26, 1855. † 'Infusionsthiere,' Abth. iii., 1878.

Examples in which, as at Pl. V. Fig. 3, the lorica is mounted on a very short or rudimentary pedicle, are not unfrequently met with among the more ordinary sessile specimens.

Salpingœca fusiformis, S. K. PL. V. FIGS. 27–31.

Lorica sessile, subfusiform or vase-shaped, widest centrally, tapering equally towards the two extremities, but expanding again anteriorly into a somewhat prolonged and everted neck; contained animalcule flask-shaped, as in *S. amphoridium*, but of larger size. Length of lorica 1–1600″.

HAB.—Fresh water, solitary.

The elegant vase-like contour of the lorica of this species readily distinguishes it from the preceding form. Though tapering gradually to a slender point at the posterior or proximal extremity, it has not yet been found in any instance to develop a distinct pedicle, as not unfrequently occurs with *Salpingœca amphoridium.* It is, furthermore, much less plentiful than that species, and must be described as of solitary rather than gregarious habits. The withdrawal of the flagellum and collar, and the exudation of the sarcode, in a manner parallel to that already described of *S. amphoridium*, have been repeatedly observed. One of the more prominent phases of these protean changes will be found illustrated by Fig. 28 of Pl. V., in which instance the superabundant sarcode is exuding in the shape of an irregular lobate process, while in Fig. 27, representing the same zooid as observed fifteen minutes later, and in which the excurrent sarcode has broken away, the animalcule has once more assumed its normal shape and condition, the body now filling little more than half of the cavity of the lorica. Still more recently, April 1877, an example of multiple fission or breaking up of the parent zooid into spore-like bodies, preceded by retraction within its lorica and a process of encystment, has been observed. Fig. 31 represents an interesting phase of this process, in which the numerous monoflagellate zooids, the result of such a sporular mode of reproduction, are issuing from the aperture of the lorica. The pulsations of the contractile vesicle in this species occur at longer intervals than in *S. amphoridium*, a period of from eighty to one hundred seconds being, as so far observed, the average time occupied between the systole of each individual vesicle.

O. Bütschli * has recently described an animalcule identical with the present form under the name of *Salpingœca Clarki:* the present title, bestowed upon it in the author's communication to the Linnæan Society in June 1877, quoted also in the 'Annals of Natural History' for January 1878, necessarily, however, takes precedence of this later one.

Salpingœca Steinii, S. K. PL. V. FIGS. 10–12.

Lorica sessile, subfusiform or vase-shaped, about two and a half times as long as broad, attenuate and pointed posteriorly, tapering towards the anterior region, but expanding again and forming an everted neck; contained zooid flask-shaped, with an inflated basal and attenuate neck-like portion occupying about one-half of the cavity of the lorica; contractile vesicles two or more in number, posteriorly located; endoplast spherical, subcentral. Length of lorica 1–600″.

HAB.—Fresh water, forming gregarious rosette-shaped clusters.

This species, figured by Stein † as synonymous with the *Salpingœca amphoridium* of H. James-Clark, is evidently a perfectly distinct type, whose more elongate lorica

* 'Zeitschrift für Wissenschaftliche Zoologie,' Bd. xxx., 1878.
† 'Infusionsthiere,' Abth. iii., 1878.

accords so closely with that of *S. fusiformis*, previously described, that but for its marked gregarious habits of growth it would be difficult to distinguish it from that species. By Stein, it is represented as forming more or less considerable stellate or rosette-shaped clusters upon the branching pedicle or zoodendrium of the Peritrichous type *Epistylis anastatica;* it has recently been met with by the author forming similar clusters on the retractile pedicles of *Vorticella nebulifera*, collected in the neighbourhood of Acton. The author has much pleasure in associating with this species the name of its eminent discoverer.

Salpingœca minuta, S. K. Pl. III. Figs. 10–12.

Lorica sessile, ovate or conical, rounded and widest basally, tapering evenly towards the apical extremity, but not prolonged in a neck-like manner; the anterior aperture not everted. Length of lorica 1–4000″.

Hab.—Fresh water, attached to the loricæ of other flagellate animalcules; solitary or sparsely scattered.

This diminutive type has up to the present time been met with attached only to the conjoint loricæ or polythecium of the minute Flagellate form *Dinobryon sertularia*, hereafter described, and under which conditions it has been obtained in tolerable abundance. On account of its extremely small size, the body within the lorica frequently not exceeding in length the 6000th part of an English inch, a more than ordinarily high power is required for its satisfactory examination. An interesting process of gemmation similar to that recorded of two former species has been observed also in this pigmy representative of the genus. At Fig. 12 of Pl. III. an example is afforded of a zooid with the sarcode flowing out of the aperture of the lorica, the flagellum being as yet unretracted, while at Fig. 10, which represents two animalcules growing upon an empty cell of *Dinobryon sertularia*, a small rounded body attached below and indicated by the letter *a*, is evidently the result of the budding-off of one of these zooids, requiring but a brief interval for its development into the characteristic parent form.

Salpingœca pyxidium, S. K. Pl. III. Fig. 16.

Lorica sessile, obovate, attached by the more pointed posterior extremity, the larger and distal end slightly involute round the edge of the minute terminal aperture; contained animalcule subglobose, filling the anterior half of the cavity of the lorica. Length of lorica 1–4000″.

Hab.—Fresh water, solitary.

The dimensions of the lorica of this species correspond closely with those of *S. minutus*, in shape it is likewise conical, but the proportions are exactly reversed, the free end being considerably the larger. The aperture also does not occupy the whole of the anterior border as in all the species hitherto described, but only a small central portion, while the margin surrounding it is involute, thus imparting to the lorica, as seen in optical longitudinal section, a somewhat heart-shaped contour. A single example only of this species has been so far met with.

Salpingœca amphora, S. K. Pl. V. Fig. 13.

Lorica vase-shaped, attenuate posteriorly, having a neck-like constriction near the anterior margin, the greatest width being immediately beneath this region; no pedicle. Length of lorica 1–2000″.

Hab.—Fresh water, solitary.

In the shape of the lorica this species most nearly resembles the pediculate marine variety *S. urceolata*, delineated in the same plate. The only example yet found was attached to the carapace of the Entomostracon *Diaptomus castor* obtained from a pond on Wandsworth Common in April 1877.

Salpingœca cylindrica, S. K. PL. VI. FIG. 37.

Lorica sessile, subcylindrical, slightly widest posteriorly, about one and a half times as long as broad; contained animalcule elongate-ovate, attached by its posterior extremity to the bottom of the lorica, its distal end level with the orifice of this structure. Length of lorica 1–3250″.

HAB.—Fresh water, solitary.

The simple subcylindrical lorica of this species agrees most nearly with that of the marine form *Salpingœca petiolatum*, and may be said at the same time to correspond closely in miniature with that of many of the sessile Peritrichous *Vaginicolæ*. The only example yet observed was found upon *Conferva* taken from a pond near Acton.

Salpingœca Carteri, S. K. PL. VI. FIG. 39.

Lorica flask-shaped, the neck very attenuate, exceeding in length the bulbose posterior portion. Total length 1–3000″.

HAB.—Fresh water: Bombay (H. J. C.).

The above specific name is here introduced for the reception of the form originally figured and described by Mr. H. J. Carter * under the title merely of a "Bell-shaped Infusorium." As more recently recognized by him, the affinity of this variety with the *Salpingœca amphoridium* of James-Clark is very close, but the greater proportional length of the lorica, as shown by comparison of the figures of the two forms in question, indicates the necessity of conferring upon it a new specific title. The illustration by Mr. Carter, here reproduced, seems to indicate that the body of the lorica is joined to the object upon which it grows, through the medium of a narrowed prolongation of its substance, presenting the aspect of a peculiarly modified and expanded footstalk. The type-example of this species was found on *Conferva* in the fresh-water tanks of Bombay.

Salpingœca (?) Wallichi, S. K. PL. V. FIGS. 23 AND 24.

Lorica irregularly pyriform or flask-shaped, inflated posteriorly, terminating anteriorly in a narrow neck, growing upon or immersed within the shell-substance of *Globigerinæ* and other Foraminifera. HAB.—Salt water.

This type was originally described by Dr. Wallich † under the title of "externally opening pyriform cavities within the shell-substance of *Globigerinæ*." It is here introduced as a probable representative of the genus *Salpingœca*, with some amount of diffidence, the living constructor of the pyriform loricæ or cavities not having so far been observed, and the bodies in question having been hitherto regarded by their discoverer, and also by Dr. Carpenter, ‡ as essential structural elements of the exogenously developed shell-substance of the organisms with which they are found associated. As such hypothetical structural elements, they are interpreted on the one hand by Dr. Carpenter as being produced through the invasion from without

* 'Ann. Nat. Hist.,' vol. viii. p. 9, pl. ii. fig. 42, 1871.

† 'The North Atlantic Seabed,' 1862, and 'Deep Sea Researches on the Biology of Globigerina,' 1876.

‡ "On the Nature of the Seabottom procured by H.M.S. *Challenger*," 'Proc. Roy. Soc.,' 1875.

inwards of portions of the normal sarcodic investment of the shell, and by Wallich as the product of shell-secretion round extruded masses of sarcode. Comparison of these structures, however, as figured by Dr. Wallich and here reproduced, with the loricæ of various *Salpingœcæ*, such as *S. amphoridium* or *S. minuta*, reveals so remarkable a similarity of outline and correspondence in size, that the conclusion has been arrived at by the author that the two represent similar elements. Such being the case, it would appear that these loricæ are developed upon the shell-surface of the Foraminifera at an early stage of their growth, becoming, as this covering thickens, gradually surrounded and immersed within it, much in the way as certain Mollusca and Cirripedes, e. g. *Magilus* and *Pirgoma*, are found embedded within the hard calcareous sclerobase of madrepores or stony corals. Should the interpretation of these minute flask-shaped parasitic bodies, as here suggested, be correct, a further careful investigation may be expected to reveal their presence attached to and standing out independently from the external surface of *Globigerinæ* in their earlier, thin-shelled, floating state.

Salpingœca petiolata, S. K. PL. III. FIG. 26.

Lorica sessile, subcylindrical, about twice as high as broad, rounded posteriorly, the oral aperture not everted; contained zooid cylindrical, its length equal to about two-thirds of that of the lorica, to the bottom of which it is affixed by a slender thread-like pedicle. Height of lorica 1-1700″.

HAB.—Salt water, solitary or scattered.

This species has been obtained by the author in some quantity at St. Heliers, Jersey, in sea-water containing Polyzoa and hydroid zoophytes obtained from the adjacent coast, which had been left standing in open jars for some months. While the lorica corresponds chiefly with that of the fresh-water *S. cylindrica*, the contained animalcule differs essentially in its possession of a slender pedicle. Several examples were met with in which the zooids had entered upon an encysted condition within their loricæ. All traces of the collar, flagellum, and pedicle had, under these conditions, disappeared, the body being contracted into a simply ovate form within the furthest recess of its transparent domicile. It will possibly be desirable later on to establish a new generic title for those species at present retained in the genus *Salpingœca* in which the animalcule is affixed, as in the present instance, within its lorica through the medium of a separate thread-like pedicle.

Salpingœca ampulla, S. K. PL. III. FIGS. 17-21.

Lorica sessile, narrow and ovate beneath, expanding superiorly in an inflated, balloon-like manner, the external surface frequently exhibiting even longitudinal sulci or striations; animalcule, including the hyaline collar, entirely enclosed within the lorica, and attached to the bottom of this structure through the intermedium of a slender thread-like pedicle; the smaller posterior portion of the lorica enveloping the body, and the balloon-shaped anterior one the expanded collar of the contained animalcule. Length of lorica 1-1250″, of animalcule's body 1-4000″.

HAB.—Salt water.

This very beautiful variety is readily distinguished from all other representatives of the genus *Salpingœca* hitherto described, both on account of the remarkable shape of the lorica, and from the fact that the whole of the animalcule, including even the flagellum and hyaline collar, is completely enclosed within that structure. This last-named feature, which is shared to some extent by the stalked form *Salpingœca campanula*, might in fact be considered as of almost sufficient importance to warrant the creation, on behalf of this particular type, of a new and independent generic title. The gradual formation of the very elegant lorica by the enclosed animalcule, as also the development of the latter from a detached and simple uniflagellate monadiform gemmule, has been observed and will be found represented in the several figures illustrative of this species. The primary condition of this lorica, Pl. III. Fig. 19, is a mere film-like mucilaginous exudation from the general surface of the animalcule's body, altogether devoid of that symmetry of form which subsequently characterizes it. From this immature and plastic condition it is gradually moulded by the action of the flagellum and collar into the intermediate condition represented at Fig. 21, and thence by degrees into the permanent adult shape. Immediately this last stage is attained the lorica at once hardens, and acquires such a density as to considerably outlast the life of the animalcule by which it is built up. Loricæ left empty through the death of their original inhabitants, as shown at Pl. III. Fig. 18, are of frequent occurrence. The longitudinal sulci which characterize certain of the adult and vacated loricæ are altogether absent in others, a circumstance which may perhaps be hereafter deemed sufficient for separating the two as distinct species; both were, however, so closely associated with one another that they are for the present regarded as mere varieties. At Fig. 19*a* of the plate just quoted will be found represented one of the monadiform free-swimming germs of *Salpingœca ampulla* which has just attached itself to the half-perfected lorica of a zooid of the same species. Within two minutes after such attachment it was observed to develop a rudimentary collar and commence the formation of its protective sheath, as shown at Fig. 20. This type was originally discovered by the author growing on algæ and zoophytes taken from the tanks of the Manchester Aquarium in May 1874, and has been since found (Feb. 1877) in considerable abundance, under similar conditions, in sea-water brought from Brighton.

Salpingœca cornuta, S. K. Pl. VI. Figs. 33–36.

Lorica vaginate or sheath-shaped, elongate, from seven to ten or twelve times as long as broad, arcuate or flexuose, tapering posteriorly and gradually widening as it approaches the anterior border, the anterior margin widest but not conspicuously everted; animalcule plastic and variable in form, elongate, subcylindrical or flask-shaped, occupying about one-fifth of the length of the lorica, often attached to it posteriorly by one or more filamentous or pseudopodic extensions of the body-sarcode. Length of lorica 1–400″ to 1–300″, of the contained animalcule 1–1250″.

Hab.—Salt water.

The great proportionate length of the lorica in this type, combined with the capacity possessed by the enclosed zooid of emitting posteriorly one or more pseudopodic processes, by which at will it attaches itself to the lateral walls of the lorica, distinguish it in a marked manner from all of the previously described representatives of the present genus. Pl. VI. Figs. 33 and 36 serve to illustrate the more important modifications of this abnormal method of attachment. In the latter of these, Fig. 36, the single attenuate pseudopodal prolongation is so thread-like and elastic as to present the aspect and possess all the attributes of a veritable retractile pedicle, permitting the animalcule to extend itself to the orifice or to withdraw suddenly within the cavity of its transparent domicile, after the manner of *Bicosœca* or *Dinobryon.* In the former example, Fig. 33, examined on the same occasion, the animalcule was found to retain or alter its position in its lorica through the medium of no less than three of these sarcode extensions, each of which, however, had a more irregular pseudopodium-like appearance than in the last variety. In numerous instances, again, zooids were seen in which no trace whatever of adherent processes could be detected.

The shape of the lorica, apart from the salt-water habitat, of this type, at once suffices to distinguish it from *Salpingœca gracilis*, which it in some respects slightly resembles. The investing sheath has never as yet been found perfectly straight as in that species, but always has one or more graceful curvatures; this, combined with its evenly increasing diameter, communicates to this structure a contour closely resembling the graceful curving horns of certain antelopes, and has suggested the specific title given.

Upon one occasion, Fig. 33, a lorica was found having a bifurcation at its distal extremity, each of the separate tubular terminations being occupied by a single zooid. Whether this example was the product through fission of a single primary individual, or was derived through the attachment of an independent gemmule to a half-formed lorica, could not at the time be satisfactorily ascertained; the former alternative would, however, appear most probable. The animalcules of *Salpingœca cornuta*, while frequently presenting the subcylindrical shape most characteristic of *S. gracilis*, is subject, through the great plasticity of its substance, to a very extensive range of variation. Not unfrequently it assumes that soda-water-bottle or clavate shape, with an attenuate anterior extremity, characteristic of various other members of the same generic group, while on other occasions again (Fig. 35) it has been observed with these proportions exactly reversed, the posterior end being the narrower one of the two, and the characteristic collar and flagellum being developed from the larger one. Examples of this species were first obtained growing on Polyzoa and hydroid zoophytes gathered at Bognor, Sussex, in September 1872, as also more recently (October 1875) from the tanks of the Manchester Aquarium.

Salpingœca tuba, S. K. Pl. VI. Fig. 38.

Lorica sessile, subcylindrical, rounded posteriorly, slightly constricted anteriorly, the frontal margin somewhat everted; enclosed animalcules mostly flask-shaped, with a rounded and inflated posterior and narrower neck-like anterior region, occupying one-half or the greater portion of the cavity of the lorica; sometimes subcylindrical and attached by their posterior extremities to the bottom of this structure; collar largely developed, equalling the body in height. Length of bodies 1–4000″ to 1–2000″.

Hab.—Salt water, social.

This species was obtained by the author in September 1879, attached in social clusters to zoophytes and marine *Confervæ* collected at St. Heliers, Jersey. But for its smaller size and salt-water habitat it might have been identified with the sessile variety of *Salpingœca gracilis* represented at Pl. VI. Fig. 32. Additional points may, however, be cited that seem to indicate its distinctness from that form. The contained animalcules always occupy at least one-half of the cavity of their respective loricæ, and not uncommonly its entire length, being under such conditions attached by their posterior extremities to the bottom of their domiciles, as indicated in the example to the extreme left in the group shown at Fig. 38. When freely suspended within their loricæ they almost invariably assume an attenuate flask-shaped contour, corresponding closely with that frequently exhibited by *Salpingœca cornuta*, but never presented by *S. gracilis*.

Salpingœca gracilis, J.-Clk. Pl. VI. Figs. 25–32.

Lorica elongate, vaginate or subcylindrical, straight, five or six times as long as broad, sometimes rounded, in other instances more or less attenuate or even pedunculate posteriorly, the anterior margin slightly everted, somewhat constricted beneath this region; contained animalcule subcylindrical elongate, occupying from one-fourth to one-third of the total length of the lorica; contractile vesicles two in number, posteriorly situated. Length of lorica 1–800″ to 1–500″, of body of contained animalcule 1–2000″ to 1–1000″.

HAB.—Fresh water, occurring singly or in small groups of three or four individuals.

The figures illustrating this species, contributed by Prof. H. James-Clark to the Memoirs of the Boston Society of Natural History for the year 1868, convey but an inadequate idea of the very considerable variation in contour that may be assumed by the protective lorica, he in all instances delineating and describing that form in which the posterior extremity is so attenuate as to constitute a veritable pedicle, as shown at Pl. VI. Figs. 26 and 27. Although frequently met with in the condition that has been alone encountered by the American authority, the examination of many hundred examples by the present author has elicited the fact that in at least British waters this very attenuated form is more exceptional, the majority tapering but moderately as in the example represented at Fig. 28 of Pl. VI. or being evenly rounded in this region as at Fig. 32. This species, in common with *S. amphoridium*, appears to be almost universally distributed, examples having been found attached mostly to confervoid algæ, obtained from numerous widely separated stations, sometimes occurring as solitary samples, and in other instances in little closely approximated clusters of three or four individuals, as in the figure last referred to. These social groups are the product by repeated transverse fission or gemmation of a single primary zooid in the manner indicated in Figs. 28 and 29, and as more fully described in connection with the marine type *Salpingœca inquillata.* The motile zooid or germ derived from this fissive process presents, in the first instance, a simple monadiform aspect, as shown at Fig. 30, and fastening itself close to the base of the parent lorica, speedily acquires all the essential characters of the adult organism. Encysted examples exhibiting a more or less advanced stage of segmentation, as shown at Fig. 31, are of frequent occurrence. Stein, in his recently published volume, connects with the present title examples only having a distinct peduncular posterior prolongation; the intermediate variety, as reproduced from his work at Fig. 24, being distinguished by the title of *Salpingœca vaginicola.*

B.—PEDICLE PERSISTENT, CONSPICUOUSLY DEVELOPED.

Salpingœca marina, J.-Clk. PL. III. FIGS. 13–15, AND PL. V. FIG. 34.

Lorica ovate, inflated and widest posteriorly, tapering evenly towards the aperture at the opposite or anterior extremity, mounted on a straight or irregularly curved pedicle, which equals or slightly exceeds the lorica in height; animalcule adapting itself to the shape of the lorica, and almost filling it. Length of lorica 1–4000″ to 1–3250″.

HAB.—Salt water, attached to the hydrothecæ of Sertularian zoophytes, solitary.

In *Salpingœca amphoridium* and *S. gracilis* the occasional or more abnormal occurrence of a very short or more or less conspicuously developed pedicle, has been already alluded to; with *S. marina*, however, we arrive at a group of forms in which a pedicle is constantly present, and usually of considerable length. But for this feature being inconstant in the two above-named species, it might have been desirable to create a new generic title, for either the pedicellate or non-pedicellate series, equivalent in value to *Cothurnia* and *Vaginicola* among the higher Ciliate types. These exceptional instances, however, serve well to illustrate the unreliability of such characters for the purposes of classification. The specimens of *Salpingœca marina* as first described and figured by Prof. H. James-Clark, agree in all respects with those obtained by the author in British waters, with the exception that in the former instance the pedicle possesses a more or less curved outline, while in those personally observed, this structure has been invariably perfectly straight; the shape and size of the lorica and all other details of importance accord, however, so harmoniously, that the two forms can scarcely be regarded otherwise than as local varieties of one and the same specific type. The lorica itself very closely approaches in shape that of the fresh-water and non-pedicellate species *Salpingœca minuta*, being like that, conical, or as Professor Clark suggests, resembling a Florence-flask with the neck cut short. The examples of this species examined were found in some profusion, in the first instance, attached to various Sertularian zoophytes gathered near low-water mark at Bognor, Sussex, and more recently under similar circumstances at St. Heliers, Jersey. An animalcule is represented at Pl. V. Fig. 34, in which the collar and flagellum being retracted, pseudopodic processes are extended from the anterior region in a manner closely resembling what has already been recorded of *S. amphoridium*. An early developmental phase previous to the production of the lorica, and in which the zooid is not to be distinguished from an ordinary stalked example of the genus *Monosiga*, is represented at Pl. III. Fig. 13.

Salpingœca longipes, S. K. PL. VI. FIG. 7.

Lorica ovate, truncate at the anterior border, slightly tapering posteriorly, mounted on a long, straight, slender pedicle, which equals four or five times its length; contained animalcule shortly ovate, occupying the anterior two-thirds of the cavity of the lorica. Length of lorica 1–2500″. HAB.—Salt water, solitary or in scattered groups.

The great length of the pedicle compared with the lorica, and the very simple contour of this latter structure, render this species easy of recognition. The contained animalcule, adapting itself to the shape of the lorica, is almost globular, and devoid of that narrow anterior prolongation pertaining to the more ordinary representatives of the genus, and which conveys to them a bottle-like contour. Examples furnishing the material for this description were discovered by the author, in November 1873, attached to *Confervæ* and Polyzoa growing in the Brighton Aquarium.

Salpingœca urceolata, S. K. PL. V. FIGS. 14–16.

Lorica urceolate, conical, gradually tapering towards its junction with the pedicle, inflated in a shoulder-like manner anteriorly, and then suddenly constricted and forming a short and somewhat contractile neck; contained zooid flask-shaped, inflated posteriorly, with a narrow neck-like anterior portion; pedicle straight and rigid, equal to or slightly exceeding the lorica in height. Length of lorica 1–2000″. HAB.—Salt water, solitary.

This species was obtained by the author in company with *S. marina*, but in less abundance, at Bognor, Sussex, in September 1872; the elegant pitcher-like shape of the lorica at once distinguishes it from the preceding or any other stalked representative of the genus that has been discovered, with the exception, perhaps, of *S. ringens*. From this latter form, however, it differs in the greater narrowness of the neck-like region, which is further remarkable for its elasticity, expanding and contracting considerably in accordance with the movements of the animalcule. In the deserted loricæ, which were frequently observed, the contraction, as shown at Pl. V. Fig. 16, attains its utmost limit.

Salpingœca teres, S. K.

Lorica attenuate, conical or subfusiform, widest anteriorly, about four times as long as broad; pedicle straight, slightly exceeding the lorica in length; enclosed animalcule elongate-ovate, occupying one-half of the cavity of lorica. Length of lorica 1–2500″. HAB.—Salt water, solitary.

A single example only of this species has as yet been met with, being then obtained in company with *S. inquillata* and *S. curvipes* on zoophytes originally brought from Brighton. Excepting for its smaller size, the lorica in its form and proportions corresponds so closely with that of the long-stalked variety of the fresh-water *Salpingœca gracilis*, as delineated at Pl. VI. Fig. 27, that its separate illustration has been omitted.

Salpingœca tintinnabulum, S. K. PL. V. FIGS. 21 AND 22.

Lorica bell- or cup-shaped, somewhat variable in its proportions, widest and everted at its anterior margin, the width usually nearly equal to the total length; pedicle varying from a less length to twice the length of the lorica; contained animalcule pyriform, tapering posteriorly, attached to the bottom of its lorica by an attenuate prolongation of the body-substance. Length of the lorica 1–3250″.

HAB.—Salt water, solitary.

This animalcule was obtained somewhat abundantly from sea-water derived from the Brighton Aquarium, containing sponges and Ascidians in a semi-decayed state. The variable length of the rigid pedicle forms a conspicuous feature of this species. At Pl. V. Fig. 22 the encysted condition of an example of the short-stalked variety is represented.

Salpingœca ringens, S. K. PL. V. FIGS. 17 AND 18.

Lorica tapering posteriorly, one and a half times as long as broad, ovate for the two-thirds forming its central and posterior portions, the anterior third expanding outwards abruptly, the greatest width being at the front margin. Pedicle straight, equal in length to the lorica; enclosed animalcule flask-shaped, attenuate anteriorly. Length of lorica 1–2000″. HAB.—Salt water, solitary.

The lorica of this species presents a certain resemblance to that of both *S. inquillata* and *S. urceolata*. From the latter of these it may, however, be at once distinguished by the greater breadth and abrupt widening out of its anterior border, and by the non-contractility of the walls of this region; a similar widening out of the anterior region, together with the shorter and broader proportions of the lorica, generally distinguishing it in a like manner from *S. inquillata*; added to this, the enclosed animalcule in the present instance is altogether distinct in shape, being in its normal condition flask-shaped or pyriform, instead of simply ovate. A perfectly quiescent or encysted condition of the animalcule, probably pending the propagation of the species by multiple fission, after the manner already described of *Salpingœca fusiformis*, was observed, and is represented at Pl. V. Fig. 18. This variety was found attached to sea-weed imported to the fish-house of the Zoological Gardens from Weymouth in April 1877.

Salpingœca inquillata, S. K. PL. VI. FIGS. 1–6.

Lorica elongate-ovate, tapering posteriorly, widest in the centre, slightly everted at the anterior margin, about twice as long as broad; contained animalcule simply ovate, occupying about one-half of the cavity of the lorica; pedicle straight and rigid, equalling or exceeding the length of the lorica. Length of lorica 1-2500".

HAB.—Salt water, solitary or scattered.

This little animalcule was obtained abundantly in February 1877 in sea-water from Brighton in company with *S. curvipes*, with which the shape of its lorica somewhat corresponds. It is at once to be distinguished from that form, however, by the much greater length of the pedicle and by the entire absence of the curvature of either this element or the posterior extremity of the lorica. The shape of the anterior extremity of the protective sheath is subject to individual variation, being often so narrowed as to communicate to the whole a subfusiform contour. The phenomena of multiplication by transverse fission, as observed by the author, possess much interest. The most prominent successive phases of this process are illustrated at Pl. VI. Figs. 2-5. In the first condition observed, as represented by Fig. 5, the body of the animalcule had become divided by a median constriction into two equal subspherical portions, the upper one still retaining the characteristic hyaline collar and flagellum, tilted, however, to one side, while from the anterior surface of the posterior segment there was projected a slender pseudopodic extension of the sarcode. In the next stage, Fig. 2, the filamentous flagellum of the anterior half was the only appendage visible, the collar having become entirely absorbed. This flagellum was shortly after withdrawn in a similar manner, the succeeding metamorphosis exhibited being delineated at Fig. 4. Here the anterior and posterior halves had separated considerably from one another, but at the same time remained connected by a thin cylindrical film of sarcode, which constituted for the time being a representation of the hyaline collar, but common to both of the imperfectly segmented moieties. Ultimately the lower or posterior half assumed the entire possession of the newly developed hyaline collar, while the anterior one, detaching itself completely, drifted away as a simple plastic sphere of sarcode. The last stage, prior to the ultimate separation of the two halves, is shown at Fig. 3. A recently attached collarless zooid, derived by the process of segmentation as just described, and in the act of constructing, by exudation, its characteristic lorica, is seen at Pl. VI. Fig. 6.

Salpingœca curvipes, S. K. PL. V. FIG. 19.

Lorica somewhat attenuate, nearly three times as long as broad, widest in the centre and at the expanded anterior margin, slightly constricted between these two areas, the tapering posterior extremity slightly curved; pedicle short, not more than half the length of the lorica, joining in the line of curvature characteristic of the posterior extremity of that structure; contained animalcule ovate, occupying one-half of the cavity of the lorica. Length of lorica 1-2500".

HAB.—Salt water, solitary.

The protective sheath of this very elegant little species is easily recognized by its elongate outline and the graceful curve shared by both the short pedicle and its own posterior extremity. It has been found sparingly in company with many other representatives of the same order attached to the hydrothecæ of Sertularian and other zoophytes procured from Brighton.

Salpingœca napiformis, S. K. PL. V. FIGS. 25 AND 26.

Lorica napiform or turbinate, depressed, widest centrally, pointed posteriorly and further produced as a short, rigid pedicle, the anterior region constricted, forming a narrow and slightly everted neck; contained animalcule flask-shaped, flattened, occupying the greater portion of the cavity of the lorica. Height of lorica, without the pedicle, 1–3250″, diameter across the centre equal to or exceeding this dimension.

HAB.—Salt water, gregarious.

This species was obtained by the author at St. Heliers, Jersey, in June 1877, clustered in profusion upon various filamentous marine algæ under conditions closely parallel with those already related of the more cosmopolitan fresh-water type, *Salpingœca amphoridium.* The depressed napiform contour of the lorica of this species isolates it completely from any of the preceding forms.

Salpingœca infusionum, S. K. PL. VI. FIGS. 8–16.

Lorica simply ovate, not everted anteriorly, about one and a half times as long as broad, mounted on a short, straight pedicle, varying from a similar length to twice the length of the lorica; contained animalcule evenly ovate, occupying from one-half to two-thirds of the cavity of the lorica. Length of lorica, without pedicle, 1–3000″ to 1–2500″.

HAB.—Salt water, more especially abundant in vegetable infusions compounded with that medium; solitary or scattered.

This species has been obtained by the author in remarkable profusion in connection with those experimental infusions of hay in salt water, productive of *Monas* (*Heteromita*) *lens*, *Dinomonas vorax*, *Dinomonas tuberculata*, and *Sterromonas formicina*, described elsewhere in this volume. Its earliest appearance, and then in a larval and immature form, was first noticed on the fourth day succeeding the setting aside of the hay to macerate, while after that date it constituted for some weeks one of the most characteristic and abundant Flagellate types. Through the artificial cultivation of this animalcule in the manner indicated, an intimate acquaintance has been made with the more important and highly interesting phases of its life-history. The earliest stage in this life-cycle, in common with that of the majority, or in all probability of all its congeners, is a simple, spherical, spore-like body measuring, in this case, the 1–10,000th of an inch in diameter; from this spore there is developed a minute spherical monadiform body bearing a single lash-like flagellum at its apical pole. This monadiform germ speedily assumes a symmetrically ovate shape, and as it pursues its nomadic course through the water might be readily regarded as a typical representative of the genus *Monas.* Delineations of such earlier migratory developmental phases of this species are given at Pl. VI. Figs. 10 and 16, the germ in the former instance, while precisely similar in character, being derived from the process of transverse fission. A little later this vagrant monad, finding a site suited to the requirements of its adult sedentary existence, anchors itself by its posterior extremity, and speedily develops from this region a delicate hair-like pedicle, as shown at Fig. 11. There is as yet no appearance of the characteristic collar, the stalked monad with its single terminal flagellum presenting at this epoch of its ontogeny a striking likeness to the sedentary states of the representatives of the genus *Oikomonas.* While under examination the missing collar gradually makes its appearance as a film-like extension of the anterior substance of the sarcode, while the pedicle, at first short, gradually lengthens and acquires a rigid consistence. The animalcule, however, see Figs. 12 and 13, by no means possesses as yet a sound claim for admission into the present generic group. The external protective sheath or lorica remains to be developed, and pending the production of that structure, the immature monad corresponds to all appearances with the members of the illoricate collar-bearing genus *Monosiga.* A few brief minutes suffice now, however, for the development of this last-named essential element, and with it the assumption by the animalcule of its complete specific features as described in the introductory diagnosis, and depicted at Fig. 8.

The successive phases of the life-history of this species as here enumerated, and fully illustrated in the accompanying plate, show that, inclusive of the mature condition, the animalcule exhibits consecutively the characteristics of no less than four well-defined generic types of the Infusoria-Flagellata, commencing with the most simple type of all, as furnished by the genus *Monas*, and passing thence through those of *Oikomonas* and *Monosiga* to its characteristic adult one of *Salpingœca.* The completion of the entire life-cycle by the encystment of the adult animalcule, followed by its resolution into numerous spore-like bodies, Fig. 15, similar to that from which it originally sprang, was ultimately observed. The contour of the lorica of *Salpingœca infusionum* corresponds most nearly with that of *S. longipes,* its proportionately shorter pedicle, however, readily distinguishing it from that type.

Salpingœca campanula, S. K. PL. IV. FIG. 11.

Lorica goblet- or bell-shaped, scarcely longer than broad, the basal region narrower, conically pointed, the anterior two-thirds expanding abruptly and in a marked manner in comparison with the first-named area, the anterior border widest, but not everted; pedicle equalling the length of the lorica; contained zooid symmetrically ovate, occupying and projecting slightly beyond the conical basal area; the fully expanded collar enclosed entirely within the wider anterior area of the cavity of the lorica, the flagellum extending for about half its length beyond its anterior border; contractile vesicles two in number, posteriorly located; endoplast spherical, subcentral. Length of lorica 1–800". HAB.—Salt water, solitary.

The single example of this specific type so far observed was discovered by the author attached to the carapace of an amphipodous crustacean allied to *Gammarus*, at St. Heliers, Jersey, in February 1878. The form of the lorica coincides considerably with that of the *Codonœca costata* of Professor Clark, and also, omitting the pedicle, to a certain extent with that of *Salpingœca ampulla*, previously described, as manifested by the complete enclosure of both the body of the zooid and its characteristic collar within the cavity of the lorica, and by the adaptation of this last-named element to the contours of these conjoint structures.

Salpingœca convallaria, Stein. PL. IV. FIGS. 13–16.

Lorica vase-shaped or campanulate, pointed posteriorly, inflated and widest a little behind the median line, slightly constricted anteriorly, scarcely one and a half times as long as broad; pedicle very slender, usually about one-third of the height of the lorica; animalcule filling the greater portion of the cavity of the lorica, the collar equalling the body in height, protruding almost entirely from the orifice of the lorica; contractile vesicles multiple, posteriorly situated; endoplast anterior, subcentral. Length of lorica 1–1600" to 1–1000".

HAB.—Fresh water, attached to the branching pedicle of *Epistylis digitalis.*

The walls of the lorica in this species are described by Stein in his index to the figures given,* as being remarkably soft and plastic. Excepting for the thick pedicle and more constricted anterior border, it would appear to closely resemble the minute

* 'Infusionsthiere,' Abth. iii., 1878.

imperfectly observed Flagellate organisms recorded by Greeff as adhering in numbers to the pedicle of *Epistylis flavicans*, and reproduced from his drawings at Pl. III. Figs. 22–24. According to Stein, this type multiplies within its lorica by longitudinal instead of transverse fission, a phenomenon distinctly observed as yet of no other representative of the genus.

Salpingœca oblonga, Stein. PL. VI. FIGS. 20–23.

Lorica pedicellate, elongate-ovate or subfusiform, widest a little behind the median line, tapering gradually towards each extremity, nearly two and a half times as long as broad; pedicle varying in length from one half to nearly twice the length of the lorica; animalcule usually occupying the two anterior thirds of the cavity of the lorica, leaving the posterior one vacant; collar equalling the body in height; contractile vesicles multiple, posteriorly situated; endoplast anteriorly located. Length of lorica 1–1200″ to 1–950″. HAB.—Fresh water.

In some of the examples figured by Stein,* including the delineation reproduced at Pl. VI. Fig. 23, the animalcules have apparently entered into a spheroidal encysted state within the cavity of their lorica, the orifice of the same being closed by a lid-like secretion. In another instance (see Fig. 22) two zooids are drawn, which are explained by Stein in the index as illustrating an abnormal instance of longitudinal fission, but which would seem quite as probably to represent the process of fusion or genetic union between a larger sedentary and a smaller illoricate motile zooid, or even an advanced phase of transverse fission closely resembling that of *Salpingœca inquillata* shown at Pl. VI. Fig. 5.

Salpingœca Clarkii, Stein. PL. VI. FIGS. 17–19.

Lorica elongate flask-shaped, from two to three times as long as broad, slightly inflated and rounded posteriorly, tapering gradually towards the anterior extremity, terminating in an attenuate, scarcely everted neck; pedicle straight, moderately stout, usually equalling the lorica in length; animalcule nearly or entirely filling the cavity of the lorica; contractile vesicles multiple, posteriorly situated; endoplast subcentral. Length of lorica 1–1200″.

HAB.—Fresh water, attached gregariously to the carapace of the rotifer *Philodina hirsuta* Ehr.

In conferring the above title upon this form, Stein † appears to have overlooked the fact that the same name had been previously proposed by Bütschli for a distinct species of the same genus. As, however, Bütschli's type has been shown to correspond with the *Salpingœca fusiformis* still earlier described by the author, Stein's title, to avoid a further change of name, is in the present instance, though somewhat irregularly, retained. In the chief figure of this species given by Stein no less than forty individuals are represented crowded upon the projecting snout of the above-named rotifer. One example among the isolated individuals he delineates has withdrawn its collar and protruded its sarcode beyond the orifice of the lorica in a bubble-like manner, while in another instance a thread-like pedicle connects the body of the animalcule with the bottom of its protective sheath. Both of these more abnormal cases are reproduced at Pl. VI. Figs. 18 and 19.

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* 'Infusionsthiere,' Abth. iii., 1878. † Ibid.

Salpingœca Boltoni, S. K.

Lorica pedunculate, elongate-conical, the anterior border widest, slightly everted, tapering and acuminately pointed posteriorly, from two to two and a half times as long as broad; pedicle straight and slender, equalling or exceeding twice the length of the lorica; enclosed animalcule symmetrically ovate or subcylindrical, occupying one-half of the cavity of the lorica, sometimes affixed to it by a thread-like prolongation of the posterior region of the body. Length of lorica 1–1250″, of contained zooid 1–2500″.

HAB.—Fresh water, solitary.

This species represents the first-fruits of the more extended acquaintanceship with this interesting order of the Flagellata acquired through the publication of the plates illustrative of all the previously known forms, in the first part of this Manual, in October 1880. Its discovery is due to Mr. Thomas Bolton, who having detected it attached to *Myriophyllum* from his aquaria, failed to identify it precisely with any of the species figured in Plates II. to X. of this treatise, and remitted examples to the author. So far as the external contour of the lorica, and the proportionate length of the supporting pedicle are concerned, it most nearly resembles the marine *Salpingœca inquillata*, represented at Pl. VI. Figs. 1–6. Apart from its fresh-water habitat, it may be distinguished from that type, however, by its considerably larger size and the greater proportionate length of the pedicle, which is surpassed by that alone of *S. longipes*.

A few weeks previous to Mr. Bolton's independent discovery of this species (September 1880) the author met with examples undoubtedly referable to the same type on vegetable debris derived from the *Victoria regia* tank in Kew Gardens, and it has since propagated abundantly in a window aquarium containing *Aponogeton*, *Myriophyllum*, *Ceratophyllum*, and other aquatic plants in a vigorous state of growth. On one occasion an example was observed in which the animalcule was attached to the side of its lorica by a contractile thread-like prolongation of the sarcode of its posterior region, in a manner resembling that already described of *Salpingœca cornutum*. A rough delineation of this species is contained, at letter *c*, in the pen-and-ink sketch executed by the author for Mr. Bolton, included in his advertisement to subscribers bound up with Part II. of the Manual, published in November 1880, this sketch being further reproduced as a lithographic plate in Part I. of the 'Northern Microscopist,' announced for January 1881. No fitter illustration of the abundant distribution of the Flagellate Infusoria can perhaps be cited than the drawing just referred to, in which no less than three varieties of collared monads and two sedentary Pantostomatous species are, as observed by the author, grouped upon a small portion of a leaflet of *Myriophyllum spicatum*.

GENUS II. LAGENŒCA, S. K.

(Greek, *lagenos*, flask; *oikeo*, to inhabit.)

Solitary, collar-bearing, flagellate animalcules, resembling those of *Salpingœca*, but secreting and inhabiting a freely detached protective sheath or lorica.

The members of this genus, of which but a single species has as yet been discovered, may be said to occupy that position with reference to the more ordinary stationary Choanophorous Flagellata that is held by the higher Ciliata *Dictyocysta* or *Tintinnus* with relation to the sedentary representatives of the primary groups to which they respectively belong.

Lagenœca cuspidata, S. K. PL. III. FIG. 25.

Lorica amber-coloured, flask-shaped, compressed, widest posteriorly and there ornamented with one long axial and four shorter, subequal and evenly disposed, peripheral, mucronate spines; contained animalcule flask-shaped, inflated posteriorly, produced anteriorly in a neck-like manner, protruding some little distance beyond the orifice of the lorica, filling posteriorly the greater portion of the cavity of this structure. Length of lorica 1–4000″. HAB.—Pond water.

The single example of this species hitherto encountered was discovered by the author in December 1871 in pond water containing *Codosiga botrytis*, *Salpingœca amphoridium*, and *Bicosœca lacustris*. The contained zooid, apart from its lorica, was indistinguishable both in form and size from that of *Salpingœca amphoridium*, the anterior, and in this case protruding, collar-bearing region being in the same way narrowly prolonged in a neck-like form, although there was in this instance no corresponding conformity in the shape of the lorica. This assumption of a clavate or flask-shaped outline in the zooid independent of a similar one in the contour of the lorica, appears to be of common occurrence among the members of the Salpingœcidæ. The lorica itself was of a pale amber colour and ornamented at its base with five sharply pointed projecting spines, conveying to the observer an aspect remarkably suggestive of one of the many varieties of flask-shaped shells distinctive of the genus *Lagena* among the Foraminifera. Although so scantily represented in the present treatise, it is highly probable that a more extended investigation will demonstrate a greatly varied and extensive distribution of free-swimming loricate types referable to this generic group.

GENUS III. POLYŒCA, S. K.

(Greek, *polys*, many; *oikeo*, to inhabit.)

Collar-bearing, flagellate, loricate animalcules, similar to those of *Salpingœca*, but forming by the serial conjunction of their respective loricæ a more or less extensive branching colony-stock or polythecium.

This genus bears the same relation to *Salpingœca* that *Codosiga* does to *Monosiga*, being the compound expression through the continued fission without complete separation of the preceding simpler types. Only one species, an inhabitant of salt water, has been so far discovered.

Polyœca dichotoma, S. K. PL. III. FIGS. 27, 28, AND PL. V. FIG. 20.

Loricæ of polythecium urceolate, pedicellate, tapering posteriorly, slightly constricted at a distance of one-third of the total length from the anterior margin, and then widening out to their greatest diameter; pedicles of each separate lorica straight, slender, varying from the same to two or three times the length of the latter structure; contained animalcules ovate, occupying respectively about one-half of the cavities of the loricæ; contour of polythecium subdichotomous, each zooid usually giving rise by transverse fission to two new ones which attach themselves to opposite sides of the parent lorica. Length of separate lorica 1–2500″. HAB.—Salt water.

The compound polythecium of this very elegant and as yet single known representative of the genus *Polyœca* may be most aptly compared to a number of zooids of

Salpingœca inquillata, whose loricæ are united to one another in systematic order through the medium of their respective pedicles. As shown in the accompanying figures, the more general dichotomous mode of gemmation in this species admits of some slight modifications. Thus at Pl. III. Fig. 28, the colony, after starting on the typical plan, is continued on each side in a uniserial order, while at Fig. 20 of Plate V., representing the largest colony of this species as yet met with, the right-hand resultant of the primary zooid gives origin to no less than two individuals at each anterior angle. Each of these, however, as is evident from the simple structure of the pedicle in its proximal region, commenced as single animalcules, these, at a short distance from the parent, dividing a second time by longitudinal fission.

This highly interesting form was found attached to the hydroid zoophytes and Polyzoa obtained in May 1874 from the Crystal Palace Aquarium. As with various other types described in this manual derived from the tanks of large public aquaria, it is impossible to predicate from what portion of the coast-line it was originally imported. The correspondence of the polythecium of this species, with reference both to its general mode of growth and to the contour of the individual loricæ, with that of the biflagellate fresh-water type *Stylobryon* (*Poteriodendron*) *petiolatum* is worthy of remark.

Fam. III. PHALANSTERIIDÆ, S. K.

Animalcules solitary or social, more or less ovate, bearing a single terminal flagellum, the base of which is encircled by a rudimentary and permanently contracted, or by a well-developed and widely extensile membranous collar; excreting and inhabiting a simple or complex mucilaginous protective sheath or zoocytium.

Compared with the preceding Choano-Flagellata, the members of this family group may be said to maintain a relationship corresponding with that which subsists between the Peritrichous genus *Ophrydium*, and such typical Vorticellidæ as *Vorticella*, *Epistylis*, and *Vaginicola*. At the same time, the new investing element or zoocytium now introduced is undoubtedly both morphologically and physiologically identical with the common mucilaginous matrix or cytoblastema which enters so largely into the composition of all sponge structures, and which is similarly excreted and inhabited by colony-stocks of corresponding collared flagellate monads. By this family group of the *Phalansteriidæ* the two sections of the Discostomata-Gymnozoida or naked collared monads, and the Discostomata-Sarcocrypta or slime-immersed collared monads as represented by the Spongida, are beyond question effectually bridged.

Genus I. PHALANSTERIUM, Cienkowski.

Animalcules normally symmetrically ovate but more or less plastic and variable in form, bearing a single terminal flagellum, whose base is enclosed by a conical, non-extensile, hyaline collar; endoplast and one or more contractile vesicles usually conspicuous; producing extensive colonies through multiplication within a variously modified common gelatinous matrix or zoocytium; the flagella only projecting beyond the zoocytium into the outer water.

As originally founded by Cienkowski,* the genus *Phalansterium* was made to include two entirely distinct flagellate forms, one of which, *P. intestinum*, possessing two flagelliform appendages, has been selected by Stein as the type of the previously

* 'Archiv für Mikroskopische Anatomie,' Bd. vi., 1870.

described genus *Spongomonas*. The single species left out of these two, to which another is now added by Stein, was recognized by Cienkowski as exhibiting a peculiar beak-like modification of the anterior region, into which the base of the single flagellum is inserted. Professor James-Clark was the first to indicate the probable homology of this beak-like prominence with the collar-like organ discovered by him in connection with the two generic forms *Codosiga* and *Salpingœca*, his inference being entirely substantiated by Stein's later illustrations. As shown in the figures reproduced from this authority, the collar-like organ or its homologue in the present genus, so far as observed, never exhibits that expanded funnel-shaped contour which is seen in all the Choano-Flagellata previously described, but exhibits rather that conical form with a wider basal or proximal, and narrower contracted distal region, that characterizes them in their retracted state. Whether or not a circulating current or cyclosis of the sarcode substance of this reduced and rudimentary form of collar developed in *Phalansterium*, is maintained, remains to be demonstrated.

As first pointed out by Professor H. James-Clark, the habit exhibited by the members of this genus of exuding and socially inhabiting a common gelatinous matrix or zoocytium, approximates them more nearly than any previously known members of the independent collared Flagellata to the important group of the Spongida. An advance in this direction is nevertheless accomplished in the recently discovered Flagellate type upon which the new generic title of *Protospongia* is here conferred.

Phalansterium consociatum, Fres. sp. PL. XII. FIGS. 5–9.

Common gelatinous matrix or zoocytium depressed, discoidal or shield-shaped, more or less granular, divided by radiating dissepiments into separate subtriangular or tubular areas representing the chambers within the zoocytium primarily constructed by the individual zooids; contained zooids elongate-ovate or pyriform, from one and a half to twice as long as broad; collar conical, having the appearance of an anteriorly developed beak-like process, about one-third the length of the body; contractile vesicles two in number, posteriorly located; endoplast spherical, subcentral. Length of zooids 1–2500″, diameter of discoidal zoocytium 1–420″.

HAB.—Fresh water.

This species was originally described by Fresenius* under the title of *Monas consociatum*, its relegation to the present generic group being accomplished, as already remarked, by Cienkowski. The zooids in their encysted condition, as reported by this authority, exhibit, as shown at Pl. XII. Fig. 8, a somewhat peculiar contour, being subspheroidal with three longitudinal keel-like ridges, one of which is produced in a mucronate manner at the two apices. According also to this observer, fission in this type takes place longitudinally, or in a direction contrary to that which, as indicated by Stein, obtains in the species next described.

Phalansterium digitatum, Stein. PL. XII. FIGS. 1–4.

Animalcules plastic and variable in form, ovate or elliptical, one and a half to three times as long as broad, building up an erect, lobate, palmate, or digitiform, subdichotomously branching, coarsely, granular zoocytium; terminations of the branches hollow, inflated, and subcylindrical, with large circular distal apertures, containing each a single or, after fission, two

* 'Beiträge zur Kenntniss Mikroskopischer Organismen,' Frankfort, 1858.

separate animalcules; flagellum attenuate, two or three times the length of the body, conical collar embracing its base for about a distance of one-eighth of its total length; contractile vesicles two in number, posteriorly situated, endoplast spherical, subcentral. Length of zooids 1–1500″, altitude of branching zoocytium 1–60″. HAB.—Fresh water.

Only in the most luxuriant and fully grown examples does the zoocytium of this species present the profusely branched contour delineated at Fig. 1 of the accompanying plate, and which, in this instance, may be appropriately compared with the gelatinous polyzoarium of the marine polyzoon *Alcyonidium gelatinosum*. As a contrast to this, it frequently exhibits a but slightly elevated lobulate aspect closely approaching that of *Spongomonas uvella*, every phase of gradation occurring between these two extremes. Multiplication in the present type is, according to Stein, effected by transverse fission. Neither this nor the preceding form appear so far to have been discovered in British waters.

GENUS II. PROTOSPONGIA, S. K.

(Greek, *protos*, first; *spoggos*, sponge.)

Animalcules normally ovate or pyriform, but more or less plastic and variable in contour, bearing a single terminal flagellum whose base is embraced by a well-developed, extensile and contractile, funnel-shaped collar; forming extensive colony-stocks, excreting and inhabiting a common mucilaginous matrix or zoocytium, within the substance of which the bodies remain constantly immersed, the collars and flagella only being projected into the surrounding water; endoplast and one or more contractile vesicles usually conspicuous; increasing by binary fission and by the subdivision of their entire body-mass into sporular elements.

This new generic group is established for the reception of a single recently discovered Flagellate type which corresponds with *Phalansterium* in so far as that the animalcules excrete, and live more or less completely immersed within, a common mucilaginous matrix or zoocytium. An important distinctive feature is, however, to be noted in the fact that the collar, in place of being rudimentary and having a permanently conical and contracted aspect, attains to its full development, being capable of contraction and expansion, exhibiting circulatory currents, and in all ways corresponding with the normal condition of this structure as existing in the preceding families of the Codonosigidæ and Salpingœcidæ, and throughout the entire section of the Spongida.

The importance of the position occupied by the typical representative of this genus with relation to the last-named group, that of the sponges, can scarcely be over-estimated, and is fully explained in its succeeding specific description. With reference to the relationship indicated, this interesting type is herewith dedicated to, and specially commended to the notice of, the illustrious evolutionist of Jena.

Protospongia Haeckeli, S. K. PL. X. FIGS. 20–30.

Zooids more or less ovate or pyriform, but exceedingly plastic and variable in shape, from one and a half times to twice as long as broad, sometimes pointed and more attenuate posteriorly, these proportions in other instances being precisely reversed, often assuming an altogether irregular amœbiform contour, the flagella and collars under such conditions being entirely retracted; collar when fully extended equalling or even exceeding the length of the body; contractile vesicles two in number, posteriorly located; endoplast spherical, subcentral; common mucilaginous matrix or zoocytium exceedingly transparent, forming a more or less extensive film-like expansion on the surface of the water or over submerged objects, containing from six to eight to as many as fifty or sixty or more zooids. Length of zooids 1–3000″. HAB.—Fresh water.

This very interesting form was obtained by the author so recently as July 1880, in water containing *Myriophyllum*, and other aquatic plants, brought from the lake in Kew Gardens. While detected in some few instances growing upon this vegetation, the more luxuriant colony-stocks were discovered forming faintly granular, film-like expansions on the glass or the surface of the water after some days' isolation in a shallow glass receptacle. Until the existence as an independent structure of the entirely transparent or very faintly granular zoocytium was definitely determined, it was presumed that the collared monads that excrete this element were colonies only of a species of *Monosiga* such as *M. socialis*, that had developed upon the surface of a bacterial film or other foreign organic mucilage. The isolation of colony-stocks and the registration of the constantly augmented dimensions of this zoocytium *pari passu* with the increase in number of the contained zooids, speedily demonstrated, however, the incorrectness of this first inference. The import of this film-like excretion being thus determined, the close affinity of the type to Cienkowski's genus *Phalansterium* was immediately recognized. Compared with that organism, it at the same time exhibited several important features of distinction, the chief of these being the well developed, in place of the rudimentary condition, of the terminal collar and the exceedingly hyaline instead of coarsely granular mucilaginous zoocytium. The collars in this type agreed essentially, in fact, in form and function, with those of the several genera *Monosiga*, *Codosiga*, and *Salpingœca* previously described. This rudimentary condition of the collar and accompanying coarsely granular condition of the zoocytium in *Phalansterium*, and the transparency of this zoocytial element in *Protospongia*, conjoined with a well-developed collar, are correlations that evidently admit of a logical explanation. In allied forms possessing similar well-developed collars it has been demonstrated by the author that all effete matters are cast out within the discoidal area circumscribed by the base of the structure, and hence in *Protospongia* they would be thrown out beyond the periphery of the zoocytium, and could not possibly get entangled in its substance. In *Phalansterium*, on the other hand, where the collar exists as a rudimentary structure only, no such terminal liberation of the waste products can take place, but instead of this are probably got rid of through the general peripheral surface, as occurs in *Rhipidodendron* and *Spongomonas*, and further becoming, as in these genera, incorporated within the substance of the zoocytium. This interpretation is entirely supported by the illustrations of the genus *Phalansterium* recently published by Stein, in which this common mucilaginous matrix is depicted as enclosing uniformly distributed coarse granular corpuscles identical in appearance with those that undoubtedly represent fæcal rejectamenta in the two previously cited genera.

The instability of contour and extreme plasticity of the constituent sarcode are more marked in the zooids of *Protospongia Haeckeli* than in any other animalcule of the Choano-Flagellate order so far examined. On the slightest disturbance the collars and flagella are withdrawn, and an altogether irregular amœbiform aspect assumed, as shown at *a*, *a*, *a*, *a*, in Pl. X. Figs. 20 and 21. The binary fission of the zooids during the assumption of a similar amœboid state, as in *Monosiga* and *Salpingœca*, was frequently observed, as also their subdivision into larger or smaller sporular elements, as at 22 *a* and 20 *s* of the same plate. The development of these sporular bodies to the characteristic collared state was likewise traced, their initial condition being that of simple uniflagellate monads, which, taking up a position in the zoocytium adjacent to the adult zooids, as shown at Pl. X. Fig. 22 *b b*, speedily acquire the parent form. The establishment of new colony-stocks by similar but single monoflagellate germs was likewise witnessed. In its initial condition such a founder of the future colony, Pl. X. Fig. 26, was scarcely to be distinguished from an ordinary representative of the genus *Oikomonas*, it being entirely naked, attached by a prolongation of its posterior extremity, and possessing merely a single terminal flagellum. The collar being next developed, the animalcule for a while was indistinguishable from such a member of the genus *Monosiga* as *M. Steinii*, while finally, a thin mucilaginous film being thrown out around its body, see Fig. 27, the appearance presented was that of an early condition of *Salpingœca ampulla*, as delineated at Pl. III. Figs. 19 and 20. From this stage onwards, two or more zooids being now included within the mucilaginous matrix, as shown at Figs. 24 and 25, the characteristic aspect of the genus *Protospongia* as here defined is permanently assumed. In many of the smaller colony-stocks, as illustrated by Figs. 21 and 23, clear traces remain of their derivation through the quadruple plan of segmentation of a single primary unit.

By far the most interesting point connected with the structural and developmental features of this type remains to be discussed. As previously intimated, it is, so far as known, the nearest concatenating form between the respective groups of the ordinary Choano-Flagellata and the Spongida. Furthermore, it may be consistently accepted as furnishing a stock-form from which by the process of evolution all sponges were primarily derived. A comparison of the figures illustrative of this species with those included in this treatise relating to the organography of the class Spongida, is alone needed to make clear this postulate. On making such comparison it will be at once recognized that typical colony-stocks of *Protospongia*, as shown at Pl. X. Figs. 20, 21, 22, correspond in a most remarkable manner with a fragment of the mucilaginous cytoblastema, with its incorporated collared monads, amœbiform cytoblasts, and sporular elements of any ordinary sponge-stock, and more especially with that of such a non-spiculiferous type as *Halisarca Dujardinii* or *H. lobularis.* It needs indeed but a slight modification of the disposition of the zooids of *Protospongia*, to such an extent that in place of protruding on the external surface of the mucilaginous zoocytium, they should debouch upon saccular invaginations of this matrix, to produce what would have to be accepted as an undoubted though very rudimentary sponge-stock. The establishment of free intercommunication between these saccular monad aggregates through the means of tubular canals, is alone wanted to further transform such a sponge-stock into a typical representative of the genus *Halisarca.*

In all minor structural and developmental details the zooids of the *Protospongia Haeckeli* accord essentially with the simpler, naked, Choano-Flagellata previously described; but in their extreme plasticity, in their excretion and occupation of a common gelatinous matrix, and in the retention of the more ordinary reproductive products within this matrix, this specific type unmistakably manifests its near affinity to the group of the Spongida.

Section II. *DISCOSTOMATA-SARCOCRYPTA* (*or SPONGIDA*).

Collared monads structurally resembling those of the Discostomata-Gymnozoida, but hidden or immersed within variously modified intercommunicating chambers of a common gelatinous matrix or cytoblastema, which may or may not be strengthened by supplementary skeletal elements.

The necessity of accepting the sponges as peculiarly modified colony-stocks of collared flagellate Infusoria, which correspond in every essential detail with the simpler or independent types previously described, is abundantly demonstrated in Chapter V., devoted to that special group of organisms, and is indeed self-evident on examination and comparison of the plates in this volume numbered II. to VI. and VII. to X. devoted respectively to the organization of the sponges and to that of the preceding less complex organic series. As there made clear, the only substantial distinction found to subsist between the Spongida and the independent collared Flagellata is manifested by the circumstance that, while in the latter instance the characteristic collared monads are naked, and more or less completely exposed to view, they are in the case of the Spongida associated together and completely concealed within specialized excavations of a common gelatinous matrix, the zoocytium or cytoblastema. Hence the two groups are here accepted as co-ordinate sections of the same primary subdivision of the Protozoa, which, as intimated on a preceding page, may be conveniently distinguished by the respective titles of the Discostomata-Gymnozoida and the Discostomata-Sarcocrypta. So far the social types *Phalansterium* and *Protospongia* are the nearest annectant forms between these respective groups, though in all probability such small hiatus as yet exists will be still more effectually obliterated by the results of future investigation.

The further subdivision of the Spongida into minor sections or sub-orders may be most conveniently accomplished with reference to the nature of their skeletal elements, as below.

Sub-Order	I.	MYXOSPONGIÆ	No accessory skeletal elements.
,,	II.	CALCISPONGIÆ	Skeletal elements represented by calcareous spicula.
,,	III.	SILICOSPONGIÆ	Skeletal elements consisting of siliceous spicula.
,,	IV.	KERATOSPONGIÆ	Skeletal elements consisting of horny fibre.

A systematic description of the multitudinous representatives of the Spongida not falling within the scope of the present manual, students desiring to familiarize themselves with their more minute histologic characteristics are referred to the complete works or separate pamphlets of Bowerbank, Carter, Oscar Schmidt, Ernst Haeckel, F. E. Schulze, W. Marshall, and numerous other authorities quoted in the bibliographical list appended to this treatise. In all instances the collared monads, as here described, constitute the one constant and primary factor of the living sponge-stock, the various plans upon which these are grouped together, and more especially the nature and mode of disposition of the skeletal elements, mostly but not universally developed, affording the readiest clue to their generic and specific identification.

Order VI. FLAGELLATA-EUSTOMATA, S. K.

Animalcules possessing one or more flagelliform appendages but no locomotive organs in the form of cilia; a distinct oral aperture or cytostome invariably developed; multiplying by longitudinal or transverse fission or by the subdivision of a whole or part of the body-substance into sporular elements.

The number of forms that have to be included in this highest section of the typical Flagellata has been largely increased through the lately published researches of Professor Stein. Previously, the entire group of the Flagellata, including even the simplest monads, had certainly been accredited by Ehrenberg with the possession of a true oral aperture; his dictum in this connection being accepted by other more recent writers, including Diesing and Pritchard. This attribution to them of so high a structural differentiation was nevertheless, in the majority of instances, purely inferential, being deduced simply from the recognized presence of ingested food-particles within the body-sarcode of the animalcules examined. As demonstrated, however, in this treatise, there exists a very considerable series of forms, scarcely to be distinguished in their broad external characters from the one now about to be introduced, in which solid food-particles, while freely ingested, do not obtain access through a specially differentiated oral aperture, but are taken in indifferently at all points of the periphery. This series, already described, has received from the author the self-suggestive appellation of the Flagellata-Pantostomata.

Among those instances in which the conclusions arrived at by Ehrenberg concerning the presence of a true mouth have been substantiated by the results of modern investigation, reference may be more especially made to the *Monas grandis* and *semen* of the last-named authority, now included by Stein with his new generic groups *Cœlomonas* and *Raphidomonas*, and to the two important family series of the Euglenidæ and Chrysomonadidæ as here circumscribed. Several structural, functional, and developmental phenomena, in addition to those furnished by the ingestive faculties, may be cited as indicative of the higher position in the organic scale occupied by the Eustomatous Flagellate group now under discussion. Among these it may be mentioned that the constituents of the body exhibit as a rule a far more well-defined separation into external and internal sarcode layers, or ectoplasm and endoplasm, than is encountered among the ordinary Pantostomata; the former element, or ectoplasm, often indeed has both the appearance and all the attributes of a true cuticle. In rarer instances, again, such as *Phacus*, *Oxyrrhis*, and *Entosiphon*, the external envelope may become so indurated as to constitute a veritable cuirass as commonly met with amongst the members of the higher Infusoria-Ciliata. Correlated with this firmer development of the ectoplasmic or cuticular element, it is further found that the members of the Eustomata rarely exhibit that plasticity and unstability of contour so generally characteristic of the Pantostomata, and which manifests itself most conspicuously in that order by the tendency of the animalcules to assume at will—though more frequently in connection with the processes of genetic union or encystment—an altogether irregular repent amœboid phase. Concerning the developmental phenomena of these two parallel groups, it is further worthy of note that while among the Pantostomata sporular reproduction is almost invariably accompanied, as in the lower Phytozoa, by the splitting up of the entire substance of the body—thus involving the death or extinction of the pre-existing zooid or individual—among the Eustomata, as exemplified by the Euglenidæ, Chrysomonadidæ, and Anisonemidæ, such sporular bodies are more frequently developed from the endoplast alone, or as entirely independent endogenous reproductive elements, the parent zooids, after giving birth to these, continuing their individual existence. Phenomena of a like nature, but exemplified by an exogenous mode of spore or germ production, is also exhibited by *Noctiluca*, and is in all instances indicative of a higher grade of organization than is found to obtain among the Pantostomata or other Flagellata previously described.

A tabular view of the families and genera of the Flagellata-Eustomata, as defined in this volume, is herewith annexed. While, as there shown, the entire series may for convenience be separated into the two sections of the *Eustomata-Monomastiga* and *Eustomata-Dimastiga*, these respective subdivisions are completely bridged in the very natural family group of the Chrysomonadidæ by such types as *Chloromonas*, *Chrysomonas*, and *Microglena*.

Section A. EUSTOMATA-MONOMASTIGA

(Flagellum single).

Fam. I. PARAMONADIDÆ, S. K.

Animalcules entirely free-swimming, more or less persistent in form, bearing a single terminal flagellum; endoplasm transparent, colourless, more or less granular; oral aperture distinct, situated near the base of the flagellum.

The presence of a distinct oral aperture alone distinguishes the representatives of this family from those of the Pantostomatous group of the Monadidæ previously

FAMILIES AND GENERA OF FLAGELLATA-EUSTOMATA.

	Family.					Genus.
A. EUSTOMATA-MONOMASTIGA (Flagellum single).	I. PARAMONADIDÆ. Animalcules free-swimming, persistent in form; endoplasm colourless.	Symmetrically ovate or spheroidal				1. *Paramonas.*
		Much flattened or compressed				2. *Petalomonas.*
		Elongate or fusiform, subcylindrical				3. *Atractonema.*
		Flask-shaped				4. *Phialonema.*
		Compressed, lunate or ensiform				5. *Menoidium.*
	II. ASTASIADÆ. Animalcules highly metabolic; endoplasm colourless.	With a distinct tubular pharynx				6. *Astasia.*
		No distinct pharynx				7. *Colpodella.*
	III. EUGLENIDÆ. Animalcules mostly highly metabolic; endoplasm coloured brilliant green.	Free-swimming	No abnormal pharyngeal dilatation.	Naked	Highly metabolic. Having a caudal prolongation	8. *Euglena.*
					Highly metabolic. No caudal prolongation	9. *Amblyophis.*
					Persistent in shape. No snout-like prominence	10. *Phacus.*
					Persistent in shape. With an anterior snout-like prominence	11. *Chloropeltis.*
				Loricate		12. *Trachelomonas.*
			With an abnormally dilated pharyngeal cavity.	Trichocysts conspicuously developed		13. *Raphidomonas.*
				No trichocysts		14. *Cœlomonas.*
		Sedentary	Solitary, inhabiting transparent loricæ			15. *Ascoglena.*
			Grouped socially on a simple or branching pedicle			16. *Colacium.*
	IV. NOCTILUCIDÆ. Endoplasm highly vacuolar or reticulate, phosphorescent.	Animalcules subspheroidal, with a supplementary tentaculiform appendage				17. *Noctiluca.*
		Animalcules discoidal, no supplementary tentacle				18. *Leptodiscus.*

B. EUSTOMATA-DIMASTIGA. (Two flagella.)	V. CHRYSOMONADIDÆ. Endoplasm enclosing two laterally-disposed olive or yellow pigment-bands. Flagellate appendages, with but rare exceptions, two in number, of similar or diverse length.	One flagellum.	Animalcules persistent in shape		.. ..	19. *Chloromonas.*
			Animalcules soft and plastic		No distinct pharynx	20. *Chrysomonas.*
					With a distinct pharynx	21. *Microglena.*
		Two flagella: naked.	Solitary	Free-swimming.	Flagella inserted beneath a lip-like prominence .	22. *Cryptomonas.*
					Flagella inserted in a lateral or ventral fossa ..	23. *Nephroselmis.*
				Affixed to a rigid pedicle	.. ..	24. *Stylochrysalis.*
			Social .		United in spheroidal free-floating clusters	25. *Uvella.*
					Grouped upon a simple or branching pedicle	26. *Chlorangium.*
		Two flagella: loricate.	Solitary	Free-swimming	.. ..	27. *Hymenomonas.*
				Sedentary	Body free within the investing lorica.. ..	28. *Chrysopyxis.*
					United to lorica by a thread-like pedicle ..	29. *Epipyxis.*
			Social .		Forming a compound branching zoothecium	30. *Dinobryon.*
					United in free-floating spheroidal clusters	31. *Synura.*
		Two flagella: immersed within a gelatinous zoocytium.	Zooids closely approximated without independent pedicles			32. *Syncrypta.*
			Zooids not directly united, possessing independent contractile pedicles			33. *Uroglena.*
	VI. ZYGOSELMIDÆ. Flagella similar in character, both vibratile; not enclosing coloured pigment-bands.	Highly metabolic	Naked	Endoplasm coloured brilliant green		34. *Eutreptia.*
				Endoplasm transparent, granular	Entirely free-swimming ..	35. *Zygoselmis.*
					Free-swimming or repent ..	36. *Distigma.*
			Loricate, free-swimming			37. *Cryptoglena.*
		More or less persistent in form.	Flagella diverse, one long and one short			38. *Sterromonas.*
			Flagella equal or subequal			39. *Dinomonas.*
	VII. CHILOMONADIDÆ. Anterior border labiate or excavate; one of the two flagella convolute and adherent.	Anterior border symmetrically labiate				40. *Chilomonas.*
		Anterior border obliquely excavate				41. *Oxyrrhis.*
	VIII. ANISONEMIDÆ. Symmetrically ovate or elongate; flagella diverse, one vibratile, the other trailing and adherent.	Variable in form, cuticle soft.	Cuticle elastic, highly metabolic			42. *Heteronema.*
			Not metabolic, simply soft and plastic			43. *Diplomastix.*
		Persistent in shape, cuticular surface indurated,	Pharynx distinct, but not protrusible..			44. *Anisonema.*
			Pharynx protrusible as a separate horny tube			45. *Entosiphon.*
	IX. SPHENOMONADIDÆ. Animalcules prismatic, persistent in shape; two vibratile flagella, one long and one short.	Polyhedral, having four or more longitudinal keel-like ridges				46. *Sphenomonas.*

described, and with which, so far as external contour only is concerned, they in many instances exhibit the closest possible correspondence.

GENUS I. PARAMONAS, S. K.

(Greek, *para*, close to; *monas*.)

Animalcules free-swimming, ovate or globular, uniflagellate, more or less persistent in shape, incepting food-substances through a distinct oral aperture which is situated anteriorly at the base of the flagellum.

The above generic title is here instituted for the reception of several forms referred to the genus *Monas* by De Fromentel,* but which are declared by him to possess a distinct oral aperture. A still larger number of the species hitherto relegated to the same generic group will probably have to be transferred in a similar manner to this present one, as soon as a more perfect knowledge of their minute structure and life-history shall have been gained. Owing to the greater density, though not absolute rigidity, of their cuticular investment, the representatives of the genus *Paramonas*, in addition to possessing a distinct oral aperture, are further characterized by their comparatively persistent shape. These features, taken collectively, secure for them a distinction from the members of the genus *Monas*, similar to that which is further on shown to subsist between the otherwise superficially corresponding generic types *Heteromita*, *Heteronema*, and *Anisonema*. The genus *Petalomonas* of Stein, represented by the *Cyclidium abscissum*, and possibly also the *C. nodulosum* and *C. crassum* of Dujardin, necessarily approaches most closely to *Paramonas*. As, however, the flattened and leaf-like contour of the body is insisted on as a leading characteristic of Stein's genus, it is requisite to establish an independent one for the globular or ovate forms included under the present title.

Paramonas globosa, From. sp. PL. XX. FIG. 1.

Body spherical, transparent, enclosing red granules; contractile vesicle subcentral; oral aperture conspicuous, situated at the base of the flagellum. Length 1–2400″. HAB.—Fresh water.

Identical with the *Monas globosa* of De Fromentel.

Paramonas ovum, From. sp.

Body ovate, transparent, coarsely granulate; flagellum constantly vibrating; mouth situated close to the base of this organ. Length 1–1500″. HAB.—Fresh water.

The *Monas ovum* of De Fromentel.

Paramonas stellata, From. sp. PL. XX. FIG. 2.

Body ovate or spherical; endoplasm green and granulate; oral aperture apical, stellate; flagellum long and fine, constantly vibrating. Length 1–1500″. HAB.—Fresh water.

Both this and the succeeding species, characterized by De Fromontel as having their endoplasmic substance coloured green, are referred provisionally only to the genus *Paramonas*. If such coloured matter represents a permanent constituent,

* 'Études sur les Microzoaires,' Paris, 1876.

and not incepted food-substance, they are referable probably to the family groups of the Euglenidæ or Chrysomonadidæ. The present type was originally included by De Fromentel in the genus *Monas.*

Paramonas deses, Ehr. sp.

Body oblong, rounded at the two extremities, colour bright green, oral aperture distinct, situated at the base of the flagellum, the latter organ long and undulating; contractile vesicle central. Length 1–1200″.

HAB.—Fresh water; solitary.

Identical with the *Monas deses* of Ehrenberg and De Fromentel.

GENUS II. PETALOMONAS, Stein.

Animalcules free-swimming, ovate, depressed, with a single long vibratile flagellum; cuticular surface indurated, often carinate; oral aperture distinct, situated close to the base of the flagellum.

Stein first founded this genus upon the *Cyclidium abscissum* of Dujardin, to which, in his recently published work,* several distinct forms are added. Dujardin's generic title of *Cyclidium* having been previously employed by Ehrenberg for certain ciliate animalcules, cannot be retained among the Flagellata.

Petalomonas abscissa, Duj. sp. PL. XX. FIGS. 5 AND 6.

Body subtriangular or irregularly ovate, flattened and leaf-like, slightly pointed anteriorly, the posterior margin somewhat truncate, the dorsal surface traversed longitudinally with one or occasionally two keel-like elevations; parenchyma transparent, slightly granular; flagellum slender throughout, about twice the length of the body, directed rigidly in advance, and vibrating only at its anterior extremity; movements slow and even; multiplying by longitudinal subdivision. Length 1–900″.

HAB.—River water.

While the subtriangular outline indicated in the accompanying figures represents the more typical contour of this species, Stein's illustrations show that examples occur in which the posterior border is evenly rounded as in *P. mediocanellata*, while more rarely the lateral borders may be irregularly contorted, or two keel-like elevations are developed on the dorsal surface.

Petalomonas mediocanellata, Stein. PL. XX. FIG. 3.

Body flattened, resembling an apple-pip in shape, acuminately pointed anteriorly, rounded and widest posteriorly, about twice as long as broad, a straight narrow groove or channel extending down the median line of the ventral surface from the oral aperture nearly to the posterior border; flagellum equalling or slightly exceeding the length of the body; contractile vesicle situated towards the anterior extremity at the left-hand side of the median groove, the endoplast located further back on the opposite side of this same channel. Length 1–700″. HAB.—Fresh water.

* 'Infusionsthiere,' Abth. iii., 1878.

Petalomonas sinuata, Stein. Pl. XX. Fig. 4.

Body flattened, obtusely pointed anteriorly; the posterior margin widest, singly or doubly emarginate, its two lateral angles prolonged outwards, no median ridge or channel, but a short oblique groove produced from the oral aperture towards the right-hand border; flagellum nearly equalling twice the length of the body; endoplast and contractile vesicle as in *P. mediocanellata*. Length 1–800″.

Hab.—Fresh water, dividing by longitudinal fission.

Petalomonas ervilia, Stein. Pl. XX. Fig. 7.

Body flattened, elongate, ovate or elliptical, slightly pointed anteriorly, twice as long as broad; the ventral surface with a broad groove or channel that extends along the left lateral border from the anterior to the posterior extremity; flagellum exceeding the length of the body; contractile vesicle and endoplast situated as in the preceding species, the former sometimes presenting a compound aspect. Length 1–580″. Hab.—Fresh water.

Doubtful species.

The *Cyclidium nodulosum* and *crassum* of Dujardin are probably referable to the genus *Petalomonas*, but the presence of an oral aperture in these forms has yet to be demonstrated. Their brief diagnostic characters, as given by Dujardin, are herewith appended.

Cyclidium (*Petalomonas ?*) *nodulosum*, Duj.—Body flat, discoidal, nodular and vacuolate, movements slow. Length 1–500″.

Hab.—River water, with *Myriophyllum*.

Cyclidium (*Petalomonas ?*) *crassum*, Duj.—Body thick and rounded at the edges; flagellum thickest at the base, slightly undulating; movements active and in a zigzag direction. Length 1–1700″. Hab.—Ditch water.

A small animalcule, as represented at Pl. XX. Figs. 8 and 9, has been recently obtained by the author from hay infusions, whose position would appear to be among or closely adjacent to the representatives of the genus *Petalomonas*. Their contour, while persistent, is less flattened than that of the more normal species previously described, and was observed to vary considerably in different individual zooids. In most instances, as at Fig. 8, the animalcules were symmetrically ovate, as in *P. abscissum*, but somewhat more elongate and less flattened, without any groove or keel-like ridge, while more rarely they were altogether irregular and nodulate, as shown at Fig. 9. The average length of these animalcules did not exceed 1–2500″.

The mode of progress through the water normally exhibited by this type is peculiar, and may assist perhaps in the substantiation or otherwise of its claim for admission to the generic group wherein it is here relegated, though unfortunately no data have as yet been published concerning the characteristic comportment of the several species already enumerated. Such locomotion in the present instance was always accomplished steadily forwards and in a straight line, the body and terminal flagellum being depressed at the angle indicated in the accompanying illustrations; the distal end only of this last-named appendage was maintained in a state of vibration, and was thrust here and there over the surface of the slide or surrounding debris, apparently in search of food. Not unfrequently the animalcules effect a momentary adherence by the distal region of this flagellum, and swinging their bodies round upon it as though on a pivot, direct their course in an opposite direction. It is provisionally proposed to distinguish this species by the name of *Petalomonas irregularis.* The presence of a distinct oral aperture has not as yet been definitely certified.

GENUS III. ATRACTONEMA, Stein.

Animalcules free-swimming, persistent in shape, fusiform or elongate; flagellum single, terminal; oral aperture at the base of the flagellum, followed by a distinct tubular pharynx, the posterior termination of which apparently communicates freely with the contractile vesicle; endoplast subcentral; endoplasm transparent, finely granular. Inhabiting fresh water.

Atractonema teres, Stein. PL. XX. FIGS. 10–12.

Body elongate fusiform, widest centrally, attenuately pointed at each extremity, four or five times as long as broad; flagellum slender, vibratile, equalling the body in length; posterior termination of the pharynx, and communicating contractile vesicle almost joining the central spheroidal endoplast; endoplasm finely granular, often enclosing between the endoplast and posterior termination a discoidal amylaceous corpuscle. Length 1–640″.

HAB.—Fresh water, dividing by longitudinal fission; movements, repent and rotatory.

In accordance with the index to Stein's figures,* the representatives of this species swim freely through the water or creep, head downwards, with the attenuate oral region applied to the surface of the objects traversed. In some of the examples delineated, see Pl. XX. Fig. 12, the flagellum has disappeared, and the central endoplast become enlarged and broken up into spore-like bodies.

GENUS IV. PHIALONEMA, Stein.

Animalcules free-swimming, persistent in form, more or less flask-shaped; oral aperture terminal, dilated, bearing on one side a single flagellum, succeeded by a curved tubular pharyngeal dilatation, which is produced backwards to or beyond the centre of the body; endoplasm transparent granular; contractile vesicle and endoplast distinct. Inhabiting fresh water.

Phialonema cyclostomum, Stein. PL. XX. FIGS. 13 AND 14.

Body flask-shaped, somewhat gibbous, about three times as long as broad, widest centrally, pointed posteriorly, with a neck-like anterior prolongation, the extremity of which is obliquely truncate, and forms a circular, thick-bordered, expanded rim around the oral excavation; curved tubular pharynx, often produced backwards to within a short distance of the posterior extremity, its distal end much dilated; cuticular surface usually obliquely striate, but these striæ occasionally replaced by a few spirally disposed projecting ribs; flagellum short, vibratile, nearly equalling the body

* 'Infusionsthiere,' Abth. iii., 1878.

in length; endoplast subcentral; contractile vesicle situated towards the anterior extremity, and to one side of the pharynx. Length 1-500″.

HAB.—Fresh water.

The animalcules of this species, in addition to swimming freely in the water, creep over the surfaces of submerged objects, with their oral region applied to the same, much in the same manner as *Atractonema*. An approach to the repent mode of progression exhibited by these two last-described generic forms would appear to be foreshadowed in the species provisionally referred by the author to the genus *Petalomonas*, under the name of *P. irregularis*, and in which the distal extremity of the flagellum persistently maintains a close relationship with the surface of the ground or objects traversed.

GENUS V. MENOIDIUM, Perty.

Animalcules free-swimming, persistent in form, lunate or ensiform, compressed, bearing a single terminal flagellum, at the base of which is situated the oral aperture, followed by a minute tubular pharynx; endoplasm transparent, granular; contractile vesicle and endoplast conspicuous, the former situated close to the termination of the pharynx. Inhabiting fresh water; movements oscillating or rotatory.

Menoidium pellucidium, Pty. PL. XX. FIGS. 15 AND 16.

Body lunate, compressed, four to six times as long as broad, with a more thickened, convex ventral, and concave dorsal border, most attenuate anteriorly, its superior edge sometimes developed above the oral aperture as a projecting tooth-like spine; flagellum slender, equalling the body in length; endoplasm transparent, more or less granular, usually containing one or more large ovate amylaceous corpuscles; contractile vesicle, apparently communicating with the termination of the pharynx; endoplast subcentral. Length 1-600″ to 1-400″. HAB.—Fresh water.

The general form of the body of this animalcule may be compared to that of a minute transparent *Closterium*. As originally figured and described by Perty, the terminal flagellum is not represented, and its existence only suspected. Stein * is the first who has published an amplified delineation of its contour and component structure, the chief details of which the author is in a position to corroborate, having recently, November 1878, encountered the species in marsh water obtained from the neighbourhood of St. Heliers, Jersey. In none of the examples as yet examined, however, was detected the anterior tooth-like projection characteristic of the majority of Stein's figures, while in all cases the endoplasm exhibited a feature previously unnoticed. In Stein's delineations the granulation of this element presents no definite plan of distribution, and is diversely developed in different individuals. In those personally investigated, the granulation was confined entirely to the posterior region of the body, and consisted of innumerable minute spherical corpuscles of uniform size, as shown at Pl. XX. Fig. 15. In most of these there was a single large, elliptical, subcentral, amylaceous corpuscle; but in some instances, as in Stein's figures, two or more smaller ones. An exceptional specimen exhibited an inflated and almost cylindrical in place of the usually compressed body contour. Dead examples occasionally occur in which the flagellum has disappeared, but the animalcule still retains its distinct tubular pharynx, thus demonstrating the indurated character of the walls of this structure.

* 'Infusionsthiere,' Abth. iii., 1878.

Fam. II. ASTASIADÆ, S. K.

Animalcules mostly free-swimming, exceedingly plastic and variable in form, bearing a single terminal flagellum; oral aperture distinct; endoplasm colourless.

Genus I. ASTASIA, Ehr.

Animalcules free-swimming, ovate or elongate, very elastic and changeable in form, metabolic, invested by a distinct cuticula; flagellum single, projecting from the more attenuate anterior extremity; oral aperture situated close to the base of the insertion of the flagellum, highly extensile, continued into a long, straight, tubular pharyngeal tract; endoplasm transparent, enclosing incepted granules, but not assimilating chlorophyll or other coloured matter; contractile vesicle and endoplast distinct. Inhabiting fresh and salt water.

Considerable difficulty has usually attended the separation of the members of this genus from those of *Euglena*, a circumstance that must be attributed to the imperfection of the distinctive characters of the two genera as first laid down by Ehrenberg, accompanied by his inclusion under the same generic heading of animalcules belonging to each of the two types. Adopting, nevertheless, the distinctions first pointed out by Dujardin, and since recognized by Carter and other later writers, it becomes evident that the genera *Euglena* and *Astasia* are not only easily distinguishable, but appertain to two widely distinct family groups. In accordance with their respective diagnoses formulated in this volume, it will be found that while in external contour and in the remarkable elasticity of the endoplasmic element with its investing cuticula the two generic types bear a considerable superficial resemblance, a strongly marked structural differentiation is developed immediately beneath. One of the most important distinctions that thus presents itself pertains to the characters of the ingestive or buccal apparatus. In *Astasia* this consists of a large, widely dilatable but simple aperture, continued backwards into a clearly defined pharyngeal tract, through which food-particles of a considerable size are readily transported. In *Euglena*, on the other hand, the oral aperture, while correlated with a peculiar modification of the anterior extremity of the body, is not dilatable or continuous with a distinct pharyngeal tract, and is capable of incepting food-particles of the minutest comparative dimensions only. The distinction subsisting between the consistence of the endoplasm or parenchyma in the two genera is even more easily appreciated. In *Astasia* this structural element consists of clear and apparently homogeneous sarcode, similar to that encountered among all the more ordinary transparent Flagellata, coloured matter, if present, remaining distinctly isolated, and clearly exhibiting its extraneous derivation; neither in *Astasia* is there ever represented that coloured pigmentary corpuscle, the so-called "eye-spot" of the earlier authors, which, although of uncertain value for the purposes of specific discrimination, is broadly characteristic of the group to which *Euglena* appertains. The endoplasm throughout all the representatives of the last-named genus is further conspicuous for its brilliant colouring, this colouring matter not being held temporarily in suspension, but being most intimately incorporated or assimilated with the substance of the endoplasm.

Dujardin has proposed to separate from the genus *Astasia* certain species in which the body was of a more globular shape, and the terminal flagellum thicker and more rigid at its base, proposing for them originally the title of *Pyronema*, and afterwards that of *Peranema*. Out of the two representative forms of this genus described by that authority, however, one, *P. protracta*, is now recognized to be identical with Ehrenberg's *Trachelius* (*Astasia*) *trichophora*, while his *P. globulus* has been demonstrated by the present author to be a transitional condition only of a Radiolarian closely allied to, if not identical with, *Actinophrys sol* (see p. 225). Stein, for reasons as yet unexplained, figures in his recently published volume,* as members of the genus *Astasia*, biflagellate animalcules corresponding most nearly with the forms upon which Dujardin has conferred the name of *Heteronema*, while the typical representative of the present genus, the *Astasia* (*Trachelius*) *trichophora* of Ehrenberg, is referred to Dujardin's genus *Peranema*, which, as just shown, possesses no sound claim for retention.

Astasia trichophora, Ehr. sp. PL. XX. FIGS. 17-21.

Body highly metabolic, variable in shape, more usually irregularly pyriform or clavate, widest posteriorly and tapering gradually towards the pointed anterior extremity, the posterior end sometimes with a short caudiform prolongation; flagellum thick and cord-like, about one and a half times longer than the body; contractile vesicle situated anteriorly, closely adjacent to the centre of the pharyngeal track; endoplast spherical, central, of large size; endoplasm clear and transparent. Length of body 1–1200″ to 1–370″. HAB.—Marsh and stagnant water.

This animalcule was first described under the title of *Trachelius trichophorus* by Ehrenberg, who mistook the thick cord-like flagellum for an attenuate neck-like prolongation of the body, similar to that met with in the ciliated genera *Lacrymaria*, *Amphileptus*, and *Trachelius*. Claparède was the first to indicate its rightful position, but not before it had been redescribed by Dujardin under the titles of both *Peranema protracta* and *Astasia limpida*. The varieties of contour assumed by this form are indeed so manifold and protean, that it seems highly probable that many, if not the majority, of species hitherto referred to the genus are merely slightly modified expressions of this single type. In its movements, which are of two kinds, repent and natatory, the body is at one moment perfectly symmetrical and perhaps almost cylindrical, while during the next it is writhing in amœba-like contortions, and, compared with its former aspect, almost unrecognizable. These contortions, as already remarked by H. James-Clark, do not consist, as in *Amœba*, of an actual outflowing of the substance of the sarcode or parenchyma, but from an exceedingly variable puckering of the cuticular surface, always accompanied by a more or less longitudinal contraction of the body. This is most clearly apparent when the animalcule becomes doubled on itself by an abrupt retrogressive motion.

Professor Clark † has proposed to demonstrate that the occasionally conspicuous caudiform prolongation of the posterior extremity of the body of this species is the rudimentary homologue of the trailing flagellum, or, as he has termed it, the "gubernaculum" of *Anisonema* and other biflagellate types. Its thoroughly inconstant and fugacious character, however, scarcely favours this interpretation. Although the possession by the representatives of the genus *Astasia* of a distinct terminal oral aperture has been recognized since the time of Ehrenberg, the connection with this structure of a distinct indurated pharynx or so-called buccal tube was first recognized and described by Mr. H. J. Carter in his notes on the Infusoria of Bombay, published in the 'Annals of Natural History' for August–September 1856, his observations in this direction being abundantly confirmed by the later investigations of Stein and Bütschli. Mr. Carter, in the publication just referred to, has adopted for this species Dujardin's name of *Astasia limpida*. An illustration of the extreme elasticity possessed by the oral aperture of this type is furnished by one of Bütschli's figures, in which an animalcule is represented as incepting a spherical organism, apparently a monad, whose diameter considerably exceeds that of its own body. A corresponding extensibility of the oral aperture is encountered in the biflagellate type *Dinomonas*,

* 'Infusionsthiere,' Abth. iii., 1878. † 'Mem. Bost. Soc. Nat. Hist.,' 1868.

described later on. The contractile vesicle of *Astasia trichophora* has been shown by Bütschli to exhibit a somewhat complex character, the water discharged in the act of systole being partly driven into smaller lateral diverticula, as obtains in *Entosiphon* and certain species of *Anisonema*, and as also observable in *Paramecium* and many higher Ciliata. Multiplication by fission in this species takes a longitudinal direction. The presence of endogenously developed germs, as represented at Pl. XX. Fig. 18, has been recorded by Mr. Carter.

Astasia contorta, Duj.

Body colourless, semi-transparent, flexible and contractile, subcylindrical, widest in the centre, bluntly pointed at the two extremities; the surface of the cuticle obliquely and closely striate, so as to impart to it a twisted aspect. Length 1–425″. HAB.—Salt water.

A second marine species described by Dujardin under the name of *Astasia inflata*, having the cuticular surface obliquely striate in a similar manner, and the same approximate dimensions, but with a more ovoid body, is apparently a variation only of *A. contorta.*

Astasia flavicans, Ehr.

Body extensile, conical or subcylindrical, rounded anteriorly, with a short, blunt, tail-like posterior prolongation; parenchyma enclosing yellowish granules. Length of body 1–430″. HAB.—Ditch-water.

Astasia pusilla, Ehr.

Body colourless, extensile, conical, largest and rounded posteriorly, and with a short pointed posterior prolongation; flagellum twice the length of the body. Length of body 1–1440″ to 1–400″. HAB.—Ditch-water; social.

This and the preceding are apparently variations only of the same form, and are, as already remarked by Carter, closely allied to if not identical with the *Astasia* (*Trachelius*) *trichophora* of Ehrenberg and *A. limpida* of Dujardin.

Astasia longifilis, Perty.

Body persistent in form, hyaline, enclosing pale-green granules, the anterior half exhibiting a longitudinal plait or furrow; flagellum at least three times the length of the body. Length 1–1000″.

Doubtful Species.

A number of fresh-water species have recently been added to the genus *Astasia* by De Fromentel,* but are in the majority of cases too ill-defined for re-identification. The figures accompanying his descriptions might at the same time do duty in most instances for one or other of the protean phases of *Astasia trichophora.* A slightly amended translation of Fromentel's diagnoses of such forms only as seem to possess appreciable distinctive characters is herewith appended.

Astasia utriculus, From.—Body flask-shaped, inflated at the base and rounded at the summit; flagellum inserted somewhat on one side of the neck-shaped anterior portion. Length 1–800″. His *Astasia cucurbita*, of similar size and shape, is apparently identical with this form.

* 'Études sur les Microzoaires,' Paris, 1876.

Astasia deformis, From.—Body hyaline, with irregular digitate expansions; contractile vesicles posteriorly situated. Length 1–600″.

Astasia turbo, From.—Body top-shaped, with a dilated, somewhat flattened central portion, and attenuate anterior and posterior regions; parenchyma finely granulate; flagellum long and slender. Length 1–400″.

Astasia fusiformis, From.—Body fusiform, attenuate at the two extremities; contractile vesicle conspicuous, posteriorly situated. Length 1–600″.

Astasia crassa, From.—Body highly contractile, subspherical, often changing its form, but retaining an attenuate, tail-like, posterior prolongation; flagellum long and slender; parenchyma white and granular. Length 1–700″.

Astasia regularis, From.—Body regularly oval, slightly flattened on one side; pharyngeal tract conspicuous; parenchyma enclosing coloured granules. Length 1–1000″.

The *Trachelius dendrophilus* of Ehrenberg *—"body ovate, subacute at each extremity, proboscis flagelliform, slender and pointed, more than twice the length of the body. Length 1–3456″." Found among moss from trees, with habits like those of *Trachelius* (*Astasia*) *trichophora*—is apparently a minute representative of the present genus.

GENUS II. COLPODELLA, Cienkowski.

Animalcules free-swimming or adherent, ovate or elongate, bearing a single anterior terminal flagellum, at the base of which is a suctorial oral aperture; contractile vesicle and endoplast conspicuous. Habits predatory, preying upon various minute Phytozoa, the cell-walls of which they perforate, and abstract the contents.

In contour and in the character of the single flagellate appendage the representatives of this genus are scarcely to be distinguished from those of *Monas* or *Paramonas*, and might, unless observed in the act of feeding, be relegated to one of these two genera.

Colpodella pugnax, Cienk. PL. XX. Fig. 22.

Body somewhat variable in form, its most characteristic shape elongate, semilunate, pointed at each extremity, with a flat ventral and convex dorsal border; flagellum equalling or slightly exceeding the body in length; contractile vesicle single, circular, situated close to the ventral border at a short distance from the posterior extremity; endoplast spherical, anteriorly located. Length 1–2000″.

HAB.—Fresh water, preying upon *Chlamydomonas pulvisculus*.

According to Cienkowski † the zooids of *Colpodella pugnax*, after fully satisfying their hunger by the extraction of the cell-contents of one or more specimens of the above-named protophyte, become encysted, and the enclosed bodies split up into eight or more sporular elements. These subsequently make their

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* 'Ber. Akad. Berlin,' 1853.

† 'Archiv für Mikroskopischer Anatomie,' Bd. i., 1865.

escape from the cysts in a form identical with that of the parent, but of smaller size. Not unfrequently, as shown at Pl. XX. Fig. 22, two or three *Colpodellæ* fasten themselves simultaneously to a single *Chlamydomonas*, and perforating its body-wall, rapidly reduce it to an empty shell. No instance of the coalescence or fusion of two or more individual zooids has as yet been recorded, but in all probability occasionally takes place.

Fam. III. EUGLENIDÆ, Stein.

Animalcules free-swimming or sedentary, naked or loricate, solitary or united in social colonies; flagellum single, terminal; oral aperture distinct; endoplasm usually coloured brilliant green, more rarely red, through the assimilation of chlorophyllaceous substances, often enclosing several highly refracted corpuscles of an apparently starch-like or amylaceous nature; one or more brightly coloured eye-like pigment-specks frequently developed at the anterior extremity; contractile vesicle and endoplast conspicuous, the former usually located close to the anterior border. Multiplying by longitudinal and transverse fission, by the subdivision of the entire body-substance into sporular elements, and by the development of independent germinal bodies out of the substance of the endoplast.

The members of this highly characteristic and very natural family group are readily recognized in connection with the brilliant coloration—the prevailing hue being green—of the endoplasmic elements, which under normal conditions more or less conspicuously distinguishes every one of the considerable number of generic and specific types as herewith comprised. The common occurrence within the body-substance of variously shaped corpuscles of considerable size and of an apparent amylaceous or starch-like nature, as also the endogenous mode of reproduction, manifested by the enlargement and subdivision of the central endoplast or nucleus, yield supplementary distinctive features of importance. With respect to the amylaceous corpuscles, it is worthy of remark that in the case of those of elongate rectangular contour developed in *Euglena deses*, Dujardin has attributed to them the nature of crystals of sulphate of lime.

Genus I. EUGLENA, Ehrenberg.

Animalcules free-swimming, more or less fusiform or elongate, exceedingly flexible and changeable in shape; bounded by an elastic and highly contractile cuticulum, terminating posteriorly in a more or less developed tail-like prolongation; endoplasm usually tinged bright green or red through the assimilation of chlorophyll or other colouring matter; flagellum single, slender and flexible throughout, issuing from an anterior funicular, notch-like excavation, at the bottom of which a minute oral aperture is situated; contractile vesicle and endoplast conspicuous; one or more distinct eye-like pigment-spots usually present at the anterior extremity. Inhabiting fresh, stagnant, and brackish waters; solitary, or occurring in such numbers on the surface of the water as to impart to it a highly characteristic feature, even as seen with the unaided vision. Increasing by longitudinal fission, and by the production of germs through the subdivision of the endoplast or of the entire mass of the internal parenchyma.

In their general contour and extreme flexibility, which permits them at will to assume the most varied and protean shapes, the members of the genus *Euglena* so closely correspond with those of *Astasia* that the two have been usually included in the same family. By Ehrenberg, indeed, the presence or absence of the so-called coloured eye-speck was regarded as representing the only distinctive feature, the natural sequence to such an artificial distinction being that many forms have been referred by him to the genus *Astasia* which properly belong to the one now under consideration. Dujardin was the first to point out the unreliable character of Ehrenberg's proposed diagnosis, substituting for it the distinctions here maintained, afforded by the coloured or transparent consistence of the endoplasm. This last-named characteristic may still be adopted as furnishing a safe and speedy means of distinguishing between the representatives of the two respective genera, although, as will be presently shown, much more important structural differences exist. The colouring matter of *Euglena*—most usually green and apparently partaking of the nature of chlorophyll—which invariably, under normal conditions, enters to a greater or less extent into the composition of the endoplasmic layer of the various species, is, as already intimated in the account given of the genus *Astasia*, not scattered in an irregular granular manner, as in numerous other infusorial forms, denoting by such a distribution its foreign nature and temporary lodgment only, but permeates its substance so completely as to be inseparable from it under the highest magnifying power, and remaining as intimately amalgamated with it when, as described later on, it breaks up within the integument into germinal masses. In this manner the endoplasm of *Euglena* is, as it were, indeed, more or less completely stained with the characteristic hue peculiar to the species.

The possession by *Euglena* of a distinct oral aperture, and its capacity of incepting solid particles of food through this orifice, have not up to a recent date been clearly demonstrated. Stein, however,* in the year 1867, went so far as to attribute the office of such a structure to the notch-like anterior cleft of *Amblyophis*, and which he described as being followed by a distinct pharyngeal tract; a similar interpretation was also arrived at by him with reference to the smaller anterior notch of *Euglena*, though in no instance was the passage of food-particles directly determined. Still later,† this authority has represented a tubular oral aperture as pertaining to all of the members of this family group as here comprised. The apparent absence of a distinct oral apparatus and ingestive capacity, taken together with the green hue of the body-plasma, previously induced most modern authorities, including Mr. Carter, to deny to the representatives of *Euglena* and its allies the rank of animal organisms, they referring them rather to the division of the Protophyta or lower unicellular plants. The present author's views, to within a comparatively recent date, harmonized with this decision, but a still later and more exhaustive examination of the type form of the genus, *E. viridis*, made in April 1877, has resulted in the adoption of an entirely opposite opinion. Keeping animalcules of this species for a prolonged interval in water with finely pulverized carmine, and submitting them to a magnification of 800 diameters and upwards, the passage into their bodies at the anterior extremity of exceedingly fine particles of this pigment was repeatedly observed, as also the accumulation, in various parts of the body-substance, of small globular aggregations of the particles ingested. Hitherto this anterior region in *Euglena* has been represented as exhibiting a bilabiate aspect, and the flagellum as a thread-like extension of the upper of the two lip-like prominences. With the aid of the high magnifying power employed on this occasion, it was, however, clearly shown that the inner surfaces of these lip-like prominences actually represented the upper and lower boundary walls of a conical or infundibular excavation or vestibulum, the innermost recess of which fulfils the office of an oral aperture by permitting the free passage of exceedingly minute food-particles. This infundibular cleft, the walls of which are so thin and transparent as to require the aid of the highest powers of the microscope for their satisfactory delineation, are at once suggestive of the infundibular, collar-like, pre-oral expansion of the Choanophorous order of the Flagellata *Codosiga*, *Salpingœca*, &c., and may not

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* 'Infusionsthiere,' Abth. ii., 1867.

† Ibid., Abth. iii., 1878.

improbably be to some extent homologous with it. The flagellum was in all cases demonstrated to take its origin within the interior and close to the bottom of the infundibuliform excavation.

Euglena viridis, Ehr. PL. XX. FIGS. 29–51.

Body elongate, subcylindrical or fusiform, exceedingly flexible and variable in shape, mostly rounded anteriorly, and with a short, transparent, conically pointed, tail-like posterior prolongation; cuticular surface faintly striate obliquely; endoplasm usually entirely bright green, but sometimes changing to dark orange or red; flagellum slender, exceeding the body in length, a red pigment-spot generally present at the anterior extremity; contractile vesicle situated at the anterior extremity, close to the coloured pigment-spot; endoplast, spherical, subcentral. Length 1–600″ to 1–140″.

HAB.—Pond and stagnant water, on the surface of which it frequently occurs in vast shoals.

The aspects presented by this animalcule under various developmental or external conditions are so numerous and diverse as to have led to its description by the earlier writers under several specific titles. There can be little doubt that the *Euglena sanguinea* of Ehrenberg, having the same external form, but of a blood-red colour, or variegated with red and green, represents one of the matured phases of the species now under consideration, while the *E. hyalina* of the same authority illustrates a still less well-marked variation, in which, through probably the absence of suitable food-material, the endoplasm is almost completely transparent. It is maintained by Perty that the *Amblyophis viridis* of Ehrenberg—which has received a separate generic title on account merely of the rounded instead of pointed and more tail-like posterior extremity—is also a variation only of *Euglena viridis*, it occurring in company with the normal animalcules, and according to him being reproduced directly from them. As the latter generic distinction is, however, allowed by more recent writers, including more especially Stein, it appears desirable to retain it in this treatise.

Endogenous multiplication, manifested by the division of the entire coloured inner substance of *Euglena viridis* into germs of variable number and subfusiform or irregular contour, as shown at Pl. XX. Figs. 36 and 37, and in a manner most nearly resembling that already recorded of *Polytoma uvella*, was observed by the present author in connection with the observations relating to the oral apparatus previously described, as also encystment, attended sometimes by and sometimes without the coalescence of two individual zooids. The result of the process of encystment, as shown at Pl. XX. Figs. 49 and 50, was the breaking up of the entire protoplasmic body-contents into numerous globular spore-like bodies, which were ultimately released as small, green, creeping amœbæ, Fig. 51, possessing at this early stage no trace of the flagellum, oral aperture, or pigment-spot which were subsequently acquired. The fusiform zooids produced by the subdivision of the internal substance of the motile *Euglenæ* appear on the contrary to be furnished in most instances with both a flagellum and eye-speck, on bursting through the investing membrane of the parent cell; this observation is further confirmed by the investigations of both Kolliker and Mr. Carter. In addition to the reproductive form of encystment just described, *Euglena* is in the habit, upon the drying up of the ponds or ditches that contain it, of assuming a spherical form and, throwing around itself a gelatinous envelope which becomes gradually indurated, of remaining in this quiescent state until the return of genial conditions. In this manner the temporarily encysted *Euglenæ* often form film-like expansions of considerable extent, and have been mistaken for independent forms of Algæ. *Microcystis olivacea* and *M. Noltii*, as also the *Protococcus turgidus* and *P. chalybius* of Kützing, are thus now regarded as representing variable phases of this resting condition of

Euglena viridis. The existence of the contractile vesicle in this species, and its rhythmical though slow pulsations, were distinctly authenticated on repeated occasions. In various instances there appeared to be two of these organs situated close to one another near the anterior eye-like pigment-spot. In demonstration of the unreliability of the characters afforded by the last-named structure, Dujardin figures an example in which no less than three of these coloured bodies are present, while instances not unfrequently occur in which it is altogether absent.

Stein, in his recently published work,* has given very copious illustrations of this cosmopolitan species. From them are here reproduced his delineations of a mode of reproduction that has not been previously recorded. This, as shown at Figs. 39–41 of Pl. XX., is brought about by the abnormal growth and enlargement of the endoplast, which next breaks up into innumerable spore-like bodies that are finally liberated during the life of the animalcule as minute monadiform germs. A similar process of reproduction is likewise attributed by this same authority to the genus *Trachelomonas.* Encysted conditions resulting in the subdivision of the entire body-mass into sporular bodies, as delineated by Stein, are reproduced at Figs. 44–48, while simple fission, as it occurs in the temporarily encysted state, is represented at Fig. 43. Fission during the motile life of this animalcule takes place in a longitudinal direction.

An interesting local variety of *Euglena viridis* has been recently described by Mr. M. H. Robson, of Newcastle-upon-Tyne, in 'Science Gossip' for October 1879, in which the distal extremity of the flagellum presents an inflated knob-like aspect, as shown at Pl. XX. Fig. 29. Possibly such modification of this important organ represents a phase preliminary to its entire withdrawal, and antecedent to the entrance of the animalcule upon the encysted or resting state.

Euglena spirogyra, Ehr. PL. XX. FIGS. 27 AND 28.

Body elongate, subcylindrical, seven or eight times as long as broad when extended; slightly truncate anteriorly, the posterior extremity produced as a transparent, ensiform, tail-like prolongation; cuticular surface ornamented with even closely approximated oblique rows of minute bead-like elevations; colour bright green, yellow, or brown; endoplasm usually containing two large ovate or elliptical amylaceous bodies, between which the ovate or subspheroidal endoplast is located; contractile vesicle situated at the anterior extremity immediately behind the scarlet eye-like pigment-spot. Length 1–240″ to 1–120″. HAB.—Fresh water, solitary.

According to Mr. Carter, the obliquely striate aspect of this and other species of *Euglena* is occasioned by the presence beneath the cuticle of a layer of pointed sigmoid fibrillæ. The examination of numerous living examples of this type by the present author, with the aid of a magnifying power of 800 diameters, has, however, failed to reveal any such complex structure, though, on the other hand, the entire surface of the cuticle was shown to be traversed by oblique rows of closely approximated bead-like prominences; the peripheral margin of the body presented at the same time a finely crenulate aspect, demonstrating that the bead-like appearance was a structural reality, and not a mere optical appearance. A similar beaded pattern of the cuticular layer, though of a more open character, is furthermore characteristic of the figures of this species as given by Stein. In addition to the central nucleus or endoplast, two large obliquely disposed elliptical or subcylindrical amylaceous corpuscles, situated, the one a little in front of, and the other shortly behind, the centre of the body, as shown at Pl. XX. Fig. 27 *a a*, were usually observed. The contractile vesicle, as in *E. viridis*, is located immediately to the rear of the eye-like pigment spot.

* 'Infusionsthiere,' Abth. iii., 1878.

Euglena oxyuris, Schmarda. PL. XX. FIG. 26.

Body elongate, subcylindrical, or ligulate, eight or nine times as long as broad when extended, often spirally contorted, terminating posteriorly in a long, slightly curved, spur-like, caudal prolongation; cuticular surface obliquely striate; amylaceous corpuscles cylindrical or elliptical, often very numerous; colour green. Length 1–130". HAB.—Fresh water.

The simple oblique striation of the cuticular surface, and less conspicuous development of the caudal spine, serve to distinguish this type from *E. spirogyra.* The figure here given of the species, reproduced from Stein's drawings, represents an animalcule in its more abnormal contorted condition.

Euglena deses, Ehr. PL. XX. FIGS. 52 AND 53.

Body elongate, vermicular, cylindrical, fifteen to twenty times as long as broad, acutely pointed posteriorly when extended, but capable of assuming the most protean contours; cuticular surface smooth; colour green; amylaceous corpuscles acicular. Length 1–760" to 1–240".

HAB.—Pond water, among Lemnæ.

The figures here given are reproduced from Stein's recently published volume; that represented at Fig. 53 is described in the index as a young non-flagelliferous example, whose locomotion is effected by peristaltic movements of the body. According to Ehrenberg, this species never swims, but confines its motions to sluggish creeping and twisting.

Euglena acus, Ehr. PL. XX. FIGS. 24 AND 25.

Body very slender and elongate, from seven or eight to ten or twelve times as long as broad, tapering towards both extremities, the anterior end abruptly truncate, the posterior one acuminately pointed; cuticular surface smooth; colour bright green; a red eye-like pigment-spot usually developed; contractile vesicle conspicuous, anteriorly situated; amylaceous corpuscles numerous, elongate rectangular. Length 1–570" to 1–110".

HAB.—Fresh and brackish water.

Quite recently, November 1880, the author has received examples of this species from the neighbourhood of Birmingham through Mr. Thomas Bolton. The specimens thus examined yielded an average length of 1–150", and were remarkable for the fact that, excepting for the anteriorly developed eye-like pigment-spot, their body-substance was perfectly transparent—a circumstance attributable probably to their having been for a long while deprived of their ordinary food-material. All the examples were exceedingly attenuate, their greatest central breadth usually scarcely exceeding that of the truncate anterior border. Their deportment in the water, unlike that of most representatives of the genus *Euglena*, was remarkably stiff. On rare occasions only were they observed to flex their bodies to the extent represented at Pl. XX. Fig. 25, while in no instances did they exhibit protean contractions and expansions as attested to in other of Stein's recent delineations. Such metamorphic properties are apparently, in accordance with the index to his figures, manifested chiefly by the older zooids. A number of examples were observed with their more attenuate posterior extremities affixed to the glass slide or accompanying organic debris, the movements of their flagella under such conditions causing their stiff acicular bodies to revolve in circles as though on a pivot. Not unfrequently a number of zooids becoming attached in this manner close to each other, recalled to mind the group of *Leptomonas Bütschlii* represented at Pl. XIII. Fig. 25. In all the examples a greater or less number of rectangular attenuate amylaceous corpuscles were clearly discerned.

Euglena rostrata, Ehr.

Body elongate, conical, tapering posteriorly, and terminating in a short tail-like process, the anterior extremity bent in a beak-like manner; colour green. Length 1–500″. HAB.—Pond water.

Euglena geniculata, Duj.

Body elongate, subcylindrical, more or less even throughout, flexible, but slightly contractile, with an obliquely directed tail-like prolongation; cuticular surface smooth, colour green; red pigment-spot conspicuous. Length 1–200″ to 1–170″. HAB.—Pond and river water.

This species may be distinguished from *E. spirogyra*, which it most nearly approaches, by the smooth surface of the cuticle and the obliquely directed caudal termination.

Euglena fusiformis, Carter. PL. XX. FIG. 58.

Body shortly fusiform, about one and a half times as long as broad, obtusely pointed at each extremity, the anterior one faintly bilabiate; no posterior tail-like prolongation; colour rich green; endoplast central, situated between two refractive, nucleated, cell-like structures, which extend round the body equatorially; contractile vesicle and eye-like pigment-spots anteriorly located; parenchyma a rich green colour; motion rotatory and oscillating. Length 1–700″.

HAB.—Fresh-water tanks, Bombay.

This species should probably be included in the genus *Amblyophis*. The *Euglena zonalis* of Carter, somewhat resembling it, is referred by Stein to the genus *Chloropeltis*.

Euglena agilis, Carter. PL. XX. FIG. 64.

Body somewhat flask-shaped, inflated and widest posteriorly, attenuate anteriorly; a short, blunt, caudal prolongation sometimes present, but not essential; multiplying in its active condition by longitudinal and transverse fission, and in its passive or encysted one by crucial or by linear segmentation; colour green; movements very active. Length 1–600″.

HAB.—Brackish water, Bombay.

This species, described by Mr. H. J. Carter in his 'Notes on the Fresh-water Infusoria of the Island of Bombay,'* is remarkable for its occasional linear mode of segmentation, briefly referred to in the foregoing diagnosis, the cyst-like envelope that encloses the segmented fragments being so transformed, Pl. XX. Fig. 64, as to assume an elongate subcylindrical contour. The germs, four in number, produced by this fissive process are each provided with a red eye-like pigment. A somewhat parallel linear mode of segmentation of the encysted animalcules has been reported by Claparède and Lachmann of the Cilio-Flagellate genus *Peridinium*, and are represented at Pl. XXV. Figs. 49 and 50.

* 'Ann. and Mag. Nat. Hist.,' Aug. and Sept. 1856.

Euglena tuba, Carter. PL. XX. FIGS. 54 AND 55.

Body fusiform, subcylindrical, fish-shaped; obtuse and bilabiate anteriorly, terminating posteriorly in a short, pointed, tail-like prolongation; eye-like pigment-spot and contractile vesicle anteriorly situated; colour green. Length 1–300″. HAB.—Fresh water, Bombay: social.

Although this animalcule in its normal free-swimming condition presents no important distinction from *Euglena viridis*, it exhibits in its quiescent or encysted state a highly characteristic deviation. In this condition, according to its discoverer, the animalcules produce by exudation, as shown at Pl. XX. Fig. 55, a common reticulate, transparent, gelatinous basis, within the tubular ramifications of which they secrete individually a flask-shaped cyst or lorica, having a round inflated basal portion and a long tubular neck, the apical extremity of which is dilated like the mouth of a trumpet. The relationship between the free-swimming animalcules and these flask-shaped encystments cannot be said to be definitely determined. Although not mentioned in the original description of this form,* Mr. Carter has personally informed the author that the motile and encysted conditions were not observed in direct connection with one another, but that the tank from which they were taken, while found on one occasion to yield the free-swimming *Euglenæ* in abundance, produced in the place of these, when visited a few days later, a complete surface-stratum of the encysted structures immersed in their gelatinous network. The contour of these cysts, with their elongate necks and everted apertures, is so distinct from what is met with among the members of the ordinary Euglenidæ, but at the same time corresponds so remarkably with that of the flask-shaped loricæ of the collared monad *Salpingœca amphoridium* and its allies, that the author is half inclined to suspect that a further investigation may elicit that this presumed encysted state of *Euglena tuba* is in no way connected with the free-swimming animalcules observed by Mr. Carter, but represents the quiescent condition of an as yet undescribed type of the Choano-Flagellate order. Should these premises prove correct, this organism will constitute a new generic type of the group indicated, corresponding closely with the mucous inhabiting *Phalansterium*, but representing in itself a most interesting departure in the direction of the sponges.

Euglena—Supplementary.

The *Euglena ovum* of Ehrenberg is now referred by Stein to the genus *Chloropeltis*, and the *E. pyrum* and *longicauda* of the same authority to that of *Phacus*. The *Euglena mucronata* of Perty, with its pointed tail and finely striped cuticle, is scarcely to be distinguished from *E. spirogyra*, while the *E. obscura* of Dujardin would seem to represent a variety only of *E. viridis*. De Fromentel has introduced into his work, † as new species of *Euglena*, several forms, all of which, however, might be referred to *E. viridis*, and differ from each other only in minor points of contour and coloration. The reproduction of these names with their diagnoses would serve only to further burden and embarrass the synonymy of the genus.

GENUS II. AMBLYOPHIS, Ehrenberg.

Animalcules uniflagellate, free-swimming, elongate, flexible and changeable in form, rounded posteriorly, never exhibiting a tail-like prolongation of this region; endoplasm coloured green; an anterior eye-like pigment-spot usually present; the front margin apparently bilabiate, indicating the presence of an oral aperture resembling that of *Euglena*, this sometimes followed by a distinct pharyngeal tract.

* 'Ann. and Mag. Nat. Hist.,' April 1869. † 'Études sur les Microzoaires,' Paris, 1876.

In accordance with the views of Perty and other writers, the type of this genus represents merely a tail-less variety of *Euglena viridis;* its generic and specific distinctness is, however, maintained by Stein.

Amblyophis viridis, Ehr. PL. XX. FIG. 63.

Body elongate, subcylindrical or compressed, rounded posteriorly, highly flexible, eight or ten times as long as broad when extended ; the anterior margin obliquely truncate, transparent, apparently bilabiate, perforated by the oral aperture and succeeding tubular pharyngeal tract, the remaining endoplasm coloured bright green ; a red eye-like pigment-spot usually present ; endoplast central, subspherical, several rod-like amylaceous corpuscles generally developed. Length 1–210″ to 1–140″.

HAB.—Pond and stagnant water, in company with *Euglena viridis.*

Amblyophys ægyptiaca, Schmarda.

Body elongate, rounded and widest posteriorly when extended, oval or spherical when contracted ; flagellum equalling the body in length ; eye-like pigment-spot conspicuous ; colour dull green. Length, 1–480″ to 1–360″. HAB.—Fresh water, Egypt. (Schmarda.*)

GENUS III. PHACUS, Dujardin.

Animalcules free-swimming, persistent in form, mostly compressed and leaf-like, terminating posteriorly in a sharp-pointed tail-like prolongation ; oral aperture terminal, not projecting, followed by a distinct tubular pharynx, giving origin to a single long, vibratile flagellum ; cuticular surface indurated ; endoplasm coloured green, usually enclosing anteriorly an eye-like pigment-spot ; contractile vesicle large, subspheroidal, situated close to the eye-like pigment-spot ; endoplast conspicuous, frequently modified as in *Euglena,* and forming by subdivision one or more large oval sporosacs. Inhabiting fresh water.

The several forms referred to this genus by Dujardin were originally described by Ehrenberg as species of *Euglena,* from which they differ essentially in their persistent form and in the more or less indurated consistence of their cuticular layer, which often remains as an empty shell after the dissolution of the enclosed contents.

Phacus pleuronectes, Müll. sp. PL. XXI. FIGS. 2–5.

Body obovate, compressed, leaf-like, one and a half times as long as broad, caudal prolongation about one-quarter the length of the body, directed obliquely towards the dorsal aspect ; cuticular surface smooth, or presenting a faintly striate appearance only in its empty state ; endoplasm bright green, often enclosing a large, central, spheroidal, amylaceous corpuscle ; endoplast spherical, posteriorly located ; contractile vesicle contiguous to the eye-like pigment-spot, frequently exhibiting irregularly developed lateral lacunæ. Length 1–1200″ to 1–480″.

HAB.—Stagnant water.

* 'Denkschrift der Kaiser. Akad. der Wiss. Wien,' 1854.

This species was originally described by O. F. Müller under the title of *Cercaria pleuronectes*, it was transferred to that of *Euglena* by Ehrenberg, and to the present one of *Phacus* by Dujardin. Examples figured in Stein's recently published volume are represented as containing three or four large ovate sporosacs, his "Keimsäcken," or the so-called "glaire-cells" of Mr. H. J. Carter, each of these enclosing an endoplastule in an apparently unaltered state.

Phacus triqueter, Ehr. sp. PL. XXI. FIG. 1.

Body ovate, compressed, leaf-like, having a raised keel-like elevation produced down the centre of the right-hand side, presenting in transverse section a triquetrous contour; caudal prolongation one-fourth or one-third the length of the body, acuminately pointed, directed obliquely towards the dorsal aspect; cuticular surface finely but distinctly striate longitudinally. Length 1–580". HAB.—Fresh water, amongst *Lemnæ*.

Identical with the *Euglena triqueter* of Ehrenberg.

Phacus pyrum, Ehr. sp. PL. XXI. FIG. 10.

Body subfusiform or pyriform, about twice as long as broad, continued posteriorly as a straight acuminate tail-like prolongation which equals or slightly exceeds in length one-half of the preceding body portion; cuticular surface coarsely and obliquely sulcate. Length 1–1200" to 1–864".

HAB.—Pond water.

First figured and described by Ehrenberg under the title of *Euglena pyrum*.

Phacus longicaudus, Ehr. sp. PL. XXI. FIGS. 6 AND 7.

Body ovate, compressed and leaf-like, often contorted or twisted upon its axis, from one and a quarter to twice as long as broad; produced posteriorly as an acuminate, mostly straight, but sometimes irregularly curved caudal prolongation, which nearly equals the body in length; cuticular surface finely striate longitudinally. Length 1–480" to 1–120".

HAB.—Fresh water.

As explained by Stein in his index to the figures given of this species,* it is enabled to change from the more normal flattened form to the screw-like or spirally twisted contour, though in consequence of the comparatively hardened consistence of the cuticle the process is very slow and gradual. In its power to alter in any way its external configuration, this type differs essentially from the preceding species, and may be said in consequence to occupy an intermediate position between the typical members of the two genera *Euglena* and *Phacus*. The animalcule was originally referred by Ehrenberg to the first-named genus.

GENUS IV. CHLOROPELTIS, Stein.

Animalcules free-swimming, persistent in shape, more or less ovate, usually compressed, terminating posteriorly in an acuminate tail-like prolongation; oral aperture terminal, situated at the extremity of a short, conical, snout-like prolongation, giving origin to a single, long, vibratile

* 'Infusionsthiere,' Abth. iii., 1878.

flagellum, succeeded posteriorly by a slender pharyngeal passage; endoplasm coloured green, generally enclosing an anterior eye-like pigment-spot; contractile vesicle and endoplast conspicuous. Inhabiting fresh water.

So far as it is possible to determine from the figures, with their accompanying indices, given by Stein,* the members of this genus are to be distinguished from those of *Phacus* by the presence only of the conical anterior prolongation which is perforated at its apex by the oral aperture. In all other respects the two appear to essentially agree.

Chloropeltis hispidula, Eichwald sp. PL. XXI. FIGS. 8 AND 9.

Body broadly ovate, compressed, nearly as broad as long; caudal prolongation straight or slightly curved, equalling one-third of the length of the body; cuticular surface longitudinally ribbed, each rib thickly hispid throughout; an anterior eye-like pigment-spot usually developed; the contractile vesicle situated close to the termination of the pharyngeal passage, and apparently communicating with it; endoplast ovate, posteriorly located. Length 1–500″. HAB.—Fresh water.

The general contour of the body of this species coincides remarkably with the flattened and longitudinally ribbed fruit of various Umbelliferous plants, and more especially perhaps with that of the common parsnep, *Pastinaca;* it was originally described by Eichwald † as a species of *Euglena.* As figured in Stein's recent work, the number of longitudinal hispid ribs is shown to vary considerably in different individuals. In some there are only half-a-dozen upon each flattened side, while in others there may be as many as or more than twice that number.

Chloropeltis ovum, Ehr. sp. PL. XXI. FIGS. 11–13.

Body somewhat variable in form, mostly symmetrically elliptical and cylindrical, but sometimes subspheroidal or subfusiform; caudal prolongation short, acuminate; cuticular surface usually finely striate in an oblique but more exceptionally in a longitudinal direction; anterior conical projection conspicuously developed; endoplasm often enclosing two large or four smaller, circular, bilaterally corresponding, amylaceous corpuscles. Length 1–1500″ to 1–640″. HAB.—Fresh water.

This species was first described by Ehrenberg under the title of *Euglena ovum.* Stein proposes to identify the more attenuate, fusiform variety with the *Euglena zonalis* of Mr. Carter.

GENUS V. TRACHELOMONAS, Ehrenberg.

Animalcules monoflagellate, plastic and changeable in form, enclosed within a free-floating, ovate or spheroidal, indurated sheath or lorica, the anterior extremity of the lorica perforated by a minute aperture, through which in its normal condition the single flagellum only is protruded; oral aperture terminal, followed by a distinct pharyngeal passage endoplasm coloured green, with usually a red pigment-spot at the anterior extremity; contractile vesicle single, spherical, located near the anterior pigment-spot. Mostly inhabiting fresh water.

* 'Infusionsthiere,' Abth. iii., 1878. † 'Infusoria Russlands,' 1847.

It has quite recently been shown by Stein * that the animalcules of this genus correspond essentially with those of *Euglena*, and from the representatives of which, indeed, they are distinguished only by their possession of a variously shaped indurated lorica. In accordance with the more recent researches of this authority, the three Ehrenbergian genera, *Lagenella*, *Chætotyphla*, and *Chætoglena* must also be merged with *Trachelomonas*, these several forms exhibiting merely slight modifications in the contour of the loricæ that possess simply a specific value. As first described by Ehrenberg, the lorica, in both *Chætotyphla* and *Chætoglena*, is reported to be siliceous, but is evidently, as in the more normal Trachelomonads, simply corneous, but at the same time of an exceedingly brittle and almost shell-like consistence. *Lagenella* was separated by Ehrenberg from *Trachelomonas* with reference merely to the neck-like prolongation of the minute terminal aperture, but which may be variously developed or even almost entirely suppressed in individuals of the same species. While under ordinary circumstances the bodies of the animalcules of this genus are entirely enclosed within their ovate or spheroidal loricæ, their lash-like flagella only protruding, it was originally observed by Perty, and more recently by Stein, that under certain conditions they contrive to squeeze through the minute anterior aperture, the extruded body under such circumstances presenting the aspect of a normal *Euglena*. This feat, comparing the large size of the animalcule's body with the minute diameter of the orifice of the lorica, appears, as remarked by Stein, to be as difficult of achievement as the passage of the proverbial camel through the eye of a needle. The various phases of this process as delineated by him, and reproduced at Pl. XXI. Figs. 15 and 22, serve to demonstrate the almost amœboid plasticity of the endoplasm and overlying cuticle. In many species the lorica is remarkable for its red or crimson hue, this tint, however, being conspicuous only as concentrated at the periphery, where it appears as a brilliantly coloured ring or band around the bright green endoplasm of the enclosed animalcule. Multiplication through the liberation from the parent body of a multitude of minute monoflagellate germs has been observed by Stein in several species of the genus.

Trachelomonas volvocina, Ehr. Pl. XXI. Figs. 14–16.

Lorica spheroidal, entirely smooth, aperture usually level with the adjacent wall but sometimes produced so as to form a minute cylindrical, projecting neck; periphery presenting the aspect of an encircling crimson ring. Length 1–1000″ to 1–860″.

Hab.—Fresh water, amongst *Confervæ*.

In one example of this species as figured by Stein, the tubular neck is produced into the interior cavity of the lorica, which in consequence resembles in contour the shell of the Foraminiferous genus *Entosolenia*; reference to this abnormal form will no doubt appear with the forthcoming descriptive text. In other figures, here reproduced, the egress of the animalcule through the minute aperture of the lorica and the liberation from the body of the parent of a swarm of monociliated germs are depicted.

Trachelomonas rugulosa, Stein. Pl. XXI. Fig. 17.

Lorica spheroidal, resembling that of *T. volvocina*, excepting that its entire external surface is finely wrinkled; anterior aperture plane or slightly prominent. Length 1–1080″. Hab.—Fresh water.

Trachelomonas lagenella, Stein. Pl. XXI. Figs. 18 and 19.

Lorica colourless, oval or elliptical, nearly one and a half times as long as broad, the anterior and posterior extremities even, sometimes

* 'Infusionsthiere,' Abth. iii., 1878.

subquadrate, its surface entirely smooth ; the anterior aperture produced as a short, tubular, obliquely projecting neck. Length 1–1200" to 1–750".

HAB.—Fresh water.

This species is identified by Stein with the *Lagenella euchlora* of Ehrenberg, and should apparently retain the specific title conferred upon it by the last-named authority. One example, Pl. XX. Fig. 19, as represented by Stein, has assumed a quiescent condition within its lorica, and become divided into two equal spheroidal moieties.

Trachelomonas cylindrica, Ehr. PL. XXI. FIG. 20.

Lorica elongate, cylindrical, about three times as long as broad, entirely smooth, anterior aperture plane or produced as a short tubular neck; colour crimson or purple. Length 1–1000". Hab.—Fresh water.

The *Trachelomonas nigricans* of Ehrenberg, coinciding in general form, but having the lorica coloured a deep reddish or blackish brown, is regarded by Perty as an older condition only of the present species.

Trachelomonas hispida, Pty. sp. PL. XXI. FIGS. 21–23.

Lorica evenly ovate or elliptical, from a little over one and a half to nearly two and a half times as long as broad, the entire surface finely and evenly hispid; anterior aperture plane or forming a short cylindrical neck; walls of peripheral border scarlet or crimson. Length 1–1150" to 1–600".

HAB.—Fresh water.

This species is identified by Stein with the *Chætoglena volvocina* of Ehrenberg and with the *Chonemonas hispida* and *C. Schrankii* of Max Perty. It is necessary to remark, however, that the enclosed animalcule is represented by Perty as having two long, equal-sized flagella, as in *Eutreptia*, instead of a single one as figured by the first-named writer. The lorica of this type is susceptible of a very considerable range of variation, it, in addition to the two contours mentioned in the foregoing diagnosis, being sometimes supplemented, as in *T. caudata* and *T. acuminata*, with a short, conical, tail-like prolongation. The empty shell has been observed by both Stein and Perty to be finely striate obliquely in cross directions, the intersection of these lines communicating to the entire structure a reticulate appearance.

Trachelomonas eurystoma, Stein. PL. XXI. FIG. 27.

Lorica ovate, bluntly pointed posteriorly, about one and a half times as long as broad, surface smooth, anterior aperture comparatively wide, slightly projecting, its edges crenulate. Length 1–812".

HAB.—Fresh water.

Trachelomonas armata, Ehr. sp. PL. XXI. FIG. 25.

Lorica broadly ovate or elliptical, about one and a quarter times as long as wide; ten or twelve long claw-like spines projecting from the posterior margin, and a number of short conical ones sometimes disposed around the short tubular anterior aperture; the intervening area smooth; the free edge of the short neck-like projection sometimes finely toothed; colour brown. Length, excluding the posterior spines, 1–650".

HAB.—Fresh water.

This animalcule is identified by Stein with both the *Chætotyphla armata* and *C. aspera* of Ehrenberg. As in many other species of the genus, the lorica presents a wide range of individual variation, this being manifested most prominently in connection with the more or less extensive development of the spinous processes.

Trachelomonas caudata, Ehr. sp. PL. XXI. FIG. 24.

Lorica elongate-ovate or flask-shaped, two or three times as long as broad, tapering posteriorly and further produced into an acuminate tail-like process, the anterior aperture developed in a neck-like manner, its free margin everted and deeply toothed; the entire surface, exclusive of the anterior and posterior prolongations, finely and densely hispid. Length 1–864″ to 1–480″. Hab.—Fresh water.

This species is identified by Stein with the *Chætoglena caudata* of C. G. Ehrenberg.

Trachelomonas bulla, Stein.

Lorica elongate-ovate, from two and a half to three times as long as broad, produced anteriorly into a conical, neck-like prolongation; the surface entirely smooth or beset with minute hispid points which are both finer and less thickly distributed than in *T. hispida* and *T. caudata*. Length 1–500″ to 1–430″. HAB.—Fresh water.

Trachelomonas acuminata, Schm. sp. PL. XXI. FIG. 26.

Lorica obovate or flask-shaped, inflated and widest posteriorly, supplemented in that region by an acuminate and somewhat irregular tail-like process, the anterior extremity produced into a cylindrical, moderately large, obliquely-truncate, neck-like prominence, the surface entirely smooth throughout. Length 1–500″. HAB.—Fresh water.

This animalcule was originally described by Schmarda under the title of *Lagenella acuminata*, and is refigured and referred to the present generic group by Stein.

Doubtful Species.

Pritchard's 'Infusoria' includes the briefest possible diagnosis of two additional species of *Trachelomonas* as follows, and without any reference to their original describers:—

"*T. areolata*, globose, surface areolated.

"*T. aspera*, similar to the preceding, but its surface covered with rough points."

GENUS VI. RAPHIDOMONAS, Stein.

Animalcules free-swimming, monoflagellate, moderately contractile; oral aperture terminal, conducting to a well-defined pharyngeal chamber; cuticular layer enclosing a large number of variously distributed trichocysts; contractile vesicle and endoplast conspicuous; colour green.

This genus is founded by Stein on the *Monas semen* of Ehrenberg; excepting for the presence of numerous and variously distributed trichocysts it closely resembles *Cœlomonas*.

Raphidomonas semen, Ehr. sp. Pl. XX. Figs. 60–62.

Body elongate-ovate, flexible and somewhat variable in form, usually rounded and widest anteriorly, tapering and slightly attenuate posteriorly, from two and a half to three times as long as broad; flagellum scarcely equalling the body in length, issuing from the anterior oral fossa; pharyngeal chamber subtriangular or lunate, transversely placed; contractile vesicle single, anteriorly situated; endoplast large, ovate, subcentral; endoplasm green; trichocysts most abundant along the anterior margin. Length 1–575″ to 1–400″.

Hab.—Marsh water, among decaying *Sphagnum*; movements sluggish, vacillating.

As originally described by Ehrenberg under the title of *Monas* (?) *semen*, this species is distinguished by the presence of a peculiar triquetrous structure beneath the frontal border, by the enclosure within its substance of numerous minute spicular bodies, and by its apparent possession of fine vibratile cilia. As now shown by Stein * the first-named structure represents a capacious subtriangular pharyngeal excavation, which communicates with the oral aperture and is homologous with the still more conspicuous spheroidal one possessed by *Cœlomonas grandis;* the presumed cilia he has further demonstrated to coincide with the anteriorly placed trichocysts in their exserted state, as shown at Pl. XX. Fig. 61. In their more normal retracted condition these trichocysts—coinciding with Ehrenberg's spicular bodies—present the aspect of simple minute bacillar bodies which underlie, as an even and closely set row, the entire frontal border, and are found distributed irregularly and in various degrees of abundance throughout the remaining body area. Although not taking the form of evenly distributed lines in the last-named region, they appear from Stein's figures to maintain mostly a uniform longitudinal disposition. Mereschkowski's genus *Merotricha*, see p. 249, would appear to represent the only other Flagellate animalcule to which the existence of trichocysts has been accurately demonstrated, though, in accordance with the recent investigations of O. Bütschli, there is reason for believing that analogous structures are possessed also by *Chilomonas paramecium*. In neither instance, however, have they been shown to possess a distinct capacity of extension and retraction, as is recorded by Stein of *Raphidomonas*.

Genus VII. CŒLOMONAS, Stein.

Animalcules free-swimming, monoflagellate, highly contractile and variable in form, having a distinct anterior oral aperture, which conducts to a capacious subspheroidal pharyngeal chamber; endoplast and contractile vesicle conspicuous, no trichocysts. Inhabiting fresh water.

This genus is founded by Stein † on the *Monas grandis* of Ehrenberg, its distinctive feature being the capacious pharyngeal chamber, usually filled with a fluid substance, that follows upon the well-developed oral cleft. While a somewhat similar pharyngeal excavation is developed in both *Raphidomonas* and *Microglena*, it does not in either of these latter types attain the proportions characteristic of the present genus. More correctly, perhaps, this so-called "body-cavity," or "*Leibeshöhle*" as it is designated by Stein in his index to the various figures given, may be compared with the vestibular fossa of *Vorticella* and other Peritricha, the resemblance in contour between these structures being more particularly prominent in the type previously described under the title of *Raphidomonas semen*.

* 'Infusionsthiere,' Abth. iii., 1878. † Ibid.

Cœlomonas grandis, Ehr. sp. Pl. XX. Fig. 59.

Body highly contractile and variable in form, regularly or irregularly elongate-ovate or subspheroidal, pharyngeal dilatation occupying nearly the entire anterior half of the body; flagellum short, not equalling the body in length; cuticular layer enclosing innumerable golden-green chlorophyll-granules; contractile vesicle single, anteriorly situated; endoplast spheroidal, subcentral. Length 1–430″.

Hab.—Marsh water; movements sluggish.

This species, as previously intimated, is identical with the *Monas grandis* of Ehrenberg.

Genus VIII. ASCOGLENA, Stein.

Animalcules solitary, monoflagellate, highly elastic and changeable in shape, enclosed within a sessile tubular or flask-shaped lorica, to the bottom of which they adhere by the posterior extremity; endoplasm coloured green, enclosing an anterior eye-like pigment-spot; oral aperture and contractile vesicle as in *Euglena*. Inhabiting fresh water.

The representatives of this genus may be described as *Euglenæ* which secrete and inhabit sessilely attached loricæ and hold in their family group a position corresponding with that occupied by *Vaginicola* as compared with *Vorticella* among the Vorticellidæ, or that of *Salpingœca* with relation to *Monosiga* among the Choano-Flagellata.

Ascoglena vaginicola, Stein. Pl. XXI. Figs. 28 and 29.

Lorica erect, tubular, subcylindrical, rounded and widest posteriorly, tapering gradually towards the anterior aperture, about three times as long as broad, its consistence finely granular with a somewhat more transparent anterior border; animalcule clearly visible through the walls of the lorica, Euglena-like and highly contractile, its distal extremity when extended reaching to the anterior aperture; dividing within the lorica by transverse fission. Height of lorica 1–640″. Hab.—Fresh water.

Genus IX. COLACIUM, Ehrenberg.

Animalcules monoflagellate, exhibiting two distinct phases of existence, the one free-swimming and the other sedentary: in the motile stage solitary, highly elastic and changeable in form, and in all essential details corresponding with simple free-swimming *Euglenæ;* in the sedentary stage affixed socially, mouth downwards, to a simple stalk or to the extremities of a more or less elevated branching pedicle or zoodendrium, which is produced by the repeated longitudinal fission of a single primary zooid; endoplasm coloured green, enclosing an anterior eye-like pigment-spot; oral system, endoplast, and contractile vesicle, as in *Euglena.* Inhabiting fresh water.

The several species referred to the genus *Colacium*, as originally instituted by Ehrenberg, are not represented as possessing any distinct flagelliform appendage, though the presence of one or more such organs was suspected by him through the observation of almost constantly recurring currents in the surrounding water. The practical demonstration of the possession by these animalcules of a single terminal flagellum, of their enjoyment of a solitary free-swimming and social colony-building existence, and of their entire structural correspondence during the former phase with the zooids of the genus *Euglena*, was arrived at by the author in the winter of the year 1877, in connection with the *Colacium stentorinum*, in part, of Ehrenberg, and the new species here described under the title of *C. Steinii.* The observations then made are substantially confirmed by Stein's figures and accompanying indices, illustrating other allied species, published in November 1878. Certain points observed by the author have, however, apparently escaped the attention of Professor Stein, and are now recorded for the first time. Chief among these it must be mentioned that in no instance does that authority indicate the possession of a flagellum by any members of the sedentary colony-stocks, the animalcules, according to his figures, after their first attachment losing this organ, and their offspring produced by repeated longitudinal fission of the primarily attached zooid, which remains affixed to the extremities of the branching pedicle, not developing any flagellate appendage. As shown, however, in the author's account and illustrations of the species quoted, the flagella are developed, though difficult to detect, by both the motile and sedentary zooids, disappearing through absorption as a preliminary only to the act of encystment and sporular reproduction.

The two cycles of existence manifested in the representatives of this genus find, with the exception of *Chlorangium*, no parallel among the entire class of the Infusoria. As in both the sedentary and motile conditions the reproductive faculties would appear to be represented—the power of multiplying by ordinary fission being retained by the natatory zooids—this generic group may be further cited as undoubtedly yielding a novel instance of the interesting phenomenon of the alternation of generation. Whether genetic reproduction, accomplished by the conjugation of two independent zooids, obtains during the sedentary or natatory phases, is an interesting problem that yet awaits solution. The remarkable fixation of the locomotive zooids of *Colacium* by their oral end, and development into stalked sedentary organisms, in which the characteristics of their natatory phase are almost completely masked, will scarcely fail to recall to mind the singular and somewhat parallel metamorphoses exhibited by the Cirrhipede Crustacea.

Colacium arbuscula, Stein. PL. XXI. FIG. 33.

Sedentary zooids elongate-ovate, about twice as long as broad when extended, shortly pyriform or subglobose when contracted, grouped at about the same level at the extremities of a slender, erect, smooth and even, dichotomously branching pedicle, the basal stem of which equals or considerably exceeds the height of an extended zooid, the secondary and succeeding ramifications being shorter; parenchyma enclosing comparatively few largish ovate chlorophyll-corpuscles. Length of bodies 1–1000″ to 1–800″; height of adult colonies 1–250″.

HAB.—Fresh water, on Rotifera.

The examples of this species figured by Stein* are represented as attached to the Rotifer *Anuræa fissa* of Mr. P. H. Gosse. No less than two adult colonies, bearing respectively six and eight zooids, and four smaller ones, are thus shown growing upon one specimen of this minute rotifer, whose movements in the water must have been much impeded by the accession of a living burden whose total bulk considerably exceeded that of its own body. No illustrations are given or references made to the free-swimming zooids of this type.

* 'Infusionsthiere,' Abth. iii., 1878.

Colacium calvum, Stein. PL. XXI. FIGS. 30–32.

Sedentary zooids elliptical or oblong, about two and a half times as long as broad, of even width throughout, scarcely rounded and almost square at the two extremities, elevated at an even altitude upon a very short, thick pedicle, the main stem and subsequent subdivisions of which do not equal a total height of one-half that of a single zooid; motile zooids highly contractile and variable in form, usually widest anteriorly; endoplasm, with the exception of a clear, cap-like, longitudinally striate, anterior area, enclosing numerous, minute, spherical chlorophyll-corpuscles, each with a central nucleus-like point; contractile vesicle large, communicating freely with the tubular pharynx; endoplast conspicuous, situated in the median line at a distance of one-third of the length of the body from the posterior extremity. Length of sedentary zooids 1–500".

HAB.—Fresh water, mostly forming small colonies of two or four zooids only.

Colacium vesiculosum, Ehr. PL. XXI. FIGS. 34–38.

Sedentary zooids subfusiform, about two and a half times as long as broad, tapering towards each extremity, but more attenuate posteriorly when extended, pyriform and widest anteriorly when contracted, seated at the same level at the summit of a short, slender, and often transversely wrinkled, branching pedicle, the entire height of which scarcely equals one-half of that of an extended zooid; motile zooids Euglena-like, variable in form. Chlorophyll-corpuscles of endoplasm oval, numerous and equally distributed. Length of sedentary zooids 1–800".

HAB.—Fresh water, on *Cyclops* and other Copepodous Crustacea; colony-stocks including from two to eight animalcules.

Colacium Steinii, S. K. PL. XXI. FIGS. 39–41.

Sedentary zooids elongate-ovate, about two and a half times as long as broad when extended, globose, pyriform, or subnapiform, with an inflated central and conically projecting anterior and posterior prolongation when contracted; pedicle branching irregularly or subdichotomously, bearing the zooids at different heights and attaining an altitude equal to two or three times that of an extended animalcule; motile zooids Euglena-like, variable in form; endoplasm enclosing numerous, evenly distributed, ovate chlorophyll-corpuscles. Length of sedentary zooids 1–900".

HAB.—Fresh water, on a species of *Cyclops*.

In the general contour of the extended zooids and comparative altitude of the supporting pedicle, this species corresponds considerably with *C. arbusculum*. It may be distinguished from it, however, by the more or less irregular instead of even dichotomous divarication of the secondary branches and by the elevation of the animalcules at diverse instead of corresponding heights. During their contracted state the napiform contour referred to in the diagnosis is of common occurrence, but does not, from Stein's figures, appear to be assumed by either of the preceding types. While this last-named contour is the most characteristic, innumerable other shapes are from time to time assumed, the parenchyma and cuticle being remarkably soft and plastic, and the animalcules, as observed by the author, being exceedingly restless, continually elongating or shortening their outline, and twisting to and fro upon their pedicles. As previously intimated, it was in connection with this species that the possession of flagellate appendages by the sedentary zooids was determined. On several occasions these sedentary individuals were seen to detach themselves from the branching pedicle and swim freely in the water after the manner of *Euglenæ*, while in other instances they were observed to absorb their flagella and form ovate encystments whose enclosed contents broke up into innumerable spore-like bodies. The rupture of these encystments and the liberation of their contents as simple non-flagellate germs were likewise witnessed. The author is inclined to believe that the *Colacium stentorinum* of Ehrenberg embraces two distinct forms, one with short, acuminate branches and attenuate, fusiform, biflagellate, sedentary zooids of a dull green hue, corresponding with the *Chlorangium stentorinum* of Stein, and another with bluntly ovate, bright green, uniflagellate animalcules forming variously shaped bush-like growths, that corresponds probably with the present species. The examples of *Colacium Steinii*, as here figured and described, were found on a species of *Cyclops* taken from a pond near Acton in December 1877.

Supplementary Species.

An animalcule most nearly resembling *Colacium calvum* in external shape, but of much more minute size—the length of the sedentary zooids not exceeding the 1–1300″, and that of the extended natatory ones the 1–1000″—has been recently obtained by the author attached to the carapaces and limbs of a species of *Cyclops* inhabiting pond-water from brickfields near Shepherd's Bush, London. In no case, however, out of the numbers so far examined, was more than a single animalcule found attached to one pedicle. The contour of these sedentary examples, while quadrate, was, moreover, much more irregular, the distal or free margin being much broader than the proximal one or that which is united to the pedicle. More usually from two to four scarlet eye-like pigment-spots were developod in place of the single one characteristic of the species previously described, while the chlorophyll-corpuscles were of much larger proportionate size, and leaving comparatively small interspaces in the exposed periphery. Pending further investigation it is proposed to provisionally distinguish this type by the title of *Colacium multoculata.* The possession of a flagellum by the sedentary zooids was amply demonstrated.

Fam. IV. NOCTILUCIDÆ, S. K.

Animalcules free-swimming, bounded by a distinct external membrane or cuticle, the contained endoplasm highly vacuolar, forming a variously modified protoplasmic network; oral aperture distinct, associated with a single vibratile flagellum, to which may be added a prolonged tentaculiform appendage. Habits pelagic, often phosphorescent.

Professor Haeckel* has proposed to elevate the most prominent and, up to within a comparatively recent date, only known generic form referable to the present family group, to the rank of a separate order of the Protozoa, or rather of his so-called "Protista," to be designated the Cysto-Flagellata. The affinities of the type in question, *Noctiluca*, with the more ordinary representatives of the Stomatode Flagellata are, however, so obvious that any such isolation of it cannot be consistently maintained. A closely identical reticulate character of the endoplasmic layer, chiefly distinctive of this form, is met with among various ciliate and flagellate Infusorial types, including such genera as *Trachelius*, *Loxodes*, and *Callodictyon*, while the non-essentiality of the caudiform tentaculate appendage is demonstrated by its entire absence in Hertwig's recently discovered and closely allied genus *Leptodiscus.*

* 'Natürliche Schöpfungsgeschichte,' Berlin, 1868.

GENUS I. NOCTILUCA, Suriray.

Animalcules free-swimming, subspherical, consisting of a smooth, hyaline investing pellicle and an internal protoplasmic mass, which radiating in every direction from the centre of the body, spreads itself in a thin peripheral layer over the inner surface of the bounding membrane; the oral aperture situated at the base of a subcentral infundibulate pit-like depression, the single slender vibratile flagellum originating from within its cavity; a supplementary long, flexible, and elastic tentaculiform appendage arising close to and overhanging the oral fossa. Endoplast conspicuous; no contractile vesicle as yet observed. HAB.—Salt water.

It has been suggested that the tentacle-like appendage in this generic type finds its homologue in the frequently larger trailing flagellum or gubernaculum of *Anisonema* and its allies, and under which circumstances the rightful position of the form would be among the Dimastigous section of the present group. Having respect, however, to the new generic group *Leptodiscus*, in which there is no such appendage, the author is disposed rather to regard this last-named structure as an entirely adventitious growth. Further investigation may not improbably establish a bond of affinity between *Noctiluca* and the correspondingly pelagic Peridiniidæ, certain of which, such as *Gymnodinium*, are devoid of an investing cuirass, while many are notable in a like manner for their phosphorescent properties.

Notiluca miliaris, Suriray. PL. I. FIGS. 34–44.

Body hyaline, peach-shaped, somewhat compressed, with a distinct meridional groove; oral fossa situated at one extremity of the meridional groove, having on one side a hard, tooth-like, projecting ridge, close to one end of which the vibratile flagellum takes its origin; tentaculate appendage transversely striate, its length about equal to the diameter of the body; a narrow ridge or rod-like induration of the cuticular membrane extending in a straight line from the aboral extremity of the meridional groove through about one-third of the circumference of the body, and there terminating abruptly. Endoplast oval, subcentral. Diameter 1–80″ to 1–20″.

HAB.—Pelagic, cosmopolitan; eminently phosphorescent.

As remarked by Professor Allman, there is perhaps no one of the phosphorescent animals as yet known to science that possesses such highly luminous properties as *Noctiluca miliaris*. To the presence of this animalcule in countless myriads upon the upper stratum of the water on calm summer nights is due especially that diffused form of phosphorescence that is more essentially characteristic of temperate latitudes. Under the most favourable of these conditions the waves falling upon the strand leave as they retreat a glittering carpet of scintillating points, the oars of the passing boat seem to dip as it were into molten silver, while on the high seas the waste of waters churned into foam by the revolving screw or paddles of the steam-vessel leaves in its wake a broad luminous track as far as the eye can reach. A glassful of water taken from the surface of the sea at such times immediately reveals the origin of this wonderful phenomenon; here and there will be seen floating minute, bladder-like, transparent spheres, resembling as nearly as possible small granules of boiled sago, and which exhibit on closer investigation with the microscope, the structural characters given in the foregoing diagnosis. Irritated by agitation in any shape or form they at once respond by, as it were, angry flashes of silvery greenish light, and it is to the coruscations in their aggregate condition of millions of these minute bodies that the several phenomena above recounted are produced. One other manifestation of pelagic phosphorescence dependent upon the presence in countless numbers of this same tiny protozoon, may be suitably recorded in these pages. By those accustomed to a seafaring life, the sight on nights when the luminosity of the sea is most conspicuous, of fish following or darting away from the sides of the vessel, apparently themselves aglow with phosphoric light, and leaving behind them, in accordance with their size, a more or less conspicuous luminous path in the murky waters, is frequently recorded. It is commonly supposed that such form of luminosity is emitted by the fish themselves, but on closer investigation it will be found that this also is due to the presence of the animalcules now under discussion, and which are disturbed into a sudden display of their phosphoric properties by the passage of the fish through their midst. This light is reflected as from a mirror by the glistening scales of the larger animal, while the *Noctilucæ* remain scintillating for some few moments in the path through which the fish has passed, thus producing the more or less conspicuous tracks of light which are left in its wake.*

The special seat of the phosphorescent properties of *Noctiluca miliaris* is presumed to be the peripheral protoplasmic layer lying immediately beneath the surface of the cuticle. This supposition is favoured by adding a small drop of alcohol to the water containing a living specimen while examined under the microscope. In place of the momentary flash of light emitted under ordinary disturbance, the little creature now exhibits its luminosity with the fullest intensity for several seconds. At the end of that time it commences to gradually disappear, and before becoming finally extinct with the life of the animalcule, presents the aspect of a mere luminous ring upon the dark background of the field of the microscope. This last phenomenon is pointed out by Professor Allman as indicating that the phosphoric properties are confined to the peripheral portion, the light when the annular appearance is presented having become so weak as to be appreciable only towards the edges of the projected sphere, and where necessarily a greater depth of the luminous stratum lies in the direction of vision. On the other hand, there appears to be no appreciable differentiation between the protoplasmic stratum beneath the cuticle and the central or radiating portions, and it is difficult to reconcile this fact with the presumed limitation of the phosphoric property. It would seem an open question, indeed, whether the last peripheral scintillations of the dying *Noctiluca* are not directly comparable with the phenomena exhibited by a burning paper in which the flame, having no longer any pabulum to support its volume, leaves upon its departure a multitude of coruscating sparks which, animated by a mysterious and irresistible centrifugal force, hurry or creep out as it were from the centre and become extinct only on reaching the periphery. If the substance of the charred paper reflected and transmitted instead of absorbed light, as is apparently the case with the smooth cuticle of *Noctiluca*, the last appearance presented in this instance also, presuming the paper was circular, would be that of a luminous ring.

The process of reproduction in *Noctiluca* has been successfully followed by Cienkowski.† Transverse fission after the manner common to almost all the Infusoria, attended by an enlargement and division of the central nucleus or endoplast, is of common occurrence. During this process the animalcule retains its normal contour or assumes a spheroidal or semi-encysted form, in which all traces of the tentacle, tooth-like process and cilium, and meridional groove entirely disappear, presenting, indeed, under such circumstances so distinct an aspect as to have been frequently and even quite recently (*vide infra*) mistaken for a separate organism. In connection with this spheroidal condition, a process of multiplication is recorded by Cienkowski that has not been previously observed. In this instance the central endoplast disappears and the protoplasmic contents of the cyst, collecting to one spot on its inner surface,

* A fuller reference to this special form of marine phosphorescence, as witnessed by the author in the Bay of Biscay, is contained in an article on "Phosphorescence in Fish," published in 'Nature,' vol. vii., for the year 1872.

† 'Archiv f. Mikroskopische Anatomie,' Band vii. Heft ii., 1871, and Band ix. Heft i., 1872.

become separated by binary segmentation into at first two and then consecutively four, eight, sixteen, thirty-two, or more masses in a manner corresponding precisely with what has been previously described of many ordinary Flagellata. The cuticular surface next becomes nodular to adapt itself to the contour of the subjacent segment-masses, and these at length penetrating through the cuticle, remain attached for a short while on its external surface, developing there a long flagelliform appendage, and become ultimately detached as simple monadiform germs. The germs or daughter-cells, thus developed, are usually aggregated in a discoidal or cake-like form at one pole of the exterior surface, as shown at Pl. I. Figs. 35 and 37, but sometimes take a more loosely reticulate arrangement, Fig. 36, or may form an equatorial girdle around the parent envelope. A considerable variety of contour is exhibited by these germs. In their most typical aspect, Pl. I. Figs. 39 and 40, they are somewhat conical, with a rostrum-like process—which apparently represents the rudimentary condition of the subsequent rod-like induration of the cuticle—are divided by an annular groove into an anterior and posterior region, and have a short, tongue-like appendage and a long, flexible, lash-like flagellum. In another and probably earlier state the germ is a simple spheroidal sac with or without the lash-like flagellum, Figs. 37 and 38.

The conjugation of adult *Noctilucæ* in either their normal or spheroidal state has been frequently observed, and is manifested in the first instance by the close apposition of their respective oral surfaces. The tentaculiform appendages are then cast off, the two endoplasts become united by a bridge of endoplasm, and the two bodies gradually coalescing, Fig. 44, are within the space of five or six hours indissolubly fused together. This process, though evidently requisite for the occasional rejuvenation of the reproductive functions, is apparently not a necessary precedent to each reproductive act. The recuperative properties possessed by this animalcule are somewhat remarkable; a crushed or otherwise mutilated zooid withdraws its flagellum, and after contracting into an irregular protoplasmic mass, develops a fresh cuticular investment, while the smallest portion of sarcode, separated from the parent, is capable of growing into a perfect zooid. The food of *Noctiluca* consists chiefly of the floating Diatomaceæ which occur in such abundance upon the upper stratum of the ocean, numerous varieties of which will frequently be found entangled within the internal radiating protoplasmic network. Elaborate and masterly accounts of the leading structural features of this highly interesting type, which have served as a basis for the foregoing technical diagnosis, have been contributed by Professors T. H. Huxley and G. J. Allman to the 'Journal of Microscopical Science' for the years 1855 and 1872.

There can be but little doubt that the organism figured by Professor Sir Wyville Thompson in the 'Proceedings of the Royal Society,' vol. xxiv., pl. 21, 1876, as a new diatom under the title of *Pyrocystis pseudonoctiluca*—his illustration of the same being reproduced at Pl. I. Fig. 45—represents the normal encysted condition of *Noctiluca miliaris* as previously described by numerous investigators, and notably by Johannes Müller, as translated in the 'Journal of Microscopical Science' for 1855. The account there given runs as follows:—"These encysted bodies constituted the principal luminous animalcules observed at Messina in the autumn of 1853. Free *Noctilucæ* at that season were not seen there; and in 1849 the same kind of encysted bodies were very common at Nice. The cyst is a perfectly transparent, spherical capsule, with a light-bluish brilliancy at the edge, and appearing like the egg-membrane of some Crustacea. Within the cyst is lodged a body in all respects resembling *Noctiluca miliaris*, except that at this time no vibratile filament can be perceived. The *Noctiluca*-like creature fills the cyst more or less entirely, though occasionally it is much smaller. In this condition the animalcules are luminous without being agitated." Professor Wyville Thompson's second species, distinguished by the title of *Pyrocystis fusiformis* (Pl. I. Fig. 54), represents apparently a similar quiescent phase of *Leptodiscus medusoides*, next described. It is a remarkable circumstance, and one perhaps not altogether worthy of congratulation, that, excepting for a passing notice of the occurrence of Peridiniidæ in certain latitudes, the very existence even of the important and highly interesting organic group described in this treatise, was completely ignored by the talented staff of the 'Challenger' expedition, its representatives indeed, when encountered, as in the present instance, being unrecognized and referred to the vegetable series. It is to be hoped that the opportunities for acquiring a further knowledge of the morphology and distribution of the hitherto little known or altogether unchronicled pelagic Infusoria will not be neglected in the future scientific expeditions of a like kind that may be organized by this country. It may be confidently anticipated that in this field alone new and interesting forms remain to be discovered, that surpass in number and variety the by no means inconsiderable series that are already known to science.

GENUS II. LEPTODISCUS, Hertwig.

Animalcules free-swimming, more or less flattened or discoidal, having, as in *Noctiluca*, a hyaline investing pellicle and an internal, radiating or reticulate, protoplasmic layer; oral aperture situated at the base of a tubular pit-like excavation; a long, lash-like, vibratile flagellum issuing from the entrance to the adoral fossa; no supplementary tentaculate appendage; endoplast conspicuous; no contractile vesicle as yet detected.

HAB.—Pelagic.

R. Hertwig,* the original discoverer of the single known member of this genus, is inclined to regard it as the type of a family distinct from *Noctiluca*. The various structural details, excepting for the absence of the transversely annulate tentaculate appendage, correspond however so closely with those of the latter type that its complete separation from it seems scarcely justified.

Leptodiscus medusoides, Hertwig. PL. I. FIGS. 46–53.

Body very much flattened, meniscoidal and orbicular, highly flexible, thickest in the centre and gradually tapering towards the periphery; oral fossa subcentral, opening on the convex surface, descending obliquely through the entire thickness of the body to the protoplasmic lining of the opposite bounding membrane; flagellum slender, vibratile, its length equal to less than one-fourth of the diameter of the disc, inserted close within the entrance to the oral fossa; endoplast oval, subcentral, consisting of a larger granular and smaller transparent region; a number of minute, spherical, oil-like globules immediately underlying the upper and convex cuticular layer. Diameter of largest individual 1–4″.

HAB.—Pelagic: Messina.

The close resemblance of the adult zooids of this singular species to minute jelly-fish (Medusæ) is very remarkable, their large size, as represented without the aid of magnifying power at Pl. I. Figs. 46 and 47 further supporting this analogy. Hertwig figures as the supposed young of *Leptodiscus* some organisms that differ altogether from the parent. These bodies, Pl. I. Figs. 52 and 53, are of more elongate outline, flattened and somewhat cushion-shaped, with a central, transversely annular constriction; there is no flagellate or other appendage, the endoplast is central, oval, and granulate throughout, and represents the point from whence the internal protoplasmic reticulations chiefly radiate, as in the adult form. The mode of natation in these hypothetic non-adult zooids is exceedingly remarkable, being effected, according to Hertwig, by the alternate contractions of the internal protoplasmic radii on each side of the central annular constriction, this contraction in

* "Ueber *Leptodiscus medusoides*," 'Jenaische Zeitschrift,' Bd. xi., Nov. 1877.

each instance being so complete that the side affected by it presents a temporary aspect of complete collapse. This locomotive phenomenon, taken together with the very distinctive contour and structure of the organism as a whole, differs so essentially from *Leptodiscus medusoides* in its normal state that it is almost impossible to repress the suspicion that this more minute organism will eventually prove to belong to an independent and perfectly distinct pelagic type.

Section B.—EUSTOMATA-DIMASTIGA.

Fam. V. CHRYSOMONADIDÆ, S. K.

Animalcules bi-flagellate, rarely monoflagellate, social or solitary, free-swimming or adherent, naked, loricate, or immersed within a common mucilaginous matrix or zoocytium; endoplasm always containing two lateral, occasionally green, but more usually olive-brown or yellow, differentiated pigment-bands; one or more supplementary eye-like pigment-spots frequently present.

The considerable series of genetic types assembled in this newly proposed family group are at once recognized by the presence of the characteristic lateral pigment-bands, these elements being here held to be of such primary import as to override the fact that in the first three genera described a single flagellum only has as yet been detected. The colour-bands in question, in addition to their distinctive tint, are apparently of firmer consistence than the surrounding transparent protoplasm, and bear a very considerable resemblance to the endochrome or colouring matter of the Diatomaceæ. The development of these pigment-bands, though constant among zooids of the same species, varies considerably among different generic and specific forms, being symmetrical or unsymmetrical, and produced either in whole or in part only down the lateral borders of the animalcule's body. While until recently the affinities of these animalcules were accepted as closely approximate to that of *Volvox*, *Protococcus*, and other undoubted Protophytes, the most recent researches of Stein, in combination with the independent investigations of the present author, have substantiated in many instances—as, for example, the genera *Dinobryon*, *Uroglena*, and *Chrysomonas*—their undoubted animal organization. So far as at present known, all the members of this family are inhabitants of fresh water.

GENUS I. CHLOROMONAS, S. K.

(Greek, *chloros*, green; *monas*.)

Animalcules more or less ovate, solitary, free-swimming, persistent in shape, flagellum single, terminal; endoplasm enclosing two differentiated lateral pigment-bands, and usually an anterior eye-like pigment-spot.

This new genus is instituted for the distinction of the form identified by Stein with the *Cryptoglena pigra* of Ehrenberg, but which, as presently explained, differs essentially from the typical *Cryptoglenæ* in the possession of the characteristic colour-bands and of a single flagellate appendage.

Chloromonas pigra, Ehr. sp. PL. XXII. FIGS. 1 AND 2.

Body ovate or conical, somewhat compressed, pointed posteriorly, the cuticular surface indurated and presenting sharpened or keel-like lateral borders; pigment-bands bright green, extending evenly on each side throughout the length of the body; eye-like pigment-spot immersed within the substance of the anterior region of one of the lateral bands; oral aperture situated close to the flagellum, continued into a distinct though minute, tubular pharynx; contractile vesicle single, conspicuously developed, located centrally close to the termination of the pharynx; endoplast occupying the median line near the pointed posterior extremity. Length 1-3000". HAB.—Pond water; movements slow.

This species is identical with the *Cryptoglena pigra* of Ehrenberg and Stein, its departure from the type of the last-named genus being made manifest more especially by the two characteristic lateral colour-bands and by the possession of a single flagellum only. By the addition of a second flagellate appendage the present type would be rendered eligible for inclusion in the genus *Cryptomonas*, and would be scarcely distinguishable from the young of *C. ovata*, as shown at Pl. XXII. Fig. 18.

GENUS II. CHRYSOMONAS, Stein.

Animalcules free-swimming, illoricate, more or less ovate or elongate, but flexible and changeable in form; flagellum single, produced from the centre of the anterior border; oral aperture conspicuous, not followed by a distinct pharyngeal dilatation; endoplasm enclosing two lateral coloured bands and an anteriorly situated eye-like pigment-spot; contractile vesicle and endoplast conspicuous. Inhabiting fresh water.

This genus is founded by Stein * on the *Monas flavicans* of Ehrenberg. Excepting for the absence of the characteristic pharyngeal excavation, it would seem to closely approach *Microglena*.

Chrysomonas flavicans, Ehr. sp. PL. XXII. FIGS. 8 AND 9.

Body soft and plastic, variable in form, usually more or less elongate-ovate or subcylindrical, three or four times as long as broad; flagellum single, scarcely equalling the body in length; endoplasm enclosing two anteriorly produced lateral colour-bands, which do not extend to the posterior extremity, and a single eye-like pigment-spot; contractile vesicle single or double, spheroidal, and of large size, situated immediately beneath the insertion of the flagellum; endoplast minute, spherical, subcentral. Length 1-1720" to 1-600". HAB.—Ditch water.

In the figures of this species given by Stein one example is represented as having devoured a *Navicula* almost equalling itself in length, and another with two incepted Chlamydomonads. Multiplication, following upon a quiescent or encysted condition as delineated by the same authority, exhibits highly interesting phenomena, one zooid forming, as seen at Pl. XXII. Fig. 9, a spheroidal granular matrix, within which it divides, by repeated longitudinal fission, into as many as sixteen units, bearing under such conditions a considerable likeness, excepting for the absence of flagella, to the characteristic spheroidal colony-stocks of *Syncrypta* and *Uroglena*.

Chrysomonas ochracea, Ehr. sp. PL. XXII. FIGS. 3-7.

Body variable in form, ovate, elongate or subglobose; endoplasm clear, ochreous yellow; colour-bands centrally located, a single eye-like pigment-

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* 'Infusionsthiere,' Abth. iii., 1878.

spot usually developed; flagellum single, equalling or exceeding the length of the body; contractile vesicle single, anteriorly situated. Length 1-600" to 1-1200". HAB.—Fresh water.

This minute species is referred by Stein, with some doubt, to the *Monas ochracea* of Ehrenberg. Multiple fission within a comparatively large spheroidal cyst or capsule, closely corresponding with the reproductive process recorded of the type last described, as figured by the same authority, is reproduced at Pl. XXII. Figs. 5 and 7.

GENUS III. MICROGLENA, Ehrenberg.

Animalcules free-swimming, illoricate, plastic and changeable in form, usually more or less ovate or elongate; oral aperture distinct, anteriorly placed, communicating with a dilated pharyngeal cavity; flagellum single, terminal; endoplasm green or yellow, enclosing two supplementary longitudinally placed coloured bands and one or more eye-like pigment-spots; contractile vesicle and endoplast conspicuous. Inhabiting fresh water.

Microglena punctifera, Ehr. PL. XXII. FIG. 10.

Body somewhat variable in form, elongate-oval or obconical, widest and rounded anteriorly, tapering and bluntly pointed at the posterior extremity, about twice as long as broad; flagellum attenuate, vibratile, issuing from the oral aperture, scarcely equalling the body in length; pharyngeal cavity capacious, subspheroidal or pyriform; endoplasm yellow, the two lateral coloured bands produced through the entire length of the body; two minute red eye-like pigment-spots at the anterior extremity; contractile vesicles numerous, spheroidal, four or six in number, located around the border of the pharyngeal excavation; endoplast ovate, subcentral. Length 1-620" to 1-500". HAB.—Fresh water.

The diagnosis of this species, and also of the genus *Microglena*, is here amended in accordance with the figures given by Stein in the recently issued volume of his 'Infusionsthiere.' The following form not having apparently fallen under the notice of this authority, has associated with it an imperfect description formulated only upon the figures and brief description originally given by Ehrenberg.

Microglena monadina, Ehr.

Body shortly ovate or subspheroidal, evenly rounded at each extremity; flagellum equalling the body in length; endoplasm brilliant green, enclosing a single, anteriorly situated, scarlet, eye-like pigment-spot; pharyngeal excavation capacious; endoplast (?) band-like, subcentral. Length 1-2400" to 1-720". HAB.—Pond water; movements rotatory.

A very distinct band-like structure, apparently corresponding with the ovate endoplast of the preceding type, is indicated by Ehrenberg in the various figures given of this species, as also a large anterior pharyngeal excavation. By Pritchard it is recorded as occurring among slimy water plants in the neighbourhood of Hampstead and Finchley.

GENUS IV. CRYPTOMONAS, Ehrenberg.

Animalcules free-swimming, illoricate, persistent in form, more or less ovate or elongate ; flagella two in number, subequal, issuing from beneath a prominent, anterior, lip-like process ; oral aperture conspicuous, opening close to the base of the flagella, continued backwards as a distinct tubular pharynx; endoplasm enclosing two lateral, longitudinally placed colour-bands; contractile vesicle and endoplast conspicuous. Inhabiting fresh water.

The animalcules of this genus, excepting for the presence of the endoplasmic colour-bands, correspond in form and structure with those of *Chilomonas.*

Cryptomonas ovata, Ehr. PL. XXII. FIGS. 16–18.

Body elongate-ovate, compressed, usually narrowest and sometimes recurved towards the dorsal aspect posteriorly, about three times as long as broad ; oral aperture large ; pharyngeal passage conspicuous, tubular, continued backwards beyond the centre of the body ; colour-bands bright green, mostly developed on the dorsal and ventral aspects throughout the entire length of the body; contractile vesicle situated immediately above the commencement of the pharynx; endoplast posteriorly located. Length 1–600" to 1–400". HAB.—Fresh water, amongst *Confervæ.*

As shown by Stein's figures,* here reproduced, Pl. XXII. Fig. 18, the young of this species differ from the adults in possessing a flexible body and an acuminately pointed, recurved posterior extremity ; the characteristic colour-bands are also limited during the earlier stages of growth to two green, subcentral, ovate corpuscles, which gradually assume a band-like outline as growth progresses, and finally extend throughout the length of the body. In those adult individuals which possess a recurved posterior region, it is explained by Stein that the cuticular surface has become indurated while retaining more nearly the external contour of the embryonic stage ; these more exceptional examples which present a somewhat sigmoid flexure, have been described by Ehrenberg as a distinct species under the title of *Cryptomonas curvata.*

Cryptomonas erosa, Ehr. PL. XXII. FIGS. 19–21.

Body elongate-ovate, compressed, about twice as long as broad, the posterior extremity bluntly rounded, recurved slightly towards the ventral aspect; pharyngeal tube scarcely produced to the centre of the body; colour-bands light green ; contractile vesicle and endoplast as in *C. ovata.* Length 1–960". HAB.—Fresh water, among *Confervæ.*

This species may be distinguished from *C. ovata* by its shorter proportional length, smaller size, and ventral curvature of the posterior extremity. By Stein's figures it is shown to divide by longitudinal fission after the manner of *Chilomonas.* The nucleus or endoplast in both this and the preceding type exhibits reproductive phenomena corresponding with those presented by *Euglena* and *Phacus.* By concentration, around this structure, of the substance of the endoplasm, or through

* 'Infusionsthiere,' Abth. iii., 1878.

the extension of its own outer wall, it assumes a comparatively enormous size. Taking an ovate form it often—as shown at Pl. XXII. Fig. 19 *n*—occupies more than half of the cavity of the parenchyma, and ultimately divides by repeated fission into innumerable minute germs or microspores. By Stein this reproductive structure is denominated the germ-sac or germ-sphere ("*Keimkugel*"), but may perhaps be more appropriately distinguished as the sporosac.

GENUS V. NEPHROSELMIS, Stein.

Animalcules solitary, illoricate, free-swimming; flagella two in number, of diverse size, issuing from the centre of one of the lateral borders; endoplasm enclosing two lateral pigment-bands. Inhabiting fresh water.

Nephroselmis olivacea, Stein. PL. XXII. FIGS. 11–13.

Body subreniform, the dorsal border convex, the ventral one concave; the two flagella of unequal length, inserted close to each other in the centre of the concave ventral surface; coloured pigment-bands extending throughout the lateral peripheries; contractile vesicle situated close beneath the insertion of the flagella, two denser and apparently amylaceous corpuscles in the dorsal or posterior region. Greatest length or diameter of bodies, 1–1000″. HAB.—Fresh water.

In form, the animalcules of this species would seem to closely resemble those of the *Pleuromonas* of Perty, but are to be distinguished from them by the possession of an oral aperture, two flagella, and distinct pigment-bands. Practically, the subreniform contour of this type may be said to be produced by the thrusting-in of the anterior border of an ordinary ovate animalcule accompanied by the compensating dilatation of the lateral peripheries. An example of multiplication by longitudinal fission is represented in Stein's drawings of this species.

GENUS VI. STYLOCHRYSALIS, Stein.

Animalcules not secreting a protective lorica, attached separately to foreign objects through the medium of a stiff non-elastic pedicle; flagella two in number, subequal; endoplasm enclosing two lateral pigment-bands. Inhabiting fresh water.

Stylochrysalis parasita, Stein. PL. XXII. FIG. 22.

Body ovate, somewhat pointed at each extremity; supporting pedicle varying from the same length to twice the length of the body; lateral pigment-bands evenly developed; contractile vesicle single, posteriorly located. Length of body, without pedicle, 1–2500″.

HAB.—Pond water, attached to *Eudorina elegans.*

In the examples of this species as yet simply figured and not described by Stein, one animalcule is delineated as undergoing the process of multiplication by transverse fission, while in all the zooids a structure which may be an eye-like pigment-spot or an oral dilatation is placed at the anterior extremity.

GENUS VII. UVELLA, Ehrenberg.

Animalcules united by their posterior extremities and forming social, free-swimming, spheroidal colonies, the individual zooids not enclosed within a membranous lorica, nor the colony as a whole immersed within a common gelatinous matrix or zoocytium ; flagella two in number, subequal ; endoplasm containing two lateral colour-bands ; an eye-like pigment-spot present or absent. HAB.—Fresh water.

The non-possession of a separate membranous investment or lorica by the animalcules of this genus serves to distinguish it from *Synura.*

Uvella virescens, Ehr. PL. XXII. FIGS. 24–26.

Bodies elongate-ovate or clavate, their united posterior extremities attenuate and stalk-like ; flagella equal or subequal, exceeding the body in length ; lateral pigment-bands bright yellowish-green, extending on each side through almost the entire length of the body ; no conspicuous eye-like pigment-speck ; contractile vesicles two in number, posteriorly located ; endoplasm subcentral ; colony-stocks containing from five or six to as many as seventy or eighty zooids. Length of bodies 1–2000".

HAB.—Pond water.

The posterior location of the contractile vesicles, independently of the absence of separate loricæ, serves at once to distinguish the zooids of this species from those of *Synura uvella,* with which in their aggregate condition they may otherwise be readily confounded. The endoplast, although not distinctly exhibited under ordinary conditions, is, according to Bütschli,* at once defined by the application of Beale's carmine. Encysted individuals possessing a delicate or irregular outer coat and a denser internal one, were encountered by this authority both in connection with the motile colonies and with the isolated animalcules. Longitudinal fission according with that of the ordinary Flagellata was likewise noticed.

GENUS VIII. CHLORANGIUM, Stein.

Animalcules more or less ovate, persistent in shape, exhibiting two distinct phases of existence, the one motile and the other sedentary ; in the former instance possessing two evenly developed, anteriorly inserted, vibratile flagella ; in the latter condition non-flagelliferous, attached in social groups, mouth downwards, to a common pedicle ; endoplasm enclosing two lateral colour-bands ; contractile vesicle and endoplast conspicuous.

This genus is instituted by Stein for the reception of the *Colacium stentorinum* of Ehrenberg, which he reports as differing from the several species of *Colacium* previously described in the possession by the motile zooids of two flagellate appendages, a more or less firm and non-contractile cuticula, and in the development of two lateral coloured pigment-bands. Probably, as demonstrated by the present author in the case of *Colacium Steinii,* it will be ultimately shown that the flagella here also are retained during the sedentary condition.

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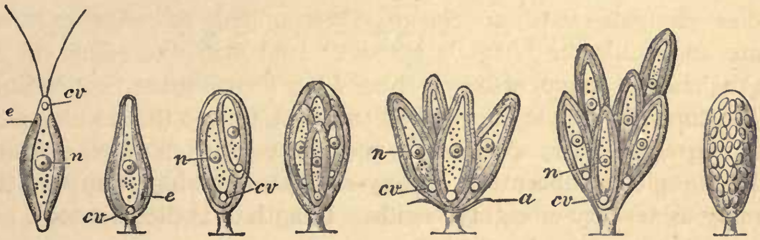
* "Studien über Flagellaten," 'Zeitschrift für Wissenschaftlicher Zoologie,' Bd. xxx., 1878.

Chlorangium stentorinum, Ehr. sp. WOODCUT, FIGS. 1–7.

Bodies elongate-ovate or subfusiform, about three times as long as broad; flagella terminal, subequal, not so long as the body; endoplasmic colour-bands bright green, produced throughout the whole extent of the two lateral borders, one of these including near its distal end an obscure eye-like pigment-spot; contractile vesicle situated at the anterior extremity, close to the insertion of the flagella; endoplast spherical, subcentral, attached during the sedentary condition to a short, simple, or slightly branching pedicle, in groups of from two or three to ten or twelve zooids. Length of zooids 1–1150″.

HAB.—Pond water, on various Entomostraca.



Chlorangium stentorinum, Ehr. sp.—1. Free-swimming biflagellate zooid; *c v*, contractile vesicle; *e*, eye-like pigment-spot; *n*, nucleus or endoplast. 2. Encysted zooid attached by a stalk-like prolongation of its anterior extremity. 3 and 4. Encysted zooids, with body-substance separated respectively into two and four segment-masses. 5. Further developed stage of the preceding example, in which the four segment masses having burst the cyst wall, remain attached distally to the parent pedicle; at *a*, residual portion of the primary cyst. 6. Adult sedentary colony-stock, produced through the further subdivision of the zooids represented in the preceding figure. 7. Single encysted zooid, whose body-mass has become subdivided into minute sporular elements. (After Stein, × 480.)

This species was first described by Ehrenberg under the title of *Stentor* (?) *pygmæus*, but is relegated in his subsequent work, 'Die Infusionsthierchen,' to the genus *Colacium*. The grounds upon which it has been found necessary to separate it from this last-named generic group, have been already indicated. The growth of the sedentary arborescent colony-stocks of this animalcule are produced, according to Stein's recently published volume, and as shown in the accompanying woodcut, by the endogenous subdivision of a primary attached zooid, whose cuticle finally bursting exposes the internally developed units, each with its anterior extremity firmly attached to the extremity of the parent pedicle. A portion of the posterior region of the parent cuticle frequently remains for a considerable interval embracing the base of the common stock and presenting, as seen in profile, Fig. 5*a*, the aspect of two lateral setose processes. Sporular multiplication, in which encysted zooids attached singly to their pedicles become divided up into a number of minute microspores, as shown at Fig. 7, is also placed on record by the authority just quoted. A distinct oral aperture has apparently as yet not been detected, but probably exists and corresponds with that possessed by *Colacium*.

GENUS IX. HYMENOMONAS, Stein.

Animalcules solitary, free-swimming, secreting a more or less flexible lorica; flagella two in number, subequal; lateral pigment-bands conspicuously developed; no eye-like speck; contractile vesicles anteriorly located. Inhabiting fresh water.

The possession of a flexible investing sheath or lorica and two flagellate appendages chiefly distinguishes this generic group from *Chrysomonas*.

Hymenomonas roseola, Stein. PL. XXII. FIGS. 14 AND 15.

Lorica ovate or ellipsoidal, soft and flexible, crenulate throughout its periphery, and assuming diverse contours in accordance with the change of form of the enclosed animalcule. Body of animalcule entirely filling the lorica, two yellow-brown pigment-bands extending evenly throughout the lateral margins. A large spheroidal fat-like or amylaceous body usually present in the posterior region; two contractile vesicles and a large vacuolar non-contractile space, possibly a pharyngeal sac, situated at the anterior extremity; no eye-like pigment-speck. Length of lorica 1–850″.

HAB.—Fresh water.

GENUS X. CHRYSOPYXIS, Stein.

Animalcules solitary, ovate or spheroidal, non-contractile, inhabiting a sessilely attached lorica, but not united to the same by a thread-like pedicle; flagella two in number, of equal length, produced from the centre of the frontal margin, this last-named region rounded and without any projecting lip-like prominence; endoplasm enclosing two lateral colour-bands, but no eye-like pigment-spot. Inhabiting fresh water.

The animalcules of this genus are distinguished from those of *Epipyxis* by their two equal-sized flagella, persistent form, and the absence of the connecting pedicle between the body and the lorica. The single species referred to it is further remarkable for the peculiar spur-shaped prolongations of the posterior border of the lorica, and which penetrating in a root-like manner into the cell-wall of the *Confervæ* to which they are usually attached, retain a close hold upon the same.

Chrysopyxis bipes, Stein. PL. XXII. FIGS. 28 AND 29.

Lorica ovate or shortly flask-shaped, rounded and widest posteriorly, with a narrow circular anterior orifice, the length but slightly exceeding the greatest breadth, two diverging and acuminate spur-like prolongations developed from the posterior border, these penetrating and hidden within the cellular substance of the plant to which it is attached; animalcules subspheroidal, occupying the posterior half of the cavity of the lorica, the two flagella projecting to a considerable distance beyond its orifice, diverging widely from one another; colour-bands brownish, produced throughout the two lateral borders; contractile vesicles one or two in number, posteriorly situated; dividing by longitudinal fission. Length of lorica 1–1600″.

HAB.—Fresh water, attached gregariously to confervoid algæ.

In his illustration of this species, Stein* indicates the presence of a presumed oral aperture at the anterior extremity, close to the insertion of the two flagella. Like *Epipyxis utriculus* the species is eminently social in its habits, a number of individuals usually occurring crowded together upon a single cell of a *Mougeotia* or other confervoid algal.

* 'Infusionsthiere,' Abth. iii., 1878.

Genus XI. EPIPYXIS, Ehrenberg.

Animalcules contractile, ovate or pyriform, inhabiting solitary, sessilely attached, erect, transparent loricæ, to the bottom or sides of which they are affixed by a contractile thread-like prolongation of the posterior extremity; flagella two in number, one short and the other long; endoplasm enclosing two longitudinal colour-bands and an anterior eye-like pigment-spot. Inhabiting fresh water.

The animalcules of this genus correspond essentially in general form and structure with those of *Dinobryon*, and are distinguished from them only by their secretion of solitary attached loricæ in place of a compound branching polythecium.

Epipyxis utriculus, Ehr. Pl. XXII. Figs. 30–33.

Lorica elongate-conical or subcylindrical, abruptly truncate or slightly everted anteriorly, widest centrally, tapering and attenuately pointed posteriorly, about four times as long as broad; enclosed animalcule elongate-ovate or pyriform, occupying about one-half of the cavity of the lorica, tapering, and continued as a thread-like pedicle posteriorly, the anterior border developed on one side as a small, conical, projecting lip; eye-like pigment-spot minute; contractile vesicle anteriorly situated, endoplast subcentral. Length of lorica 1–640″. Hab.—Fresh water on *Confervæ.*

The loricæ of this species, with their enclosed inhabitants, so closely resemble the separate thecæ and animalcules of *Dinobryon sertularia* that Stein originally held them to be early growths only of that form. In the third volume of his 'Infusionsthiere' he, however, recognizes their independent status and fully illustrates their varied aspects and habits. In some of the empty loricæ figured by this authority, a delicate reticulate pattern is spread over the entire surface, and apparently indicates the presence of contained sporular bodies, or the traces of their previous existence; multiplication by fission is effected in a somewhat oblique direction. Though usually found attached in some numbers to the filaments of *Œdogonium* and other water-plants, the loricæ are in most instances conspicuously isolated from one another, but sometimes occur, as shown at Pl. XXI. Fig. 31, in small closely set fasciculi. The species has been recently obtained by the author in the neighbourhood of Ashby-de-la-Zouch.

Genus XII. DINOBRYON, Ehrenberg.

Animalcules bi-flagellate, having one long and one short flagellum, attached by a posterior contractile ligament within the individual cells or loricæ of a compound branching polythecium; the polythecium constructed through the successive terminal gemmation of the primary zooids; endoplasm containing two lateral colour-bands and usually an anteriorly situated eye-like pigment-spot. Inhabiting fresh water.

Dinobryon sertularia, Ehr. Pl. XXII. Figs. 34–40.

Constituent cells or loricæ of polythecium obconical, narrowest and tapering posteriorly, evertile at the mouth, slightly constricted a little beneath the anterior border, joined to each other without intermediary or separate pedicles. Animalcules elongate-ovoid, not exsert, attached to the bottom of their respective lorica by a transparent elastic ligament. Eye-like pigment-speck conspicuous. Length of separate loricæ 1–1200″, of contained animalcules 1–2000″. HAB.—Pond water.

This species, which may be regarded as the typical representative of the genus *Dinobryon*, has received the attention of numerous authorities since its first discovery by Ehrenberg. By no one of these, however, Stein and Bütschli excepted, does its structure and affinities appear to have been correctly apprehended, a circumstance doubtless explained by the extreme minuteness of the individual animalcules and the consequent necessity of employing the highest available magnifying powers for their satisfactory determination. Hitherto this form has been regarded and described as a uniflagellate type much resembling *Euglena*, and from which alone it was chiefly distinguished by its compound protective lorica. Professor H. James-Clark, apparently without a previous acquaintance with the type, refers to it, in the course of his remarks on the genus *Codonœca*, as a "calyculated Euglenian."

The first results that attended the author's examination of this elegant species, in the year 1871, with a sufficient amplifying power, was the detection of two flagella, one long and the other considerably shorter, in place of the single appendage previously ascribed to it, while it was at the same time elicited that the animalcules were attached to the base of their respective loricæ through the medium of a separate retractile ligament. Those two points at once establish the near relationship that exists between this form and the genus *Epipyxis*. The compound colony-stocks of *Dinobryon sertularia* are frequently met with containing no fewer than fifty to sixty separate loricæ, which are so united to one another as to present as a whole a remarkable resemblance in miniature to the polyparies of certain of the Polyzoa or Sertularian Zoophytes. The adult colonies thus constructed are usually found progressing through the water with a rolling action and considerable velocity, being propelled by the rapid vibration of the innumerable flagella. In its younger state it is however an essentially sedentary form, the primary zooid with its investing lorica being attached to some fulcrum of support, as in other ordinary pedicellate types here described. As the colony develops, the lower or primary cells become atrophied, much in the same manner as the lower portion of the branch of a madreporic coral, and these deserted cells being unable to bear the weight of the superincumbent mass, snap off, and thus release the colony into the surrounding water under those conditions which are most usually met with. No process of reproduction in *Dinobryon sertularia* has been yet observed in addition to the ordinary one of oblique fission, as in *Epipyxis*. The resultant of such fission, however, in most cases, instead of swimming off to form the foundation of a new settlement, attaches itself just beneath the margin of the aperture of the parent lorica, and then builds up a corresponding domicile. This process in the course of a few generations results in the formation of the elegant compound polythecium characteristic of the adult colony.

Both Bütschli and Stein have recently recorded the production by this animalcule of spherical encystments, as represented at Pl. XX. Figs. 38–40; it is a remarkable fact, however, that the well-developed posterior ligament or footstalk, by the contraction of which the zooids are enabled to retreat rapidly to the further confines of their loricæ, has not been distinctly recognized in this species by either of these authorities. The oral aperture, according to Stein, is immediately adjacent to the point of insertion of the two flagella and scarcely to be distinguished from the eye-like pigment-speck.

Dinobryon stipitatum, Stein. PL. XXII. FIG. 41.

Loricæ elongate, trumpet-shaped, widest and slightly everted anteriorly, tapering, attenuate, and acuminately pointed posteriorly, the total length equalling seven or eight times the greatest breadth; zooids elongate-ovate, occupying the anterior half of the cavity of the lorica, attached to the side-wall of the same by a thread-like prolongation of the posterior region; primary flagellum exceeding the body in length and three times longer than the secondary one; eye-like pigment-spot conspicuous; contractile vesicle situated a little in advance, and the endoplast a little to the rear of the centre of the body. A large, subspheroidal, fat-like amylaceous corpuscle located near the posterior extremity. Length of loricæ, 1–300″.

HAB.—Fresh water.

The great proportional length and attenuate posterior terminations of the loricæ of this species, as figured by Stein,* distinguish it conspicuously from the preceding type. This elongate outline of the posterior region is so marked as to almost acquire the character of an independent pedicle, while the contour of each independent lorica, as a whole, may be appropriately compared with that of a post-horn.

Dinobryon juniperinum, Eichwald. PL. XXII. FIG. 23.

Cells of polythecium evenly ovate or fusiform, not everted at the anterior border but tapering equally towards each extremity, joined to one another without the intermedium of a stalk-like prolongation; the entire colony consisting of a straight median line of the constituent cells, from the anterior borders of each of which three cells originate, one directed straight forwards and continuing the main rachis, and one other on each side of this median one, which become further developed into oblique lateral branchlets, these latter subdivisions frequently giving rise to secondary oblique offshoots. HAB.—Fresh water. Dimensions unrecorded.

The compound polythecium of this species only is figured and described by Eichwald in his 'Infusorienkunde Russlands,' 1847, no reference being made to the inhabiting animalcules. The evenly ovate shape of the individual cells and the symmetrical rectilinear mode of growth of the general colony, distinguish it in a marked manner from *D. sertularia.*

Doubtful Species.

A description of two additional species of the genus *Dinobryon* is included in Pritchard's 'Infusoria,' p. 547, the characteristics of which, however, as here reproduced, are almost too vague for reidentification.

Dinobryon (?) *sociale*, Pr.—"Small; enveloped in a shell of a simply conical shape, truncated at the mouth. Developed in the form of a shrub-like polypary. In fresh water. 1–860″; cluster 1–280″."

Dinobryon gracile, Pr.—Less branching (fruticose), lorica slightly constricted at the middle, aperture truncated. Animalcule 1–2080″.

The *Dinobryon petiolatum* of Dujardin is transferred by the author of this treatise to De Fromentel's genus *Stylobryon*, and is evidently identical with both the *S. insignis* of that writer and with the *Poteriodendrum petiolatum* of Stein.

GENUS XIII. SYNURA, Ehrenberg.

Animalcules free-swimming, united in subspheroidal social clusters, each zooid contained in a separate membranous sheath or lorica, the posterior extremities of which are confluent; flagella two in number,

* 'Infusionsthiere,' Abth. iii., 1878.

subequal; endoplasm containing two lateral pigment-bands, one or more coloured eye-specks usually developed. Inhabiting fresh water.

Known only by the figures and descriptions of Ehrenberg, the single type-form of this genus has been regarded as an entirely doubtful species, and, together with *Syncrypta* and *Uroglena*, been even discarded by Mr. Carter as spermatic or developmental phases of the vegetable types *Volvox* or *Sphærophrya*. As recently shown by Stein, however, this form possesses a sound claim for independent recognition. It is further demonstrated by this authority that Ehrenberg was wrong in assigning to the spheroidal colonies the possession of a common gelatinous matrix, as in *Syncrypta* and *Uroglena*, in addition to the individual loricæ. What Ehrenberg took for such an element were probably the minute, thickly set, filamentous or spinous processes, now made known by Stein to be developed throughout the external surfaces of the loricæ of the type in question, but which are to be recognized as distinct structures only when the organism is examined with the aid of an exceedingly high magnifying power. The presence of two flagella, eye-specks, colour-bands, and other histologic details, are also for the first time demonstrated by this authority.

Synura uvella, Ehr. PL. XXIII. FIGS. 1 and 2.

Loricæ pyriform, tapering posteriorly, sometimes prolonged in a stalk-like manner, their external surface beset with evenly developed spinous processes; contained animalcules almost entirely filling the cavities of the loricæ, their posterior extremity produced towards and adherent to the bottom of the same; flagella subequal, eye-like pigment-specks minute, two in number, sometimes absent; a large vacuolar space, apparently representing a pharyngeal dilatation, developed at the anterior extremity; colour-bands produced equally throughout the length of the two lateral borders; contractile vesicles two or three in number, posteriorly located; endoplast situated in the middle line, immediately behind the two eye-like specks. Length of individual loricæ 1–740″; diameter of spheroidal colonies 1–350″ to 1–200″, these latter often consisting of as many as eighty zooids.

HAB.—Pond water.

Stein regards the type figured by him as the eyeless variety of this species, Pl. XXIII. Fig. 1, as identical with the *Uvella virescens* of Ehrenberg. Bütschli, however,* figures and describes as representing this last-named organism an entirely distinct form in which there is no lorica with its spinous processes and no conspicuous pharyngeal dilatation, such species being here accepted as typifying the genus *Uvella*. Stein has further proposed to unite with this organism the *Mallomonas Plosslii* of Max Perty, which he regards as isolated individuals of *Synura uvella*, with the setose or spinous processes of their loricæ greatly produced. *Mallomonas* is, however, an entirely distinct monoflagellate animalcule, having, as demonstrated by the author's description and illustrations elsewhere submitted, nothing in common with the Chloromonadidæ.

Doubtful Species.

Under the title of *Rhodæssa grimselina*, Perty figures and describes, apart from *Uvella virescens*, a species apparently belonging to this same genus *Synura*. No reference to a distinct lorica is given, but the margin of each body is reported to be distinctly and finely crenulate. Except for two evenly developed bright green lateral pigment-bands the body-substance is entirely transparent. The crenulation exhibited represents probably the periphery of a separate lorica. The type was obtained by

* 'Zeitschrift für Wissenschaftliche Zoologie,' Bd. xxx., 1878.

Perty in bog water on the Grimsel Alps. The length of the individual zooids is given as 1–840″ to 1–600″, and the diameters of the united colonies as 1–180″. These colony-stocks contain from three or four to as many as thirty zooids; the spheroidal mass formed, according to his delineations reproduced at Pl. XXII. Fig. 27, being very irregular.

GENUS XIV. SYNCRYPTA, Ehrenberg.

Animalcules free-swimming, illoricate, united socially by their posterior extremities in spheroidal or rosette-shaped clusters, the whole colony-stock being immersed within a granular, gelatinous matrix or zoocytium, beyond the periphery of which the flagella alone project; flagella two in number, subequal; lateral colour-bands conspicuously developed; one or more eye-like pigment-specks usually present.

Previous to the publication of Stein's recently issued volume, the position of the single specific form referred by Ehrenberg to this genus was very doubtful; Dujardin regarded it as closely allied to or identical with *Cryptomonas*, while Mr. Carter declared it to be the spermatic form of *Volvox* or *Sphærophrya*. As more thoroughly investigated by Stein, it is, however, now shown to be an independent type most nearly allied to *Uroglena*, but differing from that genus in the close approximation, without any intermediate spaces or contractile pedicles, of the zooid clusters, and through the possession by the animalcule of two eye-specks instead of a single one.

Syncrypta volvox, Ehr. PL. XXIII. FIG. 3.

Bodies ovate, tapering posteriorly, and there united together so as to form rosette-shaped colonies of four, eight, sixteen, or thirty zooids; the investing zoocytium granular, and somewhat dense; flagella two in number, subequal; colour-bands evenly developed, of a brownish hue, extending throughout the two lateral borders; eye-like pigment-specks two in number, one stationed at the anterior extremity of each of the two colour-bands; the contractile vesicle located a little behind the eye-specks and in the clear space between the colour-bands. Length of individual zooids 1–2500″, diameter of social colonies, including gelatinous zooglœa, 1–570″.

HAB.—Pond water.

As originally figured and described by Ehrenberg, the zooids of this colonial form are represented as possessing a single flagellum only, but Stein in his recently published illustrations of the Flagellata records the existence of two, as also of the eye-specks and contractile vesicles, which had not been detected by Ehrenberg. Stein is not very clear in his delineation of the relative length of the two flagella, in some cases they being delineated as equal and in others as diverse in length. The balance of evidence is, however, seemingly in favour of their uneven development, such proportions obtaining in *Dinobryon*, *Epipyxis*, *Uroglena*, and all other members of this family group that have been examined by the present author with the aid of the highest magnifying powers. It is a further significant fact that in this instance, as also in most others in which two uneven-sized flagella actually exist, Ehrenberg has represented a single one only, the smaller of the two having no doubt been beyond the defining capacity of his instruments. In the protophytes *Volvox* and *Chlamydomonas*, on the other hand, where the two flagella are of even length and calibre, this authority has as invariably assigned to them their true character and proportions.

GENUS XV. UROGLENA, Ehrenberg.

Animalcules enclosed socially within a subspheroidal gelatinous matrix or zoocytium, to the centre or deeper substance of which they are united through the medium of slender, thread-like, highly contractile, posteriorly developed prolongations; in their normal or extended condition the anterior borders of the individual animalcules impinging upon or projecting slightly beyond the periphery of the zoocytium, but capable at will, through the contractions of the filiform posterior prolongations, or pedicles, of being withdrawn entirely within its substance; flagella two in number, of diverse size; endoplasm enclosing two distinct lateral colour-bands, and usually one or more eye-like pigment-spots. Inhabiting fresh water.

Uroglena volvox, Ehr. PL. XXIII. FIGS. 4–15.

Colony-stocks subspherical or more or less asymmetrical; bodies pyriform, the anterior border rounded, somewhat obliquely truncate, tapering posteriorly, and thence continued backwards in the form of a long, slender, hyaline, and highly contractile thread-like prolongation; lateral pigment-bands yellowish-green, of uneven length; eye-like spot single, situated anteriorly and in the median line, close to the base of the two flagella; flagella of conspicuously diverse size; contractile vesicles two in number, located close together near the centre of one of the lateral borders; a large ovate and apparently amylaceous corpuscle mostly developed towards the posterior half of the body. Length of bodies 1–1200″, average diameter of social colony-stocks 1–90″. HAB.—Pond water.

This type, in common with *Syncrypta*, *Synura*, and other socially aggregated Chloromonadidæ, has been usually regarded as a doubtful form probably representing an imperfect or transitional condition only of the protophytes *Volvox* or *Sphærosira*. Quite recently, however, it has been shown by both Bütschli and Stein, to be an independent organism exhibiting, with relation to the form and characters of the individual zooids, an entire conformance with the several other generic types comprised in the Chrysomonadidæ. Examples of this species were likewise remitted to the author during the month of June 1879, by Mr. H. E. Forrest and Mr. Thomas Bolton, from the neighbourhood of Birmingham, the result of such a personal acquaintance with it being the discovery of various supplementary structural and developmental phenomena here recorded for the first time. More especially in this connection may be mentioned the establishment of the possession by the zooids of a posteriorly developed thread-like pedicle, first imperfectly observed and interpreted by Ehrenberg as a simple tail-like prolongation, but entirely overlooked by both Stein and Bütschli. This structure is, in fact, so slender and transparent as to require a high magnifying power, 600 to 800 diameters, and the nicest adjustment of the illumination for the demonstration of its existence. Such conditions being secured, however, its presence is conspicuously apparent both in living examples and in specimens treated with osmic acid and permanently preserved. Under the latter auspices, indeed, this special structure may perhaps be most readily identified, though its contractile properties and complete conformity with the contractile pedicles of *Dinobryon* and *Epipyxis* are recognizable only in the living state.

Among the data observed by the author with reference to the reproductive phenomena, it has to be recorded that zooids were abundantly found withdrawn into the common matrix or zoocytium, devoid of flagella, and presenting every step of gradation from a simply quiescent but non-encapsuled stage up to subdivision into two, four, or eight spheroidal segment-masses or sporular elements. These spores becoming distributed throughout this common gelatinous matrix, speedily acquire the adult forms and characters, and are in most instances provided with the two lateral colour-bands and eye-like pigment-spot at or immediately succeeding their earliest appearance. In the majority of the specimens examined this mode of reproduction was alone observed, and is chiefly to be seen in the two colony-stocks delineated at Pl. XXIII. Figs. 4 and 5. Not unfrequently, however, examples were met with which enclosed supplementary spheroidal structures, having a diameter of two or three times that of the bodies of the adult zooids, three of these being included in the colony-stock illustrated by Fig. 4. On making a closer investigation it was found that these supplementary structures consisted of aggregations of spore-like bodies contained within a hard and glass-like transparent membrane or sporocyst, which exhibited its brittle consistence by rupture under artificial pressure into a number of angular fragments, as shown at Pl. XXIII. Figs. 10 and 11. The sporular elements thus liberated from their indurated capsules were found to possess two entirely distinct dimensions, being in the one instance, Fig. 11, of comparatively large size, the 1–6000th of an inch in diameter, while in the second case, Fig. 10, they did not exceed the 1–20,000th of an English inch. Not improbably, however, these smaller sporular bodies represent a further segmented phase only of the larger ones, and in both instances they are so minute as to merit the designation of "microspores" in contradistinction to that of "macrospores," which may be appropriately applied to the structures derived from the simple segmentation into two, four, or eight sporular elements of the ordinary unencapsuled zooids, as previously described. The precise import of these encapsuled sporular elements has not yet been determined; but from the proportionate size of their investing sporocysts it may be consistently predicated that they were primarily derived through the conjugation or genetic union of two or more ordinary zooids, while their encapsuled state would seem further to denote that surviving the disintegration of the parent colonies, and probably the drying up of the water with the summer drought, they secure the permanent preservation of the species.

With reference to the retention and development of the larger and naked sporular elements of *Uroglena* within the common gelatinous matrix of the parent colony, the similarity of the phenomena to what obtains among the co-ordinate section of the Spongida, and as related at length in a preceding chapter, is at once made manifest. Additional testimony in this direction has to be recorded. The author has on several occasions observed within the parent colonies the presence of smaller spheroidal aggregations, apparently corresponding with the "daughter-spheres" of *Volvox* or *Eudorina*, but which, in the event of further corroboration, may be found to possess a still more important significance. These are, in fact, directly comparable with the ciliated gemmules or so-called ciliated larvæ of the sponges as they occur in their simplest state, and consist in a like manner of a vesicular moruloid structure, built up of a single stratum of closely approximated flagellate zooids. In a similar way these daughter-spheres of *Uroglena* provide for the more extensive local dissemination of the species, while the ordinary zooids by simple sporular segmentation contribute towards the enlargement of the parent colony. There can be but little doubt that, as in the case of the daughter-spheres of *Volvox* and the ciliated gemmules of the Spongida, these corresponding structures in *Uroglena* are derived from the primitive coalescence of a considerable number of single cells or zooids. Though this process has not as yet been directly observed, it may be predicated by their occupation of an area towards the periphery corresponding with that normally held by some half a dozen or more of the ordinary animalcules.

Although a single contractile vesicle only is attributed to the zooids of *Uroglena* by Bütschli, while such a structure is entirely absent in Stein's latest delineations of this species, two alternately contracting ones situated towards the centre of one lateral border have been distinctly seen by the present author. Some amount of doubt has hitherto existed as to whether the gelatinous matrix in which the zooids of *Uroglena* are immersed, is continuous to the centre of the common spheroidal mass, or whether this central space is simply fluid; Bütschli inclines to the last-named alternative, having, he says, observed diatoms and other foreign bodies moving freely in this position. The present author is, however, disposed to maintain that this matrix persists throughout, being most fluid centrally and becoming gradually denser as the peripheral region is approached. In both living and preserved examples no trace whatever could be detected of distinctly differentiated internal and external zones.

From *Volvox*, *Syncrypta*, *Synura*, and various other free-floating animal and vegetable Flagellate types, for which the colony-stocks of *Uroglena volvox* are somewhat liable to be mistaken, an easily recognized superficial feature of distinction is afforded by the general contour of the colony-masses, which rarely exhibit that perfect spherical symmetry which characterizes the several first-named forms.

Fam. VI. ZYGOSELMIDÆ, S. K.

Animalcules solitary, free-swimming or repent; flagella two in number, similar in character, both vibratile; endoplasm sometimes coloured green, but not enclosing differentiated lateral pigment-bands; oral aperture distinct, terminal; one or more eye-like pigment-specks frequently present. Mostly inhabiting fresh water.

GENUS I. EUTREPTIA, Perty.

Animalcules free-swimming or repent, plastic and changeable in form, ovate or elongate; oral aperture terminal, funicular; flagella two in number, vibratile, of equal size, issuing from the terminal oral fossa; endoplasm coloured a brilliant green, enclosing an anterior eye-like pigment-spot; contractile vesicle anteriorly situated; endoplast subcentral. Inhabiting fresh water.

Excepting for the possession of two equal-sized flagella and the exhibition of the peculiar peristaltic movements presently described, the as yet single known representative of this genus corresponds essentially with *Euglena*.

Eutreptia viridis, Pty. PL. XXI. FIGS. 54–59.

Body soft and plastic, exceedingly variable in form, its more normal contour when swimming pyriform, broadest and widest anteriorly, with an attenuate and pointed caudal prolongation, at other times elongate and subcylindrical, subfusiform, napiform, or variously constricted, often repent, creeping over the surface of submerged objects by active peristaltic contractions; flagella slender, equalling the body in length; eye-like pigment-spot conspicuous, scarlet; contractile vesicle located close to the last-named structure; endoplast spherical, subcentral. Length 1–240″.

HAB.—Pond water.

Since the discovery and description of this animalcule by Max Perty in 1852, it does not appear to have fallen beneath the observation of any other investigator and has been more usually regarded as an imperfectly recorded phase of some one of the various species of *Euglena*. As such it is dismissed by Stein in the third volume of his 'Infusionsthiere,' and until quite recently this verdict was accepted by the present author. So late as February 1879 this type has, however, been encountered in considerable numbers in pond water from near the village of Samares, Jersey, such discovery justifying its reinstatement as a well-marked generic form. In addition to the two long, equal, vibratile flagella, which were in all normal conditions distinctly seen, the peculiar and rapid peristaltic movements exhibited by the animalcule during its repent state, distinguish it in a marked manner from the various species of *Euglena* and approximate it more nearly in this respect with the members of the genus *Distigma* or the essentially repent protozoic type *Gregarina*. In the examples examined, it was noted that very soon after their transfer to the object-slide they abandoned their natatory for the repent mode of progress, which is possibly the more general and congenial. Encysted conditions were frequently observed, and also the breaking up of the contents of the encysted zooids into innumerable sporular bodies which were subsequently liberated in the form of minute, green, non-flagellate amœbæ, these phenomena corresponding with those already recorded of *Euglena viridis*. Prior to their acquirement of the typical adult state, it is worthy of note that the amœbiform germs possess a single flagellate appendage only, being under such conditions altogether indistinguishable from minute *Euglenæ*.

As compared with Perty's original figures, the animalcules of *Eutreptia* were not observed during their natatory state to assume so attenuately pyriform a contour as he delineates, the pointed caudal prolongation in the Jersey specimens rarely exceeding one-half of the length of the inflated body-portion, while in the former case it frequently equals or even exceeds this region in length. Perty's so-called variety *unifilis* of this species represents apparently the young condition only, as above described.

GENUS II. ZYGOSELMIS, Dujardin.

Animalcules highly metabolical and variable in form, swimming with the aid of two unequally developed flagellate appendages, which issue from the pointed anterior extremity; oral aperture at the base of these flagella, followed by a distinct tubular pharynx; endoplasm transparent, granular; no eye-like pigment-specks. Inhabiting fresh water.

In their constantly changing form, the animalcules of this genus may be most appropriately regarded as biflagellate *Astasiæ*. Bütschli has proposed to identify the type species *Z. nebulosum* with *Chilomonas paramecium*, an animalcule, however, with which, excepting for its possession of two flagellate appendages, it can scarcely be said to share a single point in common.

Zygoselmis nebulosa, Duj. PL. XXI. FIGS. 52 AND 53.

Body variable, ovate, globular, or pyriform, changing its form slowly from one to the other, endoplasm densely granulate; cuticular surface finely striate obliquely; flagella of conspicuously diverse length. Length of body 1–1250" to 1–500". HAB.—Pond water.

Stein records the existence of a distinct oral aperture and pharyngeal passage at the base of the two flagella, and delineates an example in his recently published volume, reproduced at Pl. XXI. Fig. 53, whose body is abnormally distended through the ingestion of two comparatively large diatom frustules. The animalcule at Fig. 59, bearing three flagellate appendages, is, as explained by Stein, about to divide by longitudinal fission. Dujardin, who appears to have observed this type on one occasion only, describes it as incessantly changing its form as it swims through the water, after the manner of an *Astasia*.

Zygoselmis inæqualis, Perty.

Body hyaline, colourless, slowly assuming various shapes; one flagellum somewhat shorter than the other; parenchyma sometimes filled with clear green granules; movements sluggish. Length 1–840".

The difference between this and the preceding species appears to be only one of size, and almost too slight for separate distinction.

GENUS III. DISTIGMA, Ehrenberg.

Animalcules free-swimming, highly elastic and changeable in form; flagella terminal, two in number, one long and one short, both vibratile; oral aperture close to the base of the flagella, succeeded by a long, tubular pharyngeal passage; endoplasm transparent, usually enclosing two anteriorly developed, minute, eye-like pigment-spots; contractile vesicle and endoplast conspicuous.

Distigma proteus, Ehr. PL. XXI. FIGS. 46-51.

Body highly metabolic, scarcely ever presenting the same contour, usually more or less elongate, with irregular constrictions and distensions; longer flagellum nearly equalling the body in length, the shorter one scarcely one-quarter that length; endoplasm transparent, enclosing numerous dark-coloured refringent corpuscles whose positions are constantly shifting from one extremity to the other in accordance with the peristaltic motions of the body; two minute, blackish, eye-like pigment-spots usually developed at the anterior extremity; tubular pharynx slender, greatly prolonged; contractile vesicle conspicuous, located close to the termination of the pharynx; endoplast ovate, subcentral. Length 1–580″ to 1–240″.

HAB.—Pond water, among *Lemnæ.*

Stein * refers this species to the genus *Astasia*, here and elsewhere more generally retained for the reception only of certain monoflagellate types. He further proposes, in his index to the figures given, to identify the countless protean forms assumed by this animalcule with the *Proteus tenax* of O. F. Müller and *Distigma proteus* et *tenax*, *Astasia flavicans* et *pusilla*, and *Monas punctum* of Ehrenberg; these last three hypothetic species being more especially identified with the earlier stages of its growth. In neither of the two first-named forms did Ehrenberg detect the presence of any flagellate appendage, and it was assumed by him that such do not exist; the movements of the animalcule were further described by this authority as simply repent and peristaltic. As shown by Stein, however, it is only the older zooids that lose their flagella and lead a repent life, the younger and more normal ones possessing two conspicuous but unequal sized flagella, as indicated in the preceding diagnosis. This elder creeping phase corresponds evidently with the amœboid one assumed by the majority of the Flagellata as a preliminary step to the act of coalescence or encystment. The peculiar peristaltic movements exhibited by the representatives of this species, both during their natatory and repent states, coincide closely with those that characterize the Gregarinada, and are, with the exception of *Eutreptia*, met with nowhere else among the Infusoria. The *Proteus tenax* of O. F. Müller, while greatly resembling the repent phase of the present species in outward form, is possibly, from the description given of the parenchyma—"pellucid and filled with black granules"—a species of Gregarina, identical probably with the one infesting various species of *Cyclops*, and not unfrequently found free in the water containing this abundantly distributed Entomostracon. As such an independent Gregarine type Stein has indeed previously recognized it, describing it† under the title of *Monocystis tenax*. The *Distigma viridis* of Ehrenberg would

* 'Infusionsthiere,' Abth. iii., 1878.

† Ibid., ii., 1867, pp. 7 and 8.

appear to be identical or closely allied to the *Eutreptia viridis* of Perty, previously described.

The author has quite recently, November 1880, received specimens of this interesting animalcule, *Distigma proteus*, from Mr. Thomas Bolton, its companions in the sample of pond water forwarded being *Spirostomum teres*, *Paramœcium chrysalis*, *Astasia trichophora*, and *Euglena acus*. The various protean forms reproduced from Stein's work in the accompanying plate were abundantly exhibited during their natatory condition by the examples examined, each change of contour being accompanied by the rapid flowing from one extremity to the other of the endoplasmic corpuscles in the manner indicated in the foregoing diagnosis.

Yet a week later the author has had remitted him, through the same agency, a small phial absolutely teeming with the young eyeless condition of this animalcule, as delineated at Figs. 49–51 of Pl. XXI. These were found to be much more persistent in shape than the adult zooids. While observed during the first four days to change their form at more or less frequent intervals, it was noted towards the end of the fifth and sixth days that they generally assumed a compressed spirally twisted contour. The diagonal striation of the cuticle in two directions, as represented in Stein's figure (Pl. XXI. Fig. 49), was conspicuously developed in almost every instance. The correspondence, in both size and contour, of the young *Distigma* with Dujardin's *Zygoselmis nebulosa* is certainly very close, and suggests the probability of their proving to be synonymous. While going to press, the animalcules are enjoying their active natatory existence, but owing probably to the absence of their customary food, have scarcely increased in size, their average length, as when first received, ranging from 1–800″ to 1–500″.

GENUS IV. CRYPTOGLENA, Ehrenberg.

Animalcules free-swimming, solitary, plastic and changeable in form, enclosed within a rigid membranous sheath or lorica; flagella two in number, subequal; endoplasm coloured green throughout; an anteriorly located eye-like pigment-speck usually developed.

The representatives of this genus were considered by Dujardin to be so closely related to *Cryptomonas* and the Phytozoon *Chlamydococcus* as to forfeit claim to independent recognition, this verdict being coincided with by Pritchard. The author of this treatise is, nevertheless, disposed to regard the type species, *Cryptoglena conica* of Ehrenberg, as a well-marked independent form, most closely allied to the genus *Eutreptia*, and occupying towards it a position corresponding to that which subsists between the two genera *Euglena* and *Trachelomonas*. The *Cryptoglena lenticularis* of Carter* is evidently a species of *Chlamydococcus*, while his *C. cordata* has been transferred by Stein to the new genus *Tetraselmis*.

Cryptoglena conica, Ehr. PL. XXI. FIG. 42.

Lorica elongate-ovate or obconical, somewhat truncate anteriorly, more or less pointed posteriorly, sometimes slightly curved; body of animalcule occupying the two anterior thirds of the cavity of the lorica; flagella two in number, evenly developed; endoplasm bluish green; a conspicuous scarlet eye-like pigment-spot developed at the anterior extremity; two more opaque, ovate, and apparently amylaceous corpuscles frequently present in the posterior region. Length, including lorica, 1–1100″.

HAB.—River water.

According to Ehrenberg the animalcules of this species progress forward rapidly in the direction of their longitudinal axis, and if interrupted in their course, spring or

* 'Annals of Natural History,' Oct. 1858.

leap briskly to one side. The *Cryptoglena cœruleus* of the same authority is evidently an illoricate type not referable to the present generic group, and whose true relationship is as yet doubtful. The form figured by both Ehrenberg and Stein under the name of *Cryptoglena pigra* is here made the type of the new genus *Chloromonas*.

Cryptoglena angulosa, Carter. PL. XXI. FIGS. 43–45.

Lorica oblong, angular, and compressed, truncate, but with a short projecting neck on the anterior margin, the posterior border rounded; in lateral view the anterior and posterior borders curved in opposite directions and exhibiting a sigmoid outline; body of enclosed animalcule occupying the greater portion of the lorica, but leaving free a conspicuous peripheral border; flagella equal in size; two contractile vesicles situated close to each other at the anterior extremity; a red eye-like pigment-spot located on one side of the periphery; from one to four amylaceous corpuscles usually developed towards the posterior extremity. Length of lorica 1–1080″. HAB.—Fresh-water lakes in the island of Bombay.

The encysted state of this species was observed by Mr. Carter,* as also its subdivision under such conditions into two and four sporular bodies, these latter being ultimately liberated, by the dehiscence of the old lorica, which becomes smooth and dilated, as zooids of smaller size, but corresponding in all other respects with the parent form. The movements of this animalcule are described by its discoverer as being directed forwards, but in an exceedingly irregular line.

GENUS V. STERROMONAS, S. K.

(Greek, *sterros*, stiff; *monas*.)

Animalcules free-swimming, elongate, more or less persistent in form bearing two flagella of diverse size at the anterior extremity, the longer of which is extended arcuately and stiffly in advance, while the shorter one is actively vibratile and flexible throughout; oral aperture indistinct; endoplasm transparent, granular; no eye-like pigment-specks; contractile vesicle and endoplast conspicuously developed.

Sterromonas formicina, S. K. PL. XXIV. FIGS. 40–42.

Body elongate, gibbous, nearly three times as long as broad, inflated and widest posteriorly, narrower in the centre, slightly widening again anteriorly, both the anterior and posterior margins obliquely truncate or angular as seen in profile; flagella inserted close to one another near the centre of the frontal border, the longer one equalling the body in length, directed stiffly in advance, arcuate at its distal termination, the shorter one less than half the length of the other, flexible and tremulous throughout; endoplasm transparent, enclosing numerous granules of irregular form and size; endoplast spherical, subcentral; contractile vesicle posteriorly located. Length of body 1–2000″ to 1–1250″.

HAB.—Vegetable infusions in salt and fresh water.

* 'Annals and Magazine of Natural History,' 1859.

The animalcule, as above characterized, presents in profile an aspect so strikingly suggestive of the body of an ant, with its gibbously inflated posterior and constricted central portion, that a specific title indicative of this likeness is herewith conferred upon it. The generic name of *Sterromonas*, from *στερρος*, rigid or unbending, bears reference again to the stiff movements in the water of this as yet single known representative of the genus, and which are chiefly induced by the constantly rigid extension of the longer flagellum. Even when altering its course, the animalcule swings round on its axis, as though on a swivel, without visibly bending its body or this organ in the slightest degree, and which thus seems to more closely resemble a stiff seta than a flagellate appendage. At the same time it would appear that this structure is motile at its free extremity, in a swift vibratory manner as in the Pantostomatous genera *Spumella* and *Oikomonas*. In addition to its normal leisurely progress in a straight line, apparently accomplished by the tremulous motions of the shorter flagellum, this animalcule occasionally darts across the field with remarkable rapidity, and it is probable that under these circumstances, the longer, arcuate flagellum constitutes the chief organ of propulsion. The species possesses prominent adaptive capacities, appearing in equal abundance in artificial infusions of hay in both fresh and salt water. The latter medium, indeed, seemed to prove the more congenial, it attaining in this one only, the larger dimensions of 1-1250″ cited in the foregoing diagnosis. An example was observed in one instance to form a spherical encystment, such entrance upon a quiescent condition being preceded by the assumption of an irregular amœboid shape. The aspect of the zooids of this species considerably resembles that of the natatory conditions of *Oikomonas mutabilis*, represented at Pl. XIII. Figs. 57 and 58. Its smaller size, persistency of shape, and possession of two flagella readily distinguish it, however, from that type.

Under the title of "Flagellaten-rhizopodenartige Protozoen" O. Bütschli has described and figured* a flagellate organism which must perhaps be accepted as a second species of the genus *Sterromonas*. The contour of this organism in dorsal view is more symmetrical than that of *S. formicinus*, being subcylindrical, with a slightly narrower anterior extremity; the frontal border is obliquely truncate, a spherical endoplast is stationed at the anterior extremity, and the contractile vesicle is adjacent to the centre of the right-hand border; the endoplasm is more evenly and finely granulate than in the form just described. Bütschli indicates a single long and apparently stiff, arcuate flagellum at the apical extremity, but it is quite possible a second shorter one exists, which has been overlooked. This form was found in water with decomposing organic substances, in company with *Anthophysa vegetans* and other flagellate types; the length given is 0·03 mm., or about 1·800″. Observing an example assume an amœboid state, accompanied by the extension of pseudopodic processes, Bütschli has adopted this amœbiform condition as the mature and adult one, regarding the flagellate monad as its larval or zoospore-like phase. This amœba-like type he further proposes to identify with the *Nuclearia simplex* of Cienkowski. It is evident, however, that this amœbiform organism represented merely that transitory condition of the flagellate monad preceding encystment common to so many members of the Flagellate class, and that it is the flagellum-bearing zooid that must be regarded as the typical expression of the species. Presuming that this animalcule is generically related to *S. formicinus*, it is here proposed to distinguish it provisionally by the title of *Sterromonas Bütschlii*.

Genus VI. DINOMONAS, S. K.

(Greek, *deinos*, terrible; *monas*.)

Animalcules free-swimming, ovate or pyriform, soft and plastic, but not metabolic; flagella two in number, equal or subequal in length, vibratile, inserted close to each other at the anterior extremity; endoplasm transparent, granular; no eye-like pigment-spot; oral aperture very expan-

* 'Zeitschrift für Wissenschaftliche Zoologie,' Jan. 1878, p. 269, pl. xiii. fig. 22*a*.

sive, located at the anterior extremity immediately beneath the insertion of the flagella, visible only at the time of food ingestion, not supplemented by a distinct pharyngeal passage; feeding voraciously on other flagellate types, which they swallow whole. Inhabiting vegetable infusions.

This genus is instituted for the reception of two species corresponding with one another both in their broad external features and in their active predatory habits. This latter characteristic, combined with the equal size of the flagella and their comparative persistency of contour, serves to distinguish them from *Zygoselmis*, with which they otherwise to a considerable extent agree.

Dinomonas vorax, S. K. Pl. XXIV. Figs. 46–48.

Body persistent in shape, subpyriform, widest and rounded posteriorly, pointed anteriorly and slightly curved towards the ventral aspect, about two and a half times as long as broad, surface smooth; flagella slender, vibratile, subequal, exceeding the body in length; oral aperture exceedingly elastic, conspicuous only during the passage of food; endoplasm finely granulate; endoplast spherical, subcentral; contractile vesicle posteriorly located. Length of body 1–1600″.

Hab.—Infusions of hay in fresh and salt water.

This species was obtained by the author at St. Heliers, Jersey, in February 1878, in an infusion of hay in spring water on the eighth day of its maceration. For the next three or four days it constituted the most abundantly developed type, but at the end of this period it disappeared as suddenly as it came, and was not again seen in the infusion. A precisely identical animalcule was found in a contemporaneously prepared hay infusion in salt water on the eleventh day of its maceration, and was correspondingly fugacious. The habits of this species are eminently predatory, the greater portion of its time being spent in hunting down and devouring such other flagellate forms as may happen to be present. A few of them, enclosed in a glass slide with a crowd of *Heteromita lens*, *Monas fluida*, &c., were observed to rush in among these smaller animalcules where they congregated in zones near the margin of the glass cover, reappearing presently with a captured monad grasped by its sharply pointed distal extremity. Remaining motionless for a few seconds, this captured prey was gradually absorbed, a wide, elastic oral aperture, not previously visible, opening and expanding to receive it, and the chase being then renewed after other victims. In this manner five or six of the smaller monads were successively devoured in a very short space of time, and it was consequently not long before these weaker types succumbed and altogether disappeared before the aggressive inroads of the new intruders. Thus was illustrated in this humblest path of organic life the persistence and immutability of that law of the "survival of the fittest" now recognized as regulating the distribution of the most highly developed sentient beings, and upon which the welfare and stability even of nations is dependent. The movements of *Dinomonas vorax*, when not occupied in the pleasures of the chase, at which times it darts about hither and thither with great rapidity, consist of an even motion in a straight line, the snout-like anterior extremity being directed obliquely downwards, while the two flagella are vibrated actively in advance. In the younger and smaller examples, as shown at Pl. XXIV. Fig 46, the body is considerably narrower, or more attenuate in proportion to its length,

Dinomonas tuberculatus, S. K. Pl. XXIV. Figs. 43–45.

Body irregularly ovate, somewhat variable in form, but not metabolic, most usually more attenuate posteriorly, the ventral border flattened, the dorsal one convex; endoplasm very clear and transparent, enclosing nodular corpuscles of irregular shape and size, many of these located on or close to the surface, and imparting to it a tuberculate aspect; flagella subequal, the anterior slightly the longer, exceeding the body in length; endoplast spherical, subcentral; contractile vesicle posteriorly situated. Length of body 1–2500″.

HAB.—Vegetable infusions in both salt and fresh water.

This form was obtained by the author in equal abundance in the hay infusions in both salt and fresh water productive of the preceding type. It is worthy of remark, however, that while in the salt-water infusion this species preceded *D. vorax* by a few days in its advent, the reverse happened in the case of the fresh-water one. Although in their predacious habits, and in the manner of chasing and incepting their food, the two species closely correspond with each other, their external appearances are altogether diverse. The smooth, persistent, subpyriform shape of the variety last described is here replaced by a contour which, while more frequently irregularly ovate, with a slightly pointed posterior extremity, as represented at Pl. XXIV. Figs. 44 and 45, may in other instances be produced at this region into a long tail-like process, as shown at Fig. 43, which communicates to it a singular rat-like contour. On the other hand, it not unfrequently assumes an almost perfectly spheroidal shape. The habits of this species appear to be slightly more omnivorous than those of *Dinomonas vorax*, for in addition to its ordinary diet of smaller monads, which are seized and swallowed in a manner similar to that already related of the last-named type, long bacillar-like filaments, as shown at Fig. 45, are not unfrequently ingested. Multiplication by longitudinal fission was observed on several occasions, as likewise the formation of spherical encystments.

Fam. VII. CHILOMONADIDÆ, S. K.

Animalcules free-swimming or temporarily adherent, illoricate; oral aperture conspicuously developed, communicating to the anterior border a bilabiate or excavate appearance; flagella two in number, both vibratile or undulating in the natatory state, but one of them coiled upon itself when the zooid is at rest, adherent through a greater or less portion of its length, and used for the purpose of temporarily anchoring it to submerged objects; endoplasm transparent, granular; no eye-like pigment-spot. Inhabiting salt and fresh water.

The most important distinction of this family group as here defined, is afforded by the anchoring faculty possessed by one of the two flagella, this feature to some extent approximating it toward the Anisonemidæ next described. In none of the representatives of this last-named group, however, does the anchoring flagellum exhibit that characteristic coiled contour so conspicuous in the present instance. Furthermore, the anchoring flagellum in *Chilomonas* and its allies is vibratile and subservient to the purpose of locomotion, in place of being trailed motionlessly in the rear, as obtains among the succeeding group. A modification of the flagella, in which loop-like coils for the purpose of attachment are developed at the base of each appendage, has been already recorded in connection with the genus *Polytoma*.

GENUS I. CHILOMONAS, Ehrenberg.

Animalcules free-swimming, ovate or elongate, not metabolic but plastic and subject to considerable alteration in form, the anterior extremity obliquely truncate, projecting superiorly, and presenting the aspect of a prominent upper lip; oral aperture distinct, opening on the anterior truncate border, followed by a conspicuous pharyngeal tract; flagella two in number, subequal, both vibratile, the one spirally coiled and anchoring the animalcule to submerged objects when at rest; contractile vesicle usually at the anterior extremity; endoplast conspicuous; increasing by longitudinal fission. Inhabiting salt and fresh water.

By the earlier investigators it was left as a matter of considerable doubt whether the members of this genus possessed a single flagellate organ only, or two of these appendages; Ehrenberg favouring the latter and Dujardin the former of these alternatives. More recent investigation has established the accuracy of Ehrenberg's anticipation. Diesing, premising that the animalcule described by these respective authorities under the title of *Chilomonas paramœcium* included two distinct types, has proposed to separate Dujardin's supposed monoflagellate variety under the title of *Plagiomastix*, associating with it the doubtful *Chilomonas obliqua* of the same writer and the *Pleuromonas jaculans* of Perty. Such a generic group, however, based upon Dujardin's misinterpretation of the characters of the flagella, has no just claim for recognition. Perty's *Pleuromonas jaculans*, on the other hand, is an entirely distinct infusorial form. As now known, the representatives of the genus *Chilomonas* correspond remarkably in general contour with those of *Cryptomonas*, previously described, and are to be distinguished from them only by the absence of the lateral pigment-bands which so conspicuously characterize that generic form, in common with all the other members of the Chrysomonadidæ.

Chilomonas paramæcium, Ehr. PL. XXIV. FIGS. 51 AND 52.

Body plastic, elongate-ovate, about two and a half times as long as broad, widest anteriorly, tapering to a rounded point posteriorly, and usually curved slightly towards the dorsal aspect; cuticular surface smooth; endoplasm transparent, colourless, enclosing numerous large spheroidal corpuscles; anterior border obliquely truncate, oral aperture situated in the centre of this border; the two flagella inserted at the apical extremity immediately beneath the lip-like prominence, subequal in size, not so long as the body; pharyngeal tract narrow and elongate, continuous with the central axis of the body through nearly half its length, finely striate longitudinally; contractile vesicle situated at a little distance from the margin of the lip-like frontal prominence; endoplast spherical, located at a distance of one-third of the entire length of the body from the posterior extremity. Length 1–1125″ to 1–650″. HAB.—Vegetable infusions.

O. Bütschli * regards this species as identical with both the *Chilomonas granulosa* and *Zygoselmis nebulosa* of Dujardin, and further proposes to unite with it the animalcule next described under the name of *Chilomonas cylindrica*. That the last-named form is, however, essentially distinct is presently demonstrated, while *Zygoselmis*, as already shown, belongs to a separate family group. The species now under consideration occurs abundantly in vegetable infusions, and yields many points of interest. Treated with acetic acid, Bütschli found that the animalcules threw out on every side ray-like prolongations mingled with minute granular bodies whose nature would seem most closely to approach the trichocysts of the higher Ciliata. He was however unable to detect any trace of these structures in the living individuals. When isolated on a glass slide for investigation the animalcules quickly lose their normal contour, become more and more spherical, finally bursting and breaking up. Increase by

* 'Zeitschrift für Wissenschaftliche Zoologie,' Bd. xxx., Jan. 1878.

longitudinal fission was frequently observed. The two flagella of this species, when the animalcule is at rest, are described by Bütschli as being folded loosely across one another, as represented at Pl. XXIV. Fig. 51.

Quite recently (August 1879), the author has had an opportunity of examining this animalcule, and while able to confirm Bütschli's more general account of its structure, has elicited certain data concerning the comportment and insertion of the flagella that have necessitated a slight modification of the diagnosis previously prepared. In no instance was it made clear that these organs were inserted otherwise than close to one another, immediately beneath the lip-like prominence, while at the same time the lower of the two, when the animalcule was at rest, was thrown into a loose spiral coil in the same manner as the homologous appendage of the genus *Oxyrrhis*, and being used in a similar manner as an organ of attachment. A turn of this coil, issuing from behind the profile of the animalcule, often presented the appearance of a distinct and separately inserted flagellum, and it is probably upon such a deceptive optical aspect that Bütschli has based his interpretation of the remote insertion of the flagella in this species. In addition to the likeness to *Oxyrrhis*, conveyed by the convolute disposition of the flagellum in question, the movements of *Chilomonas paramœcium* in the water accord to a considerable extent with those of the last-named type. These consist, in a similar way, of an intensely active condition in which the animalcule rushes to and fro, though with the anterior end foremost, at a speed too rapid almost for the eye to follow, while at the next moment it comes as it were abruptly to anchor, with its body perfectly quiescent and one flagellum thrown into a coil and adherent to the glass slide or covering glass, while the other maintains a vibratory motion.

The figures of this species included in Stein's recently published volume * accord substantially with those given by O. Bütschli, his interpretation of the insertion of the flagella, however, being identical with that maintained by the present author.

Chilomonas cylindrica, Ehr. sp. Pl. XXIV. Fig. 50.

Body moderately persistent in form, elongate, subcylindrical, straight, about three and a half times as long as broad; endoplasm yellowish-brown, enclosing irregularly scattered granules; anterior border obliquely emarginate; the oral aperture excentral, continuous with a short, wide reticulate pharyngeal tract, which extends backwards along the ventral margin to about one-quarter of the entire length of the body; the two flagella inserted close to one another above the oral aperture; contractile vesicle situated immediately above the pharyngeal passage; endoplast spherical, located at a short distance from the posterior extremity. Length of body 1–500″, and less.

Hab.—Pond water, and amongst decaying vegetation.

This species would appear to be synonymous with the *Cryptomonas cylindrica* of Ehrenberg and the *Cryptomonas polymorpha*, in part, of Perty, though, as already intimated, Bütschli has figured and described it as a variety only of *Chilomonas paramœcium*. Setting aside details of external contour, which are subject to variation, the structural characteristics of the two are, however, essentially distinct. The position of the oral aperture in this species is eccentric instead of central, the pharyngeal tract follows the same eccentric course and is much shorter and wider. The substance of the endoplasm of the two is likewise distinct, the symmetrically granular pattern being replaced in the present form by a yellow coloured stroma described by Bütschli as consisting of two even parallel layers continuous throughout the body and separated from one another by a clear linear interspace; this circumstance,

* 'Infusionsthiere,' Abth. iii. Heft i., 1878.

indeed, seems almost to justify the transference of this specific type to the genus *Cryptomonas*. The trichocyst-like structures are apparently confined entirely to *C. paramæcium*, and are probably associated with the symmetrically arranged granular bodies just referred to. It has further to be remarked that the two do not occur together, the present form being obtained mostly in ponds and standing water, and the one previously described in artificial infusions. The sizes of the two animalcules are likewise too divergent to support the opinion of their identity.

Chilomonas amygdalum, S. K. PL. XXIV. FIG. 49.

Body elongate-ovate, almond-shaped, somewhat curved towards the ventral aspect, from three to four times as long as broad; flagella subequal, exceeding the body in length; endoplasm transparent, granular. Length 1–2000″. HAB.—Salt water.

This species was obtained abundantly by the author at St. Heliers, Jersey, in November 1878, in the sea-water containing decaying sea-weed productive of *Trinema marina*, previously described. Its movements when swimming are very active and restless, mostly rotatory, the animalcules being further observed to chase and feed voraciously, after the manner of *Dinomonas*, upon the vibrions and smaller monads contained in the same water. When at rest it anchored itself by a spiral coil of the posterior of the two flagella, as recorded of *C. paramæcium*. Multiplication by longitudinal fission, similar to that which obtains in the last-named type, was frequently witnessed.

GENUS II. OXYRRHIS, Dujardin.

Animalcules free-swimming, persistent in form, ovate or conical, obliquely and unevenly emarginate or excavate anteriorly; flagella two in number, inserted close to each other within the frontal emargination, one of them entirely vibratile, the other coiled spirally and used as an organ of attachment during a state of quiescence, lashed to and fro and driving the animalcule backwards through the water during natation; oral aperture situated in the frontal emargination close to the insertion of the flagellum; endoplasm transparent. Inhabiting sea water.

There can be but little doubt that the *Glyphidium marinum* of Fresenius * and Cohn † is generically if not specifically identical with the species previously introduced by Dujardin under the title of *Oxyrrhis marina*, and which earlier conferred generic title, in accordance with the laws of zoological nomenclature, must necessarily take precedence of the later one. The affinities of this generic type, in consequence of the hitherto imperfect knowledge of its structural details, have not as yet been so much as indicated, but from what is now known of this and other Flagellata, its relationship to *Chilomonas*, last described, is clearly evident. Two species belonging to that genus, *C. paramæcium* and *C. amygdalum*, have been ascertained by the author to present a closely corresponding coiled arrangement of the inferior flagellum; while in both, the smaller notch-like anterior oral emargination may be regarded as identical with the larger and asymmetrical one of *Oxyrrhis*. A chief difficulty hitherto pertaining to the correct interpretation of this animalcule relates to the inability of previous writers, Dujardin excepted, to recognize in the smooth rounded extremity, the posterior region, and in the obliquely emarginate one the anterior one, the true import of these being entirely masked in consequence of the remark-

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* 'Die Infusorien des Seewasseraquarium der Zoologische Gärten, Frankfurt,' 1865.
† "Neue Infusorien in Seeaquarium," 'Zeitschrift für Wissenschaftliche Zoologie,' Bd. xvi., 1866.

able retrogressive motions of the species in its more active state. No one, nevertheless, would dream, on similar grounds, of correlating with the tail end of a cuttle-fish or lobster the functions of a cephalic region, simply because that extremity is directed foremost during natation.

In connection with the retrogressive motions of *Oxyrrhis*, it is worthy of remark that it is the only free-swimming infusorial type, at present known, in which a flagellate appendage serves, as in that of a spermatozoon or a Bacterium, the purpose of propelling in place of drawing the body through the water. Professor E. Ray Lankester (see Family ANISONEMIDÆ) has proposed to confer upon such an organ of propulsion the distinctive title of a "pulsellum."

Oxyrrhis marina, Duj. PL. XXIV. FIGS. 53-61.

Body conical or helmet-shaped, subcylindrical, rounded posteriorly, the anterior margin obliquely and unsymmetrically notched or emarginate, the notch being produced further backwards on the left side, the superior angle of the same region more or less conically prolonged; flagella long and slender, issuing from the posterior extremity of the oblique frontal emargination; oral aperture elastic, capable of incepting food-particles of considerable size; endoplasm transparent, enclosing food-globules and vacuolar spaces, its external surface smooth; contractile vesicle anteriorly located. Length of body 1-900" to 1-500". HAB.—Salt water.

The orginal description of this species, as given by Dujardin* and herewith reproduced in abstract, appears at first sight scarcely reconcilable with the type indicated in the foregoing diagnosis.

"*Body colourless, subcylindrical, rounded posteriorly, the anterior border emarginate, produced superiorly into a long, conical point, external surface rugose; flagella three or four in number, produced laterally from the bottom of the anterior emargination. Length* 1-500". *HAB.—Salt water.*"

The species, as above described, was obtained by Dujardin in salt water from the Mediterranean containing *Ulva*, which had been kept standing for many months. The considerable number of flagellate appendages accredited to the type by its discoverer, and as delineated in his original illustration of the type, reproduced at Pl. XXIV. Fig. 53, constitutes a feature of distinction which would appear to establish the claim of the present form to a separate specific or even generic title. It is evident, however, that Dujardin's presumed three or four flagella represent only the optical aspect of the two appendages now shown to exist, when thrown into their characteristic convolutions, as presently described. The irregular rugosity of the external surface of the body, again attested to in Dujardin's diagnosis, and as evidenced by his accompanying illustrations, coincides with the appearance merely of the miscellaneous mass of food-material usually accumulated within it. A more detailed account of the results of the author's investigation of this flagellate form, as examined in abundance at St. Heliers, Jersey, both in water brought direct from the sea and in long-standing hay infusions compounded with the same medium, may now be proceeded with.

It was not until examples had been killed with the aid of osmic acid and submitted to a magnification of 800 diameters, that the precise number and character of the flagellate appendages, as here recorded, were accurately determined. Under these auspices it was shown that these were two in number, similar in character,

* 'Histoire des Zoophytes Infusoires,' Paris, 1841.

slender throughout, and equal to from one and a half to twice the length of the body in their completely extended state, which they usually assumed under the influence of this reagent. Aided by the experience of a *post mortem* examination, it was not so difficult to recognize their character and relative position in the living examples. In the more easily examined stationary condition one of these flagella, which may be termed the superior one, is thrown backwards in an arcuate fashion over the dorsal border. The second or inferior flagellum meanwhile remains coiled in a spiral form close against the entrance to the oral aperture, and with its distal extremity only protruding and attached to the surface of the slide or cover-glass. Vibratory action, serving the purpose of entrapping food, belongs apparently, chiefly if not exclusively, to the first-named appendage, which usually during the sedentary condition exhibits rapid vibratile movements throughout its distal region. These vibratory motions, combined with the convolute disposition assumed by both flagella, frequently impart to the animalcule an appearance of possessing several shorter filaments, and thus invalidate the interpretation originally connected with the number of these appendages as given by Dujardin. When swimming actively from one spot to another, or rushing about as it is accustomed to do when disturbed, the animalcule is driven backwards through the water by means of the flagellum that remains comparatively inactive and affixed to the ground during the stationary condition, but which is now stretched out anteriorly to its full extent and vigorously lashed from side to side, causing the body to rotate upon its axis alternately from right to left and left to right as motion in a backward direction is effected. The primary or vibratile flagellum during natation appears to be coiled still more closely and completely within the pre-oral excavation. Particles of carmine were eagerly incepted by the specimens under examination, their favourite food being however the various smaller monads and algæ spores contained abundantly in the same infusion, and which were brought within reach during the sedentary condition of the animalcule by the rapid vibratory motions of the primary flagellum. These, though nearly equal in diameter to their own bodies, were swallowed whole, the loop-like convolutions of the basal portion of the inferior flagellum apparently aiding in pushing these food-substances into the oral cavity. Various vacuolar spaces and more solid spherical bodies were frequently observed within the otherwise clear endoplastic substance, one of the former towards the anterior extremity and immediately above the oral excavation representing apparently the contractile vesicle, its pulsatory properties not however being very vigorously manifested. During life, and for a considerable time after death by a natural process, the external cuticle of this animalcule appears to possess a considerable amount of rigidity, being often found, indeed, in the latter case as a mere shell devoid of all trace of the endoplasm and flagellate appendages, and exhibiting under such conditions, as shown at Pl. XXIV. Figs. 58 and 59, a sharp and clear outline of its peculiar unsymmetrically angular form. Under the treatment of dilute osmic acid the entire body however rapidly disintegrates, first assuming a rounded or spherical outline and then, as it were, melting gradually away. Increase by transverse fission, Fig. 57, is the only form of reproduction as yet positively ascertained to occur.

As already intimated, the *Glyphidium marinum* of Fresenius is beyond doubt identical with the present species. The examples referred to this type, figured by Cohn, also entirely harmonize with the form here introduced, excepting that the body is slightly shorter in proportion to the width and more evenly rounded posteriorly. The character of the flagella, while more accurately appreciated by Fresenius, is not fully elicited by either of these authorities; in some instances two flagella are figured, but in others a single one only is represented. The oral aperture is further described and figured by Cohn (see Pl. XXIV. Fig. 29) as apparently supplemented by a projecting, undulating, lip-like membrane, such structure being here readily identified with the optical aspect only of the loop-like convolution of the inferior flagellum.

Fam. VIII. ANISONEMIDÆ, S. K.

Animalcules ovate or elongate, free-swimming or temporarily adherent; flagella two in number, the anterior one or "tractellum" locomotive and vibratile, the posterior one or "gubernaculum" used for steering or trailed inactively in the rear during natation, adherent or anchorate by its posterior extremity in the sedentary condition; oral aperture distinct, mostly associated with a well-defined tubular pharynx; endoplasm transparent, granular. Inhabiting salt and fresh water.

The representatives of this well-defined family group exhibit a type of structure and habits of life strictly analogous to those already recounted of the Heteromitidæ, the one highly important differential feature being that a well-defined and often complex oral apparatus takes the place of the indefinite and dispersed inceptive area characteristic of that family. This oral apparatus in certain members of the Anisonemidæ is so complex as to approach the formula typical of *Nassula* and various other Holotrichous and Hypotrichous Ciliata, and there can be little doubt that these animalcules must be regarded as occupying the foremost position among the Stomatode Flagellata. A further development of the Anisonematous structural type towards the Ciliate division of the Infusoria is afforded by Professor Clark's genus *Heteromastix*, hereafter described, and in which an adoral fringe of cilia is added to the two flagella.

The peculiar modification of the Flagellate appendages of the Anisonemidæ, shared likewise by the Pantostomatous Heteromitidæ, see p. 290, and the Cilio-flagellate type *Heteromastix* just quoted, invites more extended attention. The desirability of introducing a suitable term for the distinction of the posterior or trailing flagellum used for the purpose of temporarily anchoring the animalcule to submerged objects, or rudder-wise for the guidance of its course during natation in these various types, was first recognized by Professor H. James-Clark,* who proposed to distinguish such appendage by the appropriate title of a "gubernaculum." Irrespective of the distinction just alluded to, it has been more recently pointed out by Professor E. Ray Lankester † that even among uniflagellate organisms the single flagellum may exercise two totally distinct functions, and merits in each case a separate appellation. Thus, among all ordinary Flagellata such as *Monas*, *Euglena*, and *Astasia*, the vibratory motion of the single flagellum draws the animalcule after it through the water. The appendage possessing such a tractive function Professor Lankester has proposed to distinguish by the title of a "tractellum." In other flagellate organisms, as illustrated most familiarly by ordinary spermatozoa and Bacteria, the filamentous appendage or appendages fulfils an entirely opposite mission, its motions propelling the body in front of it through the liquid medium. Where it thus acts as an organ of propulsion the authority last quoted confers upon it the name of a "pulsellum." Among the free-swimming monoflagellate Infusoria as at present known, where the locomotive appendage without exception fulfils during natation the rôle of a tractellum, its recognition by such title in contradistinction to a propelling organ or pulsellum is uncalled for. With the biflagellate types, however, exhibiting a differentiation of their two appendages corresponding with that presented by the group now under consideration, Professor Lankester's term as applied to the anterior locomotive flagellum, and as distinctive of the trailing flagellum or gubernaculum of Professor Clark, becomes highly useful, and is here unhesitatingly adopted.

An exceptional instance among the Dimastigous Flagellata, in which one appendage acts as a pulsellum or organ of propulsion, is afforded by *Oxyrrhis marina*, described at pp. 427 and 428. Artificially detached zooids of the

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* 'Memoirs of the Boston Society of Natural History,' 1878.

† Biological Lectures, University College, London, 1876.

normally sedentary collared monads *Codosiga*, *Salpingœca*, &c., have likewise been observed by the author to exhibit retrogressive natatory movements, a circumstance which might indeed be consistently predicated in connection with the motion of the flagellum and the direction of the current it engenders, as described at length at p. 327.

GENUS I. HETERONEMA, Dujardin.

Animalcules free-swimming, ovate or elongate, highly elastic and metabolic; flagella two in number, produced from the anterior extremity, the one vibratile, the other trailing and adherent; oral aperture distinct, situated close to the base of the flagella, usually followed by a well-defined pharyngeal tract; endoplasm transparent, granular. Inhabiting salt and fresh water.

As originally instituted by Dujardin, the genus *Heteronema* included but one imperfectly defined specific type, *H. marina*, which has been usually regarded as exhibiting too close a resemblance to *Anisonema* or *Heteromita* to merit independent recognition. Two other well-defined specific forms are added to this genus by Stein in his recently published volume which, while conforming with Dujardin's original definition, manifest their distinctness from *Anisonema*, *Heteromita*, and other superficially corresponding genera in their extreme mutability of form, or in other words highly metabolic character.

Heteronema acus, Ehr. sp. PL. XXIV. FIGS. 14 AND 15.

Body in extension attenuate fusiform, widest a little behind the centre, tapering towards and sharply pointed at each extremity, eight or ten times as long as broad; flagella slender, unequal, the anterior one, or tractellum, extended rigidly in advance, equalling the body in length, the trailing one, or gubernaculum, about half that length; contractile vesicle situated close to the anterior extremity; a large, oval, endoplast-like structure in the centre of the widest portion of the body; endoplasm finely granulate. Length of body 1-600" to 1-300".

HAB.—Fresh water: Europe and Bombay.

The form as defined in the foregoing diagnosis and accompanying illustrations, is identified by Stein with the *Astasia acus* of Ehrenberg, and referred to its present rightful position. An animalcule presenting a precisely similar external contour and metabolic properties, is likewise figured as "an *Astasia* with two filaments" in one of the note-books kindly placed at the author's disposal by Mr. H. J. Carter, such animalcule having been encountered by that authority at Bombay in the year 1856. In one of the delineations made by Mr. Carter its body is so contracted upon itself that the diameter considerably exceeds the total length, the two anterior and posterior extremities projecting as mere points from the flattened and almost discoidal central region of the body. A similar turbinate or rotulate shape is commonly exhibited among the multitude of protean configurations presented by *Euglena* and *Astasia*, or by the isomorphic Cilio-Flagellate genus *Heteromastix*.

Heteronema globuliferum, Ehr. sp. PL. XXIV. FIGS. 16 AND 17.

Body highly metabolic and changeable in shape, mostly elongate-ovate or pyriform when extended, with a truncate or rounded posterior, and a narrower pointed anterior extremity, two or three times as long as broad;

vibratile flagellum, or tractellum, about twice the length of the body in full extension, the trailing one, or gubernaculum, shorter and more slender ; oral aperture distinct, continued as a long, tubular pharynx ; endoplasm transparent, granular; cuticular surface sometimes faintly striate obliquely; contractile vesicle situated close to the termination of the pharyngeal tube; endoplast oval, subcentral. Length 1–650". HAB.—Fresh water.

The species associated by Stein with the above title is identified by that authority with the *Trachelius globulifer* of Ehrenberg and the *Peranema globulosa* of Dujardin. A form, however, more precisely according with the last-named type as examined by the author has been demonstrated, as recorded at page 225, to be a developmental phase only of the Heliozoon, *Actinophrys sol.*

Heteronema marina, Duj.

Body oblong, irregularly inflated posteriorly, narrower at the anterior extremity, about twice as long as broad ; cuticular surface obliquely striate; vibratile flagellum slender, equalling the body in length, trailing one much thicker and longer. Length 1–420". HAB.—Salt water.

This species was obtained by Dujardin from sea-water at Cette that had been kept standing for a fortnight.

Heteronema pusillum, Perty sp.

Body transparent, very elastic and changeable in shape, subglobose, ovate, or elongate-pyriform at will, mostly the latter; the two flagella developed from the apex of the more usually pointed anterior extremity, very long and slender, the anterior one two or three times the length of the body, the trailing one rather shorter. Length 1–840" to 1–768". Movements straight forward, oscillating. HAB.—Fresh water.

This species, described by Perty under the title of *Dinema pusillum*, is referred with some doubt to the present genus, being not improbably a *Heteromita.*

GENUS II. DIPLOMASTIX, S. K.

Animalcules ovate or elongate, free-swimming or temporarily adherent, plastic and variable in form, but not metabolic; flagella two in number, one vibratile, the other trailing and adherent; oral aperture well defined, situated at the base of the flagella; endoplasm colourless. Inhabiting salt and fresh water.

This new generic title is necessarily instituted for the distinction of those Anisonematous forms holding an intermediate position between *Anisonema* and *Heteronema.* This is manifested by their possession of an ectoplasmic layer, which while sufficiently soft and plastic as to permit the animalcules to assume slowly and under special conditions diverse individual contours, never exhibits that high degree of elasticity and contractility productive of rapid and protean changes of contour as met with in the last-named generic type. On the other hand, it is never so firm and indurated as obtains in *Anisonema.* Two of the species here described have been recently referred by Stein to the genus *Bodo* of Ehrenberg, but evidently possess nothing in common with the representatives of that generic group as recognized in this volume or associated with that title by most recent authorities.

Diplomastix caudata, Duj. sp. Pl. XXIV. Figs. 1–10.

Body variable in form, gibbously ovate, sometimes rounded, but more usually tapering and bent obliquely upwards posteriorly, the anterior extremity sharply pointed or rostrate, curved towards the ventral aspect; flagella slender, subequal, exceeding the body in length, inserted close to each other at the apex of the rostrate process; contractile vesicle located near the anterior extremity; endoplast subcentral; endoplasm transparent, finely granular. Length 1–1500″ to 1–500″.

Hab.—Pond water and organic infusions in both salt and fresh water.

This species is figured without an accompanying description, in Stein's recent volume,* under the title of *Bodo caudata* Stein, and with the associated synonym of *Amphimonas caudata* of Dujardin, a type again which is regarded by this last-named authority as probably identical with the *Bodo saltans* of Ehrenberg. The present author agrees with Stein in the recognition of this Ehrenbergian species as a totally distinct form, and has arrived at the conclusion that there are no less than three specific types closely resembling in general aspect the one now under consideration, but which exhibit under more minute examination easily apprehended distinctive features. All of these occur abundantly in hay and other vegetable infusions, and have recently formed the subject of special investigation. The present type, *D. caudata*, may be at once recognized by its larger size and movements in the water, which consist chiefly of steady progress forwards in a straight line for a more or less considerable distance, the rostrum directed downwards and rooting as it were among the organic debris, while the body sways to and fro with a rapid vacillating or hitching action, such mode of locomotion is quite distinct from the leaping or constantly reversed or tacking motion of the two smaller types next described under the titles of *Diplomastix affinis* and *D. saltans*. Compared with this last-named form, the contractile vesicle is also found to occupy an exactly inverse position.

The more conspicuous individual diversities of contour exhibited by the present species are amply illustrated in the accompanying figures; it is at the same time worthy of remark that the author has found the shorter and posteriorly rounded shape, Pl. XXII. Fig. 1, connected always with the earliest appearance of this form, the more or less attenuate caudal prolongation, as shown at Figs. 2 and 3, not making its appearance until the third or fourth day after the advent of the animalcule in any quantity upon the field. This attenuate extension of the posterior extremity would seem in the present type to take the place of the more irregular pseudopodic processes, emitted mostly from the same region, in many Pantostomatous forms antecedent to the act of coalescence or encystment. Both of these phenomena have been abundantly observed, as also the breaking up of the encysted zooids into four or eight oval macrospores which shortly develop flagella and assume the form and characteristic movements of their parents. It was also found that the macrospores so produced were plentifully developed on the dried hay when first placed to macerate (see Pl. XI. Fig. 2 *c*), lying scattered in little heaps, without any common investing envelope, among the ridges and sinuosities of the surface of the separate blades or stalks. The motile zooids derived from these spores did not make their appearance until the fourth day of maceration, and remained then for upwards of a month as one of the most abundantly represented types in the infusion, sometimes crowding the field of view to the exclusion of all other forms.

By Stein this animalcule is figured as possessing a distinct tubular oral aperture situated immediately beneath the recurved rostrum. Athough the inception of food was observed at this point, the author has not yet succeeded in detecting any

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* 'Infusionsthiere,' Abth. iii., 1878.

such permanently visible aperture. According to this last-named authority this type would seem also to possess the same predatory habits as Cienkowski's monoflagellate genus *Colpodella*, he in certain of his figures representing examples extracting and swallowing the nutrient protoplasm of a species of *Chlamydomonas*, while in another instance as many as eight animalcules have fastened to and are feasting, like so many rats, upon the body of a large *Colpoda cucullulus*. The example figured by Stein as illustrating one zooid preying in a similar manner upon another individual of its own species, is evidently a misinterpretation of the first stage of coalescence or genetic union, in which, as frequently observed by the author, see Pl. XXIV. Fig. 4, one animalcule fixes itself by its rostrum to the dorsal region of its selected mate, the substance of the two becoming gradually amalgamated. Although obtained in hay-infusions simultaneously prepared from both salt and fresh water, it was found by the author to develop far more abundantly in the latter medium.

Diplomastix caudata may be said to be one of the most ubiquitous representatives of the Flagellate series, it putting in its appearance wherever decaying organic matter, animal or vegetable, may be found.

Diplomastix affinis, S. K. Pl. XXIV. Fig. 13.

Body gibbously ovate, the posterior extremity rounded, or pointed and bent towards the ventral aspect, the anterior end rostrate and recurved in the same direction; flagella of uniform size, slender, exceeding the body in length; contractile vesicle single, posteriorly situated; endoplast spherical, subcentral. Length 1–1500″ to 1–1200″.

Hab.—Hay-infusions in salt and fresh water.

The smaller size, persistent ventral curvature of the posterior extremity, and location of the contractile vesicle, serve to distinguish this species from the preceding, to which may be added the still more easily recognized and distinct mode of locomotion. In *D. caudata* this, as already described, consists chiefly of progress through the water in a straight line for a considerable distance, accompanied by a peculiar vacillating or hitching gait; a similar vacillating action is noticeable in the present type, but the animalcule never maintains its straight course for a long distance, it bringing itself up suddenly and with a jerking motion every few seconds through the adhesion of the trailing flagellum or gubernaculum, and then starting off, like a ship tacking, in a different direction. Frequently also it remains anchored by its gubernaculum, and fishes steadily with its extended anterior flagellum or tractellum after the manner of an ordinary *Heteromita* or *Anisonema*. This sedentary phase has not so far been observed in *D. caudata*. Developmental phenomena similar to those recorded of the last-named species were observed of the present type, and it was further found that it multiplied with equal rapidity in hay-infusions in both fresh and salt water.

Diplomastix saltans, Ehr. sp. Pl. XXIV. Figs. 11 and 12.

Body irregularly ovate, rounded posteriorly, with a convex dorsal and concave ventral surface, the anterior extremity pointed, more or less curved, often presenting a notched or bilabiate aspect; the trailing appendage, or gubernaculum, longer and stouter than the vibratile flagellum, or tractellum, nearly twice the length of the body, the two inserted at some little distance from the anterior extremity; contractile vesicles two in number, anteriorly situated; endoplast subcentral. Length 1–1600″ to 1–900″.

Hab.—Vegetable infusions.

This species is distinguished from the preceding by the notched or bilabiate contour of the anterior extremity and by the more posterior insertion of the flagella, Its habits are mostly sedentary, the animalcules remaining attached or anchored in social clusters by the temporary adhesion of their gubernacula, and briskly springing to and fro to the full length of their "tether" in various directions. By Ehrenberg this species was first described under the title of *Bodo saltans*, the same name accompanying the illustrations which alone are given in Stein's recently issued work.

GENUS III. ANISONEMA, Dujardin.

Animalcules ovate, free-swimming or temporarily attached, persistent in form, having a more or less indurated cuticular investment; oral aperture distinct, usually followed by a well-defined pharyngeal tract; anal aperture postero-terminal; flagellate appendages two in number, of diverse function, originating close to one another on the ventral surface, the anterior filament, or tractellum, extended in advance, vibratile, subserving the purposes of locomotion and the capture of food, the posterior flagellum, or gubernaculum, trailing in the rear, distally adherent, non-vibratile, utilized during natation as a rudder and also for temporarily attaching the animalcule, cable-wise, to foreign objects; contractile vesicles and endoplast conspicuously developed; multiplying by longitudinal fission, and by the production of internal germ-masses. Inhabiting fresh and salt water, and infusions.

By many recent writers it has been proposed to merge both *Heteromita* and *Heteronema* in the present genus, upon the supposition that the softer consistence of the external envelope and contained body-substance in these types represents merely a slightly more marked difference of degree, insufficient for the purposes of generic diagnosis. As demonstrated, however, on a previous page, *Heteromita* is a perfectly distinct, though isomorphic form, of much lower organization, having no distinct oral aperture, and belonging necessarily to the same Pantostomatous primary group as *Monas*, *Spumella*, and *Anthophysa*. *Heteronema*, on the other hand, manifests its distinctness from the present genus by the extreme plasticity of its cuticular investment and extraordinary metabolic properties. Evidence supporting the opinion that the members of the genus *Anisonema* possessed a distinct oral aperture was first adduced by Professor H. James-Clark * who, while unable to demonstrate the exact position of this aperture in *A. grande*, distinctly saw food-particles pass in at the anterior extremity. This authority likewise suspected the existence of an anal aperture at the posterior end of the body, such anticipation being entirely confirmed by the investigations of the present author, which are again further corroborated by Stein. The determination of the precise position and structure of the oral aperture, with its accompanying well-defined pharyngeal tract, has been recently accomplished by both Stein and O. Bütschli.

Anisonema grande, Ehr. sp. PL. XXIV. FIGS. 26–30.

Body ovate or oblong, depressed, the dorsal surface slightly convex, the ventral one flat, or more or less concave, rounded posteriorly, narrower and pointed anteriorly, about twice as long as broad; cuticular investment smooth and indurated; flagella originating at a little distance from one another close to the anterior extremity, the anterior vibratile flagellum, or tractellum, slender, scarcely equalling the body in length, the trailing flagellum, or gubernaculum, three or four times the length of the other,

* 'Memoirs Boston Soc. Nat. Hist.,' 1868.

usually considerably thicker towards the base; oral aperture adjacent to the origin of the posterior flagellum, communicating with a short, tubular pharyngeal tract; contractile vesicle single, situated behind or a little to the left of the oral aperture; endoplast spherical or ovate, located on the right-hand side towards the posterior extremity. Length 1–1250" to 1–900".

HAB.—Pond water, amongst *Confervæ.*

This typical species of the genus, more generally known by Dujardin's name of *Anisonema acinus*, and recently figured and described by Professor Clark as *Anisonema concavum*, is identified by Stein with the *Bodo grandis* of Ehrenberg, whose primarily conferred specific title necessarily takes the precedence of all others. The motions of this animalcule in the water, typifying also those of the genus generally, are very characteristic, but at the same time closely resemble those of the ordinary members of the genus *Heteromita* previously described. Progress through the water consists chiefly of a smooth, gliding motion in a straight line, the shorter anterior flagellum, or tractellum, being projected and vibrating in advance, while the long posterior one, or gubernaculum, as it is designated by Professor Clark, trails cable-wise, like a boat dragging its anchor, in the rear. This even locomotion is occasionally varied by a laborious hitching gait, accompanied by a swinging of the animalcule from side to side, while now and then the body is brought up sharply and propelled in an opposite direction, through the adhesion to the ground, and simultaneous loosely spiral contraction, of the trailing gubernaculum. The locality proving auspicious and the food-supply plentiful, the little animalcule often fixes itself by the distal extremity of the last-named organ and rides gracefully at anchor, fishing vigorously with its extended tractellum, detaching itself after a short interval, and progressing as before in search of a new pasture-ground.

The aspect of this species as seen in profile is subject to considerable variation according to the point of view taken, and in consequence of the asymmetrical development of the ventral excavation. Its most characteristic concavo-convex or meniscoid contour is best illustrated when seen end-on from behind, as represented at Pl. XXIV. Fig. 26. The ventral excavation, so conspicuous under these conditions, is shown to be abruptly and obliquely deepened on its left-hand border, which thus appears to be recurved over it, while it narrows off gradually on the right-hand one. It is this character of the ventral furrow that imparts to the animalcule a meniscoid contour as seen only from the right-hand side, a view from the opposite or left-hand one yielding the simpler plano-convex shape that has been more frequently ascribed to it. As shown by Bütschli, individuals vary somewhat in their dorsal contour, the ovate or "pip-shaped" outline being sometimes replaced by a shorter, broader, and almost elliptical form. Increase by longitudinal fission has been observed in this species by various investigators, the two flagella destined for the new zooid often being developed at the anterior extremity of the primary individuals prior to the commencement of the dividing process. At this stage, Pl. XXIV. Fig. 27, the animalcule has the appearance of possessing two or three vibratile anterior flagella, and a single or double trailing one. De Fromentel,* supposing it to represent a new type, has figured and described this transitional condition under the title of *Diplomita insignis*, while he confers that of *Heteromita crassa* upon the ordinary biflagellate condition of the same animalcule.† Stein, in his recently published volume,‡ represents the anteriorly located contractile vesicle as having frequently a rosette-like aspect through the association of smaller lateral lacunæ, and also the development, within the central endoplasm, of

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* 'Études sur les Microzoaires,' Paris, 1876.

† This earlier though fruitless employment of the term *Diplomita* by De Fromentel had escaped the author's attention when proposing the same title for the biflagellate animalcule described at p. 289. It being desirable to substitute a new generic name for this altogether distinct form, that of *Diploselmis* is herewith given in exchange.

‡ 'Infusionsthiere,' Abth. iii., 1878.

two large ovate germ-masses, modified apparently from a single pre-existing endoplast. Illustrations of these special features as observed by Stein are reproduced at Figs. 28 and 29 of the accompanying plate. This more complex modification of the contractile vesicle, while of rare occurrence among the Flagellata, will be found to recur repeatedly with the more highly differentiated Ciliata described in the succeeding volume.

Anisonema truncatum, Stein. Pl. XXIV. Figs. 24 and 25.

Body elongate, obconical or subtriangular, widest and truncate anteriorly, tapering gradually towards the posterior extremity, rather over twice as long as broad; trailing flagellum about twice the length of the body, the vibratile one slender, not one-half as long as the preceding; parenchyma coarsely granular; contractile vesicle situated close to the termination of the short, tubular pharynx; endoplast elongate ovate, located posteriorly near the left lateral border. Length 1–600″.

Hab.—Fresh water.

Anisonema ludibundum, S. K. Pl. XXIV. Figs. 35 and 36.

Body elliptical, very slightly depressed, somewhat narrower, but rounded at the anterior extremity, cuticular surface smooth; parenchyma transparent, granulate; flagella equally slender, about one and a half times the length of the body, inserted at some little distance from the anterior extremity; contractile vesicles two in number, located side by side above the point of insertion of the flagella; anal aperture distinct, posteroterminal. Length 1–2500″. Hab.—Vegetable infusions, gregarious.

This species was obtained by the author in some abundance from a flower-vase in which the plants had been left until their stems were in an advanced state of decomposition. Viewed in profile the body is seen to be much thicker than either of the preceding species, from which it also differs in its considerably smaller size, in the possession of two conspicuous contractile vesicles, and in the more rearward insertion of the flagella. A number of animalcules were generally found in close proximity, attached by their gubernacula and vigorously fishing with their extended anterior flagella or tractella. Ever and anon a single individual would, in the course of its oscillations, come in contact with a neighbour, causing it to rebound against its fellows, stimulating those also into abnormal action; the whole colony thus aroused would whirl about for some seconds, apparently in sport with each other, and in a manner comparable to flies playing, or to that recorded further on of the Ciliate type *Cyclidium glaucum*. Effete granular matter was distinctly observed passing out at the posterior extremity of one of the zooids, as shown at Pl. XXIV. Fig. 35.

Anisonema intermedium, S. K. Pl. XXIV. Figs. 37–39.

Body oval, depressed, slightly narrower anteriorly, surface smooth; in lateral view thicker posteriorly, and gradually narrowing towards the anterior end; the ventral surface flat or slightly concave; flagella inserted close to the anterior extremity, equally slender, about twice the length of the body. Length 1–2000″. Hab.—Sea water.

The contour of this animalcule as seen in profile, together with its minute size and salt-water habitat, appears to justify its recognition as a distinct species. A refringent ovate body, apparently the endoplast, was detected in one example close to the centre of the left-hand border, and a clear vacuolar space near the posterior extremity, which may have been the contractile vesicle, and which would in that case be situated in a position precisely opposite to that of the previously described species. Mingled with the ordinary forms, smaller flattened ovate zooids, attached by the pointed anterior end by a long anchoring flagellum, and having as yet no second vibratile one, were observed; these, as delineated at Pl. XXIV. Fig. 38, apparently represented an earlier and larval condition of the adult individuals, though their growth to the same has yet to be determined. As shown in the account given of *Heteromita rostrata* and *H. uncinata*, a similar mono-flagellate larval condition obtains also in that isomorphic genus.

Anisonema (?) griseolum, Perty sp.

Body elongate-ovoid, twice as long as broad, narrower posteriorly; flagella equal, not much exceeding the body in length; endoplasm granular, greyish brown. Length 1–250″.

HAB.—Pond water; movements slow, mostly rotatory.

This species, described and figured by Perty under the title of *Dinema griseolum*, and referred by Diesing to the genus *Heteronema*, does not appear to have been met with by any recent investigator. Its dimensions exceed those of any other representative of the present genus yet recorded, the rotatory motion attested to by Perty is also abnormal.

Doubtful Species.

De Fromentel * has bestowed new names on several forms included by him in the genus *Heteromita*, held by him, in common with many other writers, to be the equivalent of the genera *Heteromita*, *Heteronema*, and *Anisonema* of Dujardin. Certain of these possibly belong to *Anisonema*, but are too vaguely figured and described in most instances for reidentification. His *Heteromita* (*Anisonema* ?) *gibbosa*, characterized by its oval dorsal contour and gibbous enlargement of the posterior extremity as seen in profile, with a thicker trailing flagellum, equalling twice the length of the body, is the only one out of these it is desirable to retain. No dimensions or details as to habitat are given with his description, though if drawn to the same scale as most of the other figures in his plate, its length would be about the 1–1000th part of an inch. The *Heteromita crassa* of the same writer is beyond doubt identical with the *Anisonema acinus* of Dujardin.

The magnification of 400 diameters only, employed by De Fromentel for the delineation and description of the Flagellate forms treated of in his book, is altogether inadequate for their successful or even serious investigation.

GENUS IV. ENTOSIPHON, Stein.

Animalcules free-swimming, persistent in shape, more or less ovate, usually compressed, the cuticular surface indurated; flagella two in number, the one trailing and the other vibratile, inserted close to each other near the oral fossa; oral aperture terminal, followed by a distinct tubular pharynx, the walls of which are indurated and capable of protrusion in the form of a horny tube beyond the anterior margin; endoplasm transparent, granular; contractile vesicle and endoplast conspicuous. Inhabiting fresh water.

This genus is founded by Stein † on the *Anisonema sulcata* of Dujardin; the essential feature distinguishing it from the ordinary members of the genus *Anisonema*

* 'Études sur les Microzoaires,' 1876.

† 'Infusionsthiere,' Abth. iii., 1878.

being the possession of a separately protrusible pharyngeal tube, apparently of a corneous nature, and comparable to that met with in *Prorodon*, *Nassula*, *Chilodon*, and many other Ciliata.

Entosiphon sulcatus, Duj. sp. PL. XXIV. FIGS. 31–34.

Body oval, depressed, slightly narrower anteriorly, the frontal border obliquely notched on the left-hand side; the dorsal and ventral surfaces usually traversed by four or five longitudinal furrows; flagella equally slender, inserted at a little distance from each other, slightly to the left and close to the anterior notch, the posterior appendage or gubernaculum two or three times the length of the body, the anterior vibratile one usually shorter; pharynx tubular, extending in a median line from the oral aperture at the anterior extremity through nearly three-quarters of the entire length of the body, independently exsertile; contractile vesicle single, situated a little behind the insertion of the flagella and to the left of the pharyngeal tube; endoplast spherical, located posteriorly towards the centre of the left-hand border. Length of body 1–1250". HAB.—Pond water.

The cuticular sulci, obliquely notched contour of the anterior border, and enormous development of the pharyngeal tube, together with its protrusible properties, serve to distinguish this type from the various species of *Anisonema* with which it was originally included by Dujardin. Longitudinal fission, commencing at the anterior extremity and separating the body into two equal moieties, has been observed in this species by both Stein and Bütschli, the animalcule, preparatory to such process, developing two additional flagella. The young zooids, according to Stein, are perfectly smooth and pointed at each extremity. The contractile vesicle is represented by this last authority as often exhibiting a rosette shape similar to that of *Anisonema grandis*, while a large ovate germ-mass may in like manner be developed from the pre-existing simple spheroidal endoplast. After the death of the animalcule the indurated cuticle, with the enclosed horny pharyngeal tube, resists decay for a considerable interval, presenting under such conditions the aspect delineated at Pl. XXIV. Fig. 34.

Fam. IX. SPHENOMONADIDÆ, S. K.

Animalcules free-swimming, persistent in shape, cuticular surface indurated; flagella two in number, one long and one short, both vibratile and extended anteriorly; oral aperture succeeded by a distinct tubular pharynx; endoplasm colourless, granular; endoplast and contractile vesicle conspicuous.

GENUS I. SPHENOMONAS, Stein.

Animalcules free-swimming, persistent in shape, subfusiform, angular or facetted; flagella terminal, two in number, one long and the other short, both extended and vibratile; oral aperture situated at the base of the flagella, followed by a distinct tubular pharynx, the distal end of which usually communicates with the contractile vesicle; endoplasm transparent, granular.

This generic group, as here defined, is made to include the genus *Tropidocyphus* of Stein, in addition to that of *Sphenomonas* as constituted by that authority; the distinction between the two specific forms only as yet relegated to these respective genera being apparently too slight for generic separation. Excepting for the presence of the second shorter flagellum these animalcules would appear to correspond chiefly with those of the monoflagellate form *Petalomonas*.

Sphenomonas quadrangularis, Stein. PL. XXIV. FIGS. 21–23.

Body subfusiform, or quadrangular, twice as long as broad, widest centrally and tapering towards each extremity, divided by four oppositely placed, longitudinal, keel-like ridges, so as to form a quadrate outline in transverse optical section; longer flagellum stout, nearly twice the length of the body, shorter one slender, scarcely one-quarter the length of the preceding; endoplast subcentral; parenchyma transparent, often enclosing a large, ovate, apparently amylaceous body; contractile vesicle confluent with distal end of the tubular pharynx. Length 1–600″.

HAB.—Fresh water; dividing by longitudinal fission.

Sphenomonas octocostatus, Stein sp. PL. XXIV. FIGS. 18–20.

Body symmetrically ovate or subfusiform, compressed, about one and a half times as long as broad, the posterior extremity pointed, the anterior one deeply notched or emarginate; cuticular surface ornamented with eight longitudinal and sometimes obliquely twisted keel-like ridges; both flagella slender, the longer one about twice the length of the body, the smaller one about one-quarter the length of the preceding; endoplasm coarsely granular; contractile vesicle situated close to but not confluent with the posterior termination of the tubular pharynx; endoplast subcentral, reniform, often developing into a large ovate germ-mass. Length 1–400″.

HAB.—Fresh water.

This species is figured by Stein* under the title of *Tropidocyathus octocostatus;* in the absence of full descriptive details it appears, however, to accord so closely in all essential points with the type last described, that it has been thought desirable to include it in the same genus. The addition to the *Sphenomonas quadrangularis* of four intervening longitudinal ridges and the emargination of the anterior border are alone required to produce, in accordance with Stein's figures, an animalcule absolutely identical with the present form. The encysted condition of this species, as shown at Pl. XXIV. Fig. 20, presents a remarkable resemblance to the carinated seed of an umbelliferous plant, such as *Petroselinum* or *Coriandrum*.

Order VII. CILIO-FLAGELLATA, C. & L.

Animalcules free-swimming, locomotive appendages consisting of one or more lash-like flagella, and a supplementary more or less highly developed ciliary system; oral aperture usually distinct.

As first instituted by Claparède and Lachmann,† this order included only the several genera forming the single family group of the Peridiniidæ. The results of more recent investigation have, however, rendered it necessary to extend its

* 'Infusionsthiere,' Abth. iii., 1878.
† 'Études sur les Infusoires,' Geneva, 1858.

FAMILIES AND GENERA OF CILIO-FLAGELLATA.

Fam. I. PERIDINIIDÆ. Bearing one or more flagella and a distinct ciliary girdle.	Flagellum single	Ciliary girdle central.	No cuirass.	Cilia describing a half-circle ..		.. 1. *Hemidinium.*
				Cilia forming a complete girdle.	No supplementary cilia. ..	.. 2. *Gymnodinium.*
					With supplementary cilia .	.. 3. *Melodinium.*
			En-cuirassed.	No horn-like processes.	Cuirass simple	.. 4. *Glenodinium.*
					Cuirass facetted	.. 5. *Peridinium.*
				With horn-like processes		.. 6. *Ceratium.*
		Ciliary girdle excentric.	With raised ventral plates			.. 7. *Dinophysis.*
			No ventral plates			.. 8. *Amphidinium.*
		Ciliary girdle terminal.	Body encuirassed, smooth			.. 9. *Prorocentrum.*
	Two flagellate appendages ..		.. Encuirassed and horned, ciliary girdle central			.. 10. *Dimastigoaulax.*
Fam. II. HETEROMASTIGIDÆ. Bearing one vibratile and one trailing flagellum, cilia forming a short adoral fringe.			Body highly metabolic			.. 11. *Heteromastix.*
Fam. III. MALLOMONADIDÆ. Flagellum single, terminal; body clothed with long setose cilia.			Body oval, persistent in form			.. 12. *Mallomonas.*
Fam. IV. STEPHANOMONADIDÆ. Flagellum single, terminal, produced from the centre of a wreath-like crest of cilia.			Flagellum unretractile			.. 13. *Stephanomonas.*
			Flagellum retractile..			.. 14. *Asthmatos.*
FAM. V. TRICHONEMIDÆ. Flagellum single, supplemented by a more or less complete ciliary investment.			Body metabolic			.. 15. *Trichonema.*
			Body persistent in form			.. 16. *Mitophora.*

boundaries for the admission of diverse other types which maintain under variously modified conditions the characteristics of the two larger sections of the Flagellata-Eustomata and ordinary Ciliata, and thus intimately connect together these, at first sight, seemingly altogether independent groups. In illustration of a few of the more prominent relationships that are established between the two series of the typical Flagellata and Ciliata through the intermedium of the present order, it may be submitted that the retraction of the single flagellum is alone needed, in the genera *Stephanomonas* and *Asthmatos*, to convert these types into simple Peritricha resembling *Strombidium*, though in the case of *Asthmatos* it is worthy of remark that the constituent elements of the terminal tuft of cilia are so long as to partake almost of the nature of flagella, thus conveying to the animalcules an aspect closely corresponding with that of the multiflagellate type *Lophomonas*. In *Trichonema* and *Mitophora* a similar suppression of the single flagellate appendage would transform these animalcules into simple Holotricha; while in the case of *Heteromastix*, where the flagella constitute the most important orgahs of locomotion, it requires only the obliteration of the adoral ciliary fringe to produce a typical representative of the simply flagellate genus *Heteronema*. The affinities of the important family group of the Peridiniidæ are discussed at length in connection with the description given of that earliest recognized and typical section of the Cilio-Flagellata.

K. M. Diesing, in his 'Revision der Prothelminthen,'* distinguishes this Cilio-Flagellate order of the Infusoria by the title of the *Mastigophora Trichosomata*.

An analytical key to the various families and genera of the Cilio-Flagellata, as here delimited, is given on the opposite page.

Fam. I. PERIDINIIDÆ, Ehr.

Animalcules free-swimming, persistent in form, sometimes naked, but mostly invested by an indurated carapace or cuirass; flagellum usually single, ciliary system constituting a more or less perfectly developed zone-like girdle; oral aperture distinct; an eye-like pigment-spot frequently developed. Inhabiting salt and fresh water, often highly phosphorescent. Increasing by fission and by subdivision into sporular elements.

The representatives of this highly characteristic family group are readily distinguished by the girdle-like disposition of the cilia which supplement the customarily single, but in one instance double flagellate appendage. It is further found that the body is with but few exceptions enclosed within a densely indurated carapace or cuirass, which is itself frequently composed of a greater or less number of polygonal and often elegantly sculptured facets. By far the larger number of species are inhabitants of salt water, agreeing in this respect with the pelagic *Noctilucæ*, with which they further correspond, in many instances, by the exhibition of brilliant phosphoric properties. Excepting for the presence of the equatorial ciliary girdle it may be further noted that in such a non-encuirassed form as *Gymnodinium* the resemblance of external contour to that of *Noctiluca* is so conspicuous—including the possession in each case of a corresponding and apparently homologously developed non-ciliated vertical or ventral groove—that it would not seem inconsistent to anticipate that forms will yet be met with that still more closely connect these two types with one another. In no representative of the Peridiniidæ, however, as yet examined, has the internal body-substance or endoplasm been observed to exhibit that peculiar vacuolar or reticulate character so eminently distinctive of the Noctilucidæ. In the possession, more especially by the fresh-water members of this group, of a frequently brilliant scarlet eye-like pigment-spot, combined with the pervading green or other coloured hue of the general body-substance, some distant affinity with the family of the Euglenidæ would seem to be

* 'Sitz. der Kaiser. Akad. der Wiss. Wien,' 1865.

maintained. In common with these simpler Flagellata, it is further noteworthy that they often occur in such prodigious numbers as to impart a distinct tint to the water they inhabit. Interesting data connected with this last-named circumstance will be found recorded in the descriptions hereafter given of *Peridinium sanguineum* and *Melodinium uberrimum.*

GENUS I. HEMIDINIUM, Stein.

Animalcules free-swimming, persistent in form, but not encuirassed; flagellum single, supplemented by an adoral fringe of cilia which is developed in a groove that extends half-way only round the circumference of the body, and at one extremity of which groove the oral aperture is located.

Hemidinium nasutum, Stein.

Body much compressed, somewhat kidney-shaped, the left border straight, the right one convex; the equatorial, semicircular, ciliated furrow continued obliquely backwards from the ventral towards the dorsal region of the left body-half; the anterior moiety of the ventral surface further distinguished by a faintly impressed vertical groove, the bottom of which gives origin to the single flagellum; endoplast roundish, located in the hinder body-half. Dimensions unrecorded.

HAB.—Fresh water; colour yellow.

This as yet single known representative of the genus *Hemidinium* is briefly described without accompanying figures in the text of Stein's recently published volume.* The oral aperture, though not directly observed, was adjudged to be located close to the ventral extremity of the semicircular ciliated groove, while the capacity of assimilating solid nutriment was fully proved by the presence of incepted green corpuscles of considerable size. The integument in this type is reported by Stein to be of firm consistence, and although not indurated and differentiated to such an extent as to partake of the nature of a cuirass or carapace, exhibits a marked contrast in this respect to the comparatively soft and yielding cuticular surface of *Gymnodinium.*

GENUS II. GYMNODINIUM, Stein.

Animalcules free-swimming, more or less persistent in form, but not encuirassed; cilia forming a continuous fringe along the interior of a transverse groove or furrow which completely encircles the equatorial region of the body, a second non-ciliated groove produced mesially on the ventral surface from the transverse furrow towards the anterior or apical extremity; oral aperture and the insertion of the single, long, lash-like flagellum located ventrally, in close vicinity to the juncture of the transverse and longitudinal grooves. Inhabiting salt and fresh water.

This genus is instituted by Stein † for the reception of several forms, including notably the as yet very imperfectly observed *Peridinium fuscum* and *pulvisculus* of Ehrenberg and the *Peridinium monadicum* and *P. corpusculum* of Perty, in which the body and locomotive appendages, while according with those of the ordinary *Peridinia*, differ from these in the entire absence of an indurated cuticular investment or cuirass. As a consequence of this naked and comparatively soft consistence of the external

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* 'Infusionsthiere,' Abth. iii., 1878. † Ibid.

envelope, the animalcules assume after death various irregular shapes, and speedily undergo complete disintegration. As indicated by Stein, *Gymnodinium* may be regarded as the ground or stock form of the various more complex representatives of the Peridiniidæ.

Gymnodinium fuscum, Ehr. sp. PL. XXV. FIGS. 17 AND 18.

Body oval, slightly compressed, rounded posteriorly, acuminately pointed anteriorly, nearly twice as long as broad ; surface smooth, colour light brown ; no eye-like pigment-spot. Length 1–430″ to 1–280″. HAB.—Fresh water.

In the figures of this species, as given by Ehrenberg in connection with the title of *Peridinium fuscum*, and here reproduced, the flagellate appendage was apparently overlooked, while the vertical as well as the transverse groove is represented as bordered with cilia. The presumed example of longitudinal fission delineated by the same authority (see Pl. XXV. Fig. 18), is regarded by Stein as an advanced phase of the process of fusion or genetic union between two previously independent zooids, which he has frequently observed to take place under similar auspices in connection with the species next described.

Gymnodinium pulvisculus, Ehr. sp. PL. XXV. FIGS. 19 AND 20.

Body subspheroidal, slightly trilobate, surface smooth ; flagellum conspicuous, two and a half times as long as the body ; colour light brown or greenish-yellow. Length 1–2300″ to 1–1150″.

HAB.—Amongst *Confervæ* with *Chlamydomonas pulvisculus*, often in great numbers.

As represented in Ehrenberg's figures of this species, coloured matter is freely incepted. Perty reports the presence of an eye-like pigment-spot in the anterior body-half, but such a structure is not indicated in Ehrenberg's original drawings and descriptions. The process of conjugation or fusion has been observed by Stein, who identifies with this phenomenon the representations of presumed longitudinal fission given by Ehrenberg.

Gymnodinium corpusculum, Perty sp.

Body ovate or elliptical, segments very unequal, the posterior one considerably the smaller ; flagellum conspicuous, about twice the length of the body ; no eye-like pigment-spot ; enclosing variously coloured granules. Length 1–1120″. HAB.—Fresh water, among *Marchantia polymorpha.*

Described by Perty * under the title of *Peridinium corpusculum.*

Gymnodinium monadicum, Perty sp.

Body ovate or subspheroidal, segments unequal, the hinder one being considerably the smaller of the two ; eye-like pigment-speck distinct, subcentral ; flagellum conspicuous, two or three times as long as the body ; endoplasm colourless, enclosing green food-corpuscles. Length 1–1120″.

HAB.—Pond water.

This species was reported by Perty from the Bernese Alps. Stein † has encountered an apparently identical form in the neighbourhood of Prague, recording of it

* 'Zur Kenntniss kleinster Lebensformen,' Berne, 1852.
† 'Infusionsthiere,' Abth. iii., 1878.

that the body is transparent or bluish-white, with a sharply defined red eye-like pigment-speck, a long flagellum, and very delicate ciliary girdle; the body was usually observed to contain a greater or less number of devoured *Chlamydomonas monadina.* By a careful examination a round light spot was detected near the point of junction of the characteristic equatorial and longitudinal body grooves, which apparently betokened the oral aperture; the long flagellum was inserted close to this oral fossa. Stein had previously provisionally conferred upon this type the name of *Peridinium vorticella*, but recognizes in his most recently published volume its probable identity with Perty's type.

Gymnodinium marinum, S. K. PL. XXV. FIGS. 60 AND 61.

Body subspheroidal or trilobate from the dorsal or ventral aspect, kidney-shaped, with a convex dorsal, and concave ventral surface, as seen in profile; flagellum conspicuous, its length equalling twice the diameter of the body; endoplasm transparent, usually enclosing numerous spheroidal corpuscles; oral aperture distinct. Diameter 1–1000″. HAB.—Salt water.

This species was obtained abundantly by the author in an infusion of hay in sea-water made at St. Heliers, Jersey, in February 1879, and after the expiration of just one month from the first preparation of the maceration. The motions of the animalcule in the water were rapid and oscillating, and its habits eminently predatory, closely resembling those of *Dinomonas.* As observed of the two species of the last-named genus, it was continually engaged in chasing and devouring the smaller *Heteromitæ* and other monads contained in the same infusion, its oral aperture during the engulfment of its captured prey, as shown at Pl. XXV. Fig. 61, being expanded and conspicuously indicated. It would seem just possible that the *Peridinium monas* of Ehrenberg, briefly described as "very small, obtuse, without horns, remarkably social. Diameter 1–1728″. Hab. Baltic Sea," may be identical with this species.

Gymnodinium Lachmanni, S. K. PL. XXV. FIGS. 58 AND 59.

Body elliptical, twice as long as broad, equatorial groove very oblique; endoplasm transparent, enclosing spheroidal corpuscles. Length 1–600″.
HAB.—Salt water.

This species is simply recorded by Claparède and Lachmann as a minute *Peridinium*, encountered in salt water on the coast of Norway. Its relationship to the other members of the present genus is obvious, though at the same time it differs, in its greater proportionate length and in the conspicuously oblique direction of the equatorial groove, from the marine form previously described.

Gymnodinium roseolum, Schmarda sp. PL. XXV. FIG. 53.

Body elliptical; segments uneven; flagellum indistinct; colour pale pink; enclosing an eye-like pigment-spot. Length 1–720″.
HAB.—Fresh water.

Described by Schmarda * as a species of *Glenodinium.* Incepted Chlamydomonads and other food-material were observed by its discoverer.

The *Peridinium inerme*, a minute subspheroidal form (Pl. XXV. Fig. 54), and the *Peridinium inæquale*, having conspicuously narrow segments, of the same writer, are apparently identical with the *Gymnodinium monadicum* and *G. corpusculum* previously described.

* "Zur Naturgeschichte Egyptens," 'Denkschrift der Kaiser. Akad. der Wiss. Wien, 1854.'

GENUS III. MELODINIUM, S. K.

(Greek, *melon*, a peach; *dine*, a vortex.)

Animalcules naked, persistent in form but not encuirassed, having a central equatorial ciliated groove, and a second shorter longitudinal furrow extending from the transverse one towards the apical extremity; flagellum single, issuing from a depression in the ventral groove; entire surface of the body ciliated, as well as the annular furrow; coloured stigma present or absent.

This new genus is provisionally established for the reception of the *Peridinium uberrimum* of Professor Allman, characterized by the distribution of vibratile cilia throughout the whole extent of its cuticular surface, and by the consequent absence of an indurated carapace or cuirass. It is at the same time not altogether impossible that future investigation may demonstrate this animalcule to be a shell-less developmental condition of certain ordinary *Peridinia*, Claparède and Lachmann having shown that a shell-less or non-encuirassed state is common to the earlier phases of many of these latter. In the interim, nevertheless, it appears to be desirable to institute an independent generic name for a type whose characters differ so widely from those of the genus with which it has been hitherto associated.

Melodinium uberrimum, Allman sp. PL. XXV. FIGS. 34 AND 35.

Body subspheroidal, having a transverse annular furrow and a supplementary vertical groove developed on the ventral surface, which extends from the centre of the annular furrow to the apical extremity; entire cuticular surface finely ciliate; endoplast conspicuous, ovate, subcentral; a red eye-like pigment-spot usually present in the apical region. Length 1–1000″ to 1–500″; colour reddish brown.

HAB.—Fresh water, ponds in the Phœnix Park, Dublin; gregarious.

As already notified, this species is synonymous with the *Peridinium uberrimum* of Professor Allman, first described in the 'Quarterly Journal of Microscopical Science,' p. 21, for the year 1855. In its broader details it would seem to correspond closely with the animalcule figured and described by Claparède and Lachmann (See Pl. XXV. Fig. 5) as a possible shell-less or transitional condition of an ordinary *Peridinium*, such as *P. tabulatum*. At the same time no trace of an entire ciliary clothing is mentioned or figured by these writers, but which may nevertheless have been too fine to attract notice with the magnifying power employed.

Some estimate of the essentially gregarious habits of this animalcule may be arrived at in connection with the following abstract of Professor Allman's original record. Speaking at the Dublin Academy, in June 1854, he remarked,—that for the three previous weeks the brown colour assumed by the water in the large ponds in the Phœnix Park was owing to the presence of prodigious numbers of a species of *Peridinium*, this colour being sometimes uniformly diffused through the water, and at others being collected in dense clouds varying from a few to upwards of one hundred square yards in extent. Later on, the coloration of the ponds brought about by the agency of these minute organisms had much increased in density; by the 9th of July the water was so deep a brown that a white disc, half an inch in diameter, was invisible when plunged to a depth of from three to six inches, while a copious exit stream, constantly flowing away from the ponds, presented a similar deep brown hue. In many places the animalcules had descended from the surface, and were found congregated in immense masses near the bottom of the water; in these instances they had, for the most part, assumed a quiescent or encysted state, the flagellum and cilia having disappeared, and the body being contracted within the centre of an external hyaline envelope. Multiplication by transverse fission, as represented at Pl. XXV. Fig. 35, is the only mode of reproduction that was observed by Professor Allman, though doubtless the encysted state, in common with that of all ordinary Flagellata—see also *Peridinium sanguineum*—is accompanied by the breaking up of the body into sporular elements.

Genus IV. GLENODINIUM, Ehrenberg.

Animalcules free-swimming, encuirassed, body separated by a transverse or equatorial ciliated furrow into two equal or subequal portions, a more or less conspicuous non-ciliated groove produced from the ventral aspect of the equatorial furrow towards the apical extremity; cuirass consisting of two equal or subequal segments, which invest and correspond with the anterior and posterior halves of the body, leaving bare the equatorial and longitudinal grooves, not further subdivided into polygonal facets; oral aperture and insertion of the flagellum located on the ventral aspect near the junction of the two grooves; endoplasm often, but not invariably, enclosing a coloured eye-like pigment-spot. Inhabiting salt and fresh water.

As first instituted by Ehrenberg, this genus was made to include all those forms of *Peridinium* and its allies that were distinguished by the possession of an eye-like pigment-spot. As shown, however, by Claparède and Lachmann, and other recent observers, this proposed feature of distinction is, as in the genus *Euglena*, inconstant even among representatives of the same species, and cannot therefore be made the basis of generic diagnosis. Quite recently, however, Stein * has pointed out that among the animalcules referred to the genus *Glenodinium* by the authority first-named, there occurs one, *G. cinctum*, which differs from all its co-associated types in the smooth and undivided character of the two segments of the cuirass, and that this distinctive characteristic is likewise shared by other animalcules previously relegated to the genus *Peridinium*. For these he proposes collectively to retain the generic name of *Glenodinium*, introduced by Ehrenberg, and it is with a similar significance included in this volume.

Glenodinium cinctum, Ehr. Pl. XXV. Figs. 27–29.

Body ovate or elliptical, about twice as long as broad, entirely smooth and homogeneous; cuirass composed of two even anterior and posterior segments only, and not of separate plates or facets; a red eye-like pigment-spot present or absent, when developed large and crescentic, subcentral; colour light brown. Length 1–570″. Hab.—Fresh water.

This species is identical with the *Glenodinium cinctum* of Ehrenberg, but not with the *Peridinium cinctum* of that same authority; this latter form, as presently explained, representing examples only of *P. tabulatum*, in which an eye-like pigment-spot is conspicuously developed. The encysted state of this animalcule has been observed by Claparède and Lachmann, a condition of the same, with the valves of the cuirass falling asunder, being delineated at Pl. XXV. Fig. 29.

Glenodinium acuminatum, Ehr. Pl. XXV. Figs. 21 and 22.

Body ovate or spheroidal, slightly trilobate; cuirass smooth, terminating posteriorly in a short acuminate point; colour brownish yellow. Length 1–570″. Hab.—Salt water, highly phosphorescent.

* 'Infusionsthiere,' Abth. iii., 1878.

GENUS V. PERIDINIUM, Ehrenberg.

Animalcules free-swimming, encuirassed; body divided by a transverse ciliated furrow into two equal or subequal moieties; a second, shorter, non-ciliated groove produced from the centre of the ventral aspect of the equatorial furrow towards the apical extremity; cuirass consisting of two primary anterior and posterior segments, which are further subdivided into a variable number of smaller smooth or variously sculptured polygonal facets; flagellum single, inserted close to the oral aperture near the junction of the equatorial and vertical furrows; a coloured eye-like pigment-spot frequently developed. Inhabiting salt and fresh water.

The genus *Peridinium*, as here constituted, embraces most representatives of the genera *Peridinium* and *Glenodinium* of Ehrenberg, but from out of both of which, as previously explained, are eliminated and associated with the last-named title those forms only in which the cuirass or carapace is composed of two simple undivided segments. The ciliary groove and wreath of *Peridinium* and its allies, although usually described as forming an uninterrupted girdle around the centre of the animalcule's body, is shown by Claparède and Lachmann to deviate more or less conspicuously from so simple circuitous a course. As made apparent more especially by those observers in connection with the marine form *Peridinium spiniferum* (see Pl. XXV. Fig. 15), the left extremity or limb of this ciliary girdle takes its origin from a point considerably in advance of the precise centre of the ventral surface, and after obliquely encircling the dorsal region of the animalcule's body, terminates again in the middle line of the ventral aspect, but at a point as much to the rear of the same imaginary centre; the right and left limbs of the groove, with its accompanying cilia, lie consequently on two distinct levels. A similar deviation of the course of the equatorial groove and ciliary girdle is in a less marked degree—being sometimes scarcely perceptible—shared by all the representatives of the several genera, *Peridinium*, *Glenodinium*, and *Ceratium*. Another characteristic common also to the majority of these closely allied encuirassed forms, is the presence on the ventral surface, and immediately opposite the anteriorly produced non-ciliated vertical furrow, of a deep inlet or emargination in the substance of the posterior segment of the cuirass, which consequently leaves the body of the animalcule naked and exposed. It is within or in the immediate vicinity of this circumscribed area that the oral aperture would appear to be situated, though its existence has not yet been so clearly demonstrated as in the case of *Gymnodinium*. Immediately above, and in advance of this emargination, will be found inserted the single long flagelliform appendage.

Although the reproductive phenomena of the present genus, and of the Peridiniidæ in general, have not as yet been completely elucidated, some important data in this connection have been recorded, through the joint work of Messrs. Claparède and Lachmann. Encystment has been observed by these authorities to take place in a large number of forms and under diverse conditions; segmentation on a more or less extensive scale being in many cases the direct product of the process. In some instances, as shown at Pl. XXV. Figs. 4, 10, and 29, encystment is effected within the normal carapace or cuirass, and is not attended by any supplementary metamorphoses. Other instances were observed, however, in which the cuirass of the typical motile zooid being cast off, a new and continuous cyst, comparable in all ways to that produced by the ordinary Flagellate and Ciliate Infusoria, was secreted. The animalcule, pending the secretion of this second envelope, temporarily maintains a naked phase of existence, which is, as shown at Pl. XXV. Fig. 5, directly comparable to the permanent form of *Gymnodinium*. This variety of encystment is sometimes, as among the ordinary Infusoria, associated only with the temporary retreat or hibernation of the animalcule, or it may have as its object the further propagation of the species. Under these last conditions the cyst produced is mostly found to exhibit a peculiar modification of contour. In place of being subspheroidal or ovate, as obtains under ordinary conditions, one or both of the extremities are prolonged into an attenuate, curved, and acuminate point. These recurved points in the latter instance being produced in the same plane, the result is a crescentic or lunate-shaped cyst, somewhat resembling in shape the Desmid *Closterium*. Examples of these lunate or subcrescentic cysts are reproduced from Claparède and Lachmann's drawings at Pl. XXV. Figs. 47, 48, and 49, 50; those in the two former instances representing a marine, and in the two latter ones a fresh-water type, whose specific identity could not in either case, unfortunately, be precisely determined. The delineation given at Fig. 49 is of special interest, since in that instance the primarily enclosed single zooid has become metamorphosed by linear or serial segmentation into no less than eight sporular elements or daughter-cells, having each the characteristic trilobate contour of the parent, but wanting the investing carapace; they are in fact at this early phase of their development indistinguishable from the members of the genus *Gymnodinium*, previously described, and with which they are thus shown to be intimately and phylogenetically related. It is further noteworthy, in this connection, that the assumption of a similar and comparatively simple *Gymnodinium* phase is frequently resorted to by the animalcules of the present genus as a preliminary to the process of encystment, while it is only under such temporarily naked state that increase by fission, or genetic union, can be accomplished. This assumption by the members of the genus *Peridinium* of an alternating encuirassed and naked state considerably enhances the difficulty of determining which forms possess a sound claim for relegation to the genus *Gymnodinium*, and it is necessarily only those types which are found to persistently maintain the naked condition that can be allotted to this group.

Peridinium tabulatum, Ehr. sp. PL. XXV. FIGS. 1–5 AND 55–57.

Body ovate or subcircular as seen in dorsal or ventral view, much flattened or depressed, with a convex dorsal and concave ventral surface, as seen in lateral aspect; cuirass composed of numerous polygonal facets, which individually exhibit under high magnification a delicate reticulate structure; colour yellowish green or brown; one or more red eye-like pigment-spots frequently but not invariably developed. Length 1–570" to 1–430". HAB.—Fresh water; gregarious.

This species, originally described by Ehrenberg as a species of *Glenodinium*, is one of the most cosmopolitan members of the present genus, and frequently occurs in pond-water in such abundance as to impart to the water its own characteristic rust-brown hue. A considerable amount of variation is found to obtain in the contour of the two apical poles of the cuirass of this species in examples derived from diverse localities. Sometimes, as shown at Pl. XXV. Fig. 1., both of these poles are uniformly smooth and rounded; more often, however, it is found that the facets of the anterior segment of the cuirass project apically in such a manner as to impart a notched or shortly bifurcate aspect to the anterior border, and so prepare the way to the closely parallel but more decided horn-like projections in this region that are found in *Ceratium divergens*. Examples with a rounded posterior and distinctly notched anterior pole are delineated at Figs. 55–57. A still more complex modification of the cuirass is included in the representations of this species given by Ehrenberg, in some of which, as reproduced at Pl. XXIV. Fig. 2, the posterior segment is likewise produced apically into three or four acuminate points. The number of large polygonal plates or facets reckoned by Stein to enter into the composition of the two segments of the cuirass in this species, is no less than twenty-one, sometimes more, and of which fourteen to sixteen belong to the anterior and seven to the posterior moiety; added to this, he says, are smaller linear or band-like indurations, which bound the equatorial and vertical furrows. The elegant sculpturing of the larger polygonal and usually five- or six-sided facets, may be most readily examined in connection with the empty or disintegrated carapaces that are usually found abundantly distributed in the water that supplies the living zooids. A delineation of such a highly magnified single facet is given at Fig. 3. The encystment of this species within its cuirass has been observed by Claparède and Lachmann, as also the naked *Gymnodinium*-like phase, both of these conditions being reproduced from their drawings at Figs. 4 and 5. In examples examined by the author, a long curved band-like endoplast or nucleus, similar to that commonly met among the *Vorticellidæ*, has been occasionally observed, one such distinctly nucleated specimen being represented at Fig. 56. The species has been obtained by the author in profusion from various localities in the suburbs of London, and has also been received from the neighbourhood of Birmingham, through Mr. Thomas Bolton.

Very recently, November 1880, the author has received this animalcule in company with other Flagellata, through Mr. John Hood, from the neighbourhood of Dundee. The chief interest attached to such consignment is connected with the fact that many lunate encystments, corresponding essentially with those first described of an unknown form by Claparède and Lachmann, and represented at Pl. XXV. Figs. 49 and 50, were detected among the sedimentary matter at the bottom of the phial in which they were transmitted. The contents of these cysts, which were usually divided into two equal moieties, exhibited the same rust-brown hue as the motile zooids. There can be but little doubt that the similar shaped encystments in the figures quoted belong to the present very widely distributed species.

Peridinium apiculatum, Ehr. sp. Pl. XXV. Figs. 6 and 7.

Body oval, depressed; cuirass composed of large polygonal reticulate facets, the edges of which are finely hispid and separated from one another by clear, smooth intervals; colour yellowish-green; an eye-like pigment-spot of oblong form usually present. Length 1–570″ to 1–350″.

Hab.—Fresh water.

This species was described by Ehrenberg under the title of *Gymnodinium apiculatum*, and does not so far appear to have been encountered by any other authority. Stein is inclined to regard it only as a variety or older phase of *Peridinium tabulatum.*

Peridinium reticulatum, C. & L. Pl. XXV. Fig. 41.

Body ovoid; cuirass composed of numerous minute, smooth, polygonal facets, equatorial furrow obliquely developed; colour brown. Length 1–570″. Hab.—Salt water: Norwegian coast (C. & L.).

Peridinium spiniferum, C. & L. Pl. XXV. Figs. 15 and 16

Body ovoid, rounded posteriorly; cuirass composed of large polygonal facets; two closely approximated spines developed at the apical extremity of the anterior segment; transverse furrow very oblique, forming an elongate spire. Length 1–620″.

Hab.—Salt water; Norwegian coast (C. & L.).

Peridinium splendor-maris, Ehr.

Cuirass ovate or subglobose, transparent, facetted, cribrate or granular, neither apiculate nor provided with horn-like processes; margins of the transverse groove projecting, and presenting laterally the aspect of tooth-like processes; facets developed on each side of equatorial furrow, five in number. Diameter 1–1152″ to 1–480″.

HAB.—Salt water: Naples. Highly phosphorescent.

In contour this species would appear to closely resemble the smooth variety of the fresh-water *Peridinium tabulatum.*

Peridinium chilophænum, Ehr.

Cuirass subglobose, hornless, its surface smooth, neither facetted nor punctate; equatorial furrow distinct, its margins presenting laterally the appearance of projecting teeth; oral fossa narrow, curved. Diameter 1–648″.

HAB.—Salt water: entrance of Davis Straits, and Iceland, with soundings from a depth of 1158 feet.

Peridinium sanguineum, Carter.

Body subcircular, paraboloidal or kite-shaped, compressed, sulcate ventrally; equatorial groove deep, its upper border distinctly ciliate; cuirass faintly facetted over the anterior or conical half, the posterior or rounded half entirely smooth; an eye-like pigment-spot and endoplast usually conspicuous. Length 1–1120″ to 1–700″.

HAB.—Salt-water pools, and in the sea on the shores of the Island of Bombay. Movements waddling, the small end forwards and the long flagellum floating behind; colour changing successively from green or golden yellow to brown and vermilion or minium red.

This species, described by Mr. H. J. Carter in an article on "The Red Colouring Matter of the Sea round the Shores of the Island of Bombay," contributed to the 'Annals of Natural History' for April 1858, is of special interest in connection with the light it throws upon the phenomena frequently observed, but not previously explained in a satisfactory manner, concerning the sudden assumption by the sea, or other waters, of a blood-red hue. According to Mr. Carter, this animalcule, during the earlier and active phase of its existence, is green and translucent, reflecting little or no light, the colouring matter out of which its body-substance is composed being akin to or identical with the chlorophyll of plants. Gradually, as the time approaches for it to assume its quiescent or encysted state, a number of semi-translucent, refractive oil-globules are secreted within the interior; the green colour now disappears and a bright red one takes its place, mixing with the oil, and thus the animalcules become visible to the naked eye, the whole portion of the sea charged with them acquiring a deep vermilion hue. This colour is so prominently developed under these conditions that in the sea-water pools left by the reflux of the tide on the shores of the Island of Bombay, such pools present to the uninitiated the appearance of having had a quantity of vermilion or minium thrown into them. An examination of this water under a microscope shows, however, that the red colours are entirely due to the *Peridinia.* The vermilion hue now arrived at only lasts a few days; the animalcules assembling together become individually encapsuled, and in this state float on the surface or sink to the bottom. Duplicative subdivision now takes place within the capsules or encystments, each animalcule by such process becoming divided into two or four equal fragments, which are subsequently liberated by the bursting of the cyst. In other, rarer instances, it is affirmed by Mr. Carter that a litter of ciliated monads may be developed in a distinct cell within the ordinary capsule, such brood being the product of a true act of generation (conjugation), or the final formative effort of the protoplasm.

Many earlier records of the observation of phenomena connected probably with the presence of an animalcule identical with, or allied to, *Peridinium sanguineum* are quoted by Mr. Carter. Thus, Charles Darwin * observed an apparently identical animalcule which coloured the sea red, a degree south of Valparaiso. Salt, in his 'Voyage to Abyssinia,' mentions the presence of animalcules in the Red Sea, which produced the red colour characteristic of those waters during the day, and became luminous at night by agitation after the manner of numerous other *Peridinia.* Olafsen and Povelsen are further cited as having recorded, so long since as 1694, of the sea on the shores of Iceland, that during the daytime it was as red as blood, and in the night apparently as though on fire. Mr. Carter finally suggests the high probability that the plague of Egypt—manifested by the apparent turning of all the waters into blood, in which the fish in the river died, and the river stank, and the Egyptians could not drink of the water of the river—may be consistently interpreted in connection with an abnormal development of an animalcule allied to this species. Such interpretation is further supported by facts connected with the discoloration of the sea, that Dr. Buist recorded in the 'Proceedings of the Bombay Geological Society' for the year 1855. On the 27th of October 1849 it was observed by that authority that the water at Ponbunder, on the coast of Khattywar, was changed from the usual tint to a deep red, emitting a most foul smell; the fish were speedily all destroyed, and were washed upon the beach in large quantities. It was conjectured by the narrator that the phenomenon was owing to some submarine eruption of mud, but the locality being one in which red water produced by the presence of animalcules is extremely common, the cataclysmic interpretation suggested is scarcely warranted. The offensive effluvium exhaled by waters in which *Peridinia* and lower Protophytes have developed in large quantities is personally testified to by Mr. Carter in the case of a *Peridinium* obtained by him from a fresh-water tank at Bombay, and where he says it not only " turned the water quite brown, but imparted a smell and insipid taste to it, which almost rendered it undrinkable." He further cites the case of a little algal, *Aphanizomenon flos-aquæ*, frequently developed under like conditions in the same fresh-water tanks, which often not only " renders the water undrinkable, but produces an intolerable stench by its putrefaction."

It may be suitably mentioned in connection with the foregoing data that Ehrenberg, in the 'Monatsbericht der Berliner Akademie' for the year 1853, records the fact that during the remarkable cholera epidemic prevalent throughout Europe in the year 1848, two flagellate organisms, *Chloraster gyrans* and *Spondylomorum quaternarium*, were so abundantly developed in the water-tanks in the streets of Berlin as to render the fluid completely green and unfit to drink. If not the direct cause of zymotic disease, there can be but little doubt that an abnormal development of these and kindred lowly organized beings in ordinarily potable water indicates that such fluid has been contaminated by the accession of extraneously derived organic matter to an extent making it not only unsuitable, but highly deleterious for human consumption.

Peridinium æqualis, S. K. Pl. XXV. Fig. 14.

Body symmetrically bi-conoidal, widest in the centre, tapering evenly at an angle of about 67° towards the anterior and posterior extremities, both of which terminate in two or more short, pointed cusps; equatorial zone of cilia broad and evenly developed; a second furrow of equal breadth proceeding from the centre of the equatorial one towards the anterior pole; measurement between the two poles scarcely exceeding that of the width; endoplast conspicuous, band-like. Dimensions unrecorded.

HAB.—Salt-water.

* 'Journal on board H.M.S. *Beagle*,' pp. 17, 18.

The above title is here conferred on the species of *Peridinium* figured and briefly described, without a name attached, by Dr. von Willemoes-Suhm in the 'Zeitschrift für Wissenschaftliche Zoologie,' Bd. xxi. p. 303, and Taf. xxxi., 1871. The even and elegant symmetry of its form distinguishes it conspicuously from all other known species of the genus. The character or even existence of the flagellum appears to have escaped the notice of its discoverer.

GENUS VI. CERATIUM, Schrank.*

Animalcules free-swimming, encuirassed, body divided by a central ciliated furrow into two equal or subequal portions, a second shorter, non-ciliated groove extending from the centre of the ventral aspect of the equatorial furrow towards the anterior pole; cuirass consisting of two equal or subequal segments, separated by the equatorial groove, which may or may not be subdivided into secondary plates or facets; one or both of these segments produced into more or less conspicuous horn-like prolongations; flagellum single, inserted close to the oral aperture at or near the junction of the equatorial and longitudinal furrows; eye-like pigment-speck rarely developed. Inhabiting salt and fresh water.

The representatives of this genus, while formerly included in that of *Peridinium*, are conveniently separated and distinguished by the presence of the more or less conspicuously developed horn-like extensions of the cuirass. The close affinity of the two genera is at the same time abundantly demonstrated by such an intermediate or annectant form as *Ceratium divergens*, which practically possesses but a slightly more differentiated modification of the cuirass than obtains in the more normal variety of *Peridinium tabulatum*. The larger number of species of this genus are pelagic, many of them being noted for their phosphorescent properties. An interesting feature connected with certain of these pelagic types is the marked isomorphic resemblance presented by the cuirasses with their long, divergent, horn-like prolongations, to other floating organisms with which they are associated. In this manner the attenuately prolonged, triradiate cuirass of *Ceratium tripos* (var. *macroceros*) finds its countertype not only in the skeletal framework of the floating larva or "Pluteus" of various Echinodermata, but in the larval or free-floating "zoæa" conditions of many of the highly organized Podophthalmous Crustacea, such as *Porcellana*, in which a like production of the chief skeletal element, the carapace, into three attenuate horn-like prolongations many times longer than the body, is encountered. An even more astonishing mimetic resemblance subsists, however, between the above-named species of *Ceratium* and the larval forms, the nauplii, or so-called "Archezoa" (Dohrn) of the Cirripede *Lepas fasciculatus* as figured by Dr. R. von Willemoes-Suhm in the 'Philosophical Transactions,' pl. i., for the year 1876. Here three long, serrated, spinous processes are developed in the same order and maintain the same preponderating proportions with relation to the central body, the superficial resemblance indicated being so complete that under a low magnifying power the essentially distinct nature of the two organisms would scarcely be detected. Finally, the four-horned *Ceratium longicorne* is obtained in company with a Rotifer (*Anurea longispina*) characterized by the possession of great spinous processes that attain a similar proportionate length, and decussate in the same order from the surface of its carapace. The utility of these arm-like appendages, giving their possessors greater buoyancy and marked fitness for a pelagic or floating existence, is obvious; their coincidence of plan in four such very divergent organic groups being at the same time most remarkable.

* 'Fauna Boica,' 1793.

A.—HORN-LIKE PROCESSES SHORTER THAN THE BODY.

Ceratium divergens, Ehr. sp. PL. XXV. FIGS. 8–13.

Cuirass rhomboidal, widest centrally, attenuate and acuminate posteriorly, the anterior extremity armed with two short, straight, pointed horns, each of them having a tooth-like process at the basal portion of their inner margin. Diameter 1–576″.

HAB.—Salt water: Baltic Sea. Colour yellow.

This animalcule was first described by Ehrenberg under the title of *Peridinium divergens.* Claparède and Lachmann regard the *P. depressum* of Bailey (Pl. XXV. Figs. 12 and 13) as identical with this species. These same authorities, as shown in the figures here reproduced, have observed the species in both its encysted and naked or *Gymnodinium* phases of existence. The contour of the empty cuirass, as shown at Figs. 8 and 9, presents a remarkably elegant facetted crystalline aspect.

In the 'Monatsbericht der Berliner Akademie' for the year 1854 Ehrenberg has described, under the title of *P. divergens* var. *reniforme*, a modification of the present form characterized by a somewhat wider reniform contour of the cuirass, the posterior extremity being further produced as a short, obtusely pointed, stylate process.

Ceratium Michaelis, Ehr. sp. PL. XXV. FIG. 23.

Cuirass ovate, having two short, straight, anterior and one postero-terminal, subcylindrical, horn-like processes, the extremities of which are abruptly truncate; surface entirely smooth. Length 1–570″.

HAB.—Salt water. Highly phosphorescent; colour yellow.

The truncate termination of the horns, in addition to the absence of tooth-like processes at the base of the two anterior ones, distinguishes this form from *C. divergens*, which it otherwise most nearly resembles.

Ceratium tridens, Ehr.

Cuirass resembling that of *C. Michaelis* and *C. divergens*, bearing three acute frontal horns, the posterior extremity attenuate, surface granular. Length 1–576″. HAB.—Salt water: Baltic Sea. Colour yellow.

Ceratium bicorne, Schmarda sp. PL. XXV. FIG. 62.

Cuirass ovate or subspheroidal, having two anteriorly developed horn-like processes only, the one taking the form of a straight, axial, acuminate point, the second antero-lateral, curved, and spur-like, equal in length to about one-half of the length of the body. Length 1–1080″ to 1–840″. Colour brick red. HAB.—Salt water.

Ceratium pyrophorum, Ehr.

Cuirass ovate or subspherical, with two little acuminate points at the anterior extremity; surface delicately areolate and granular. Length 1–570″ to 1–480″.

HAB.—Baltic Sea, near Kiel, and also as a fossil in the flints of the chalk formation from the neighbourhood of Brighton and Gravesend.

Ceratium delitiense, Ehr.

Cuirass ovate or subspheroidal, with a single median, lateral, short, acuminate process. Length 1–430″ to 1–280″.

HAB.—Fossil in the chalk flints of Delitzsch.

The inclusion of this species among the representatives of the present genus, or indeed, in the Protozoic sub-kingdom, is necessarily probational.

B. HORN-LIKE PROCESSES AS LONG OR LONGER THAN THE BODY.

Ceratium tripos, Müll. sp. PL. XXV. FIGS. 24, 33, AND 36.

Body somewhat triangular, truncate in front and tapering posteriorly, the anterior segment of the cuirass bearing two long, laterally developed, recurved, horn-like processes, and the posterior one a single, similarly long or longer and straight median process; the edges of these processes usually more or less denticulate. Length of body, including the horns, 1–140″; without the horns, 1–430″.

HAB.—Salt water. Colour yellow; highly phosphorescent.

This species, originally described by O. F. Müller under the title of *Cercaria tripos*, is subject to great individual variation, and more especially with respect to the proportionate size, and angle of divergence from the body, of the horn-like processes. Two of the more prominent of these variations, indeed, originally received a separate specific description at the hands of Ehrenberg, under the respective titles of *Peridinium macroceros* and *P. arcticum.* Briefly epitomized, *Ceratium tripos* and its two leading varieties may be thus distinguished:—

C. tripos (*normal form*), Pl. XXV. Fig. 33.—The two anterior horns much shorter than the posterior one, about equal to the body in length, arched backwards in such a manner that, if continued, their points would cross the hinder and median process; the margin of anterior horns finely and indistinctly denticulate.

Var. α (*P. macroceros*, Ehr.), Pl. XXV. Fig. 24.—All three horns very long and slender, the two antero-lateral ones usually the longer, sometimes exceeding six times the length of the body, produced first in advance of the body, the right one more so than the left, and then curved round and continued backwards in a straight line and at an angle of divergence from the posterior and terminal horn; denticulation of the margin of the two anterior processes more distinct than in the normal form.

Var. β (*P. arcticum*, Ehr.), Pl. XXV. Fig. 36.—Horns subequal, very thick, about twice the length of the body, all three curved, strongly and uniformly denticulate; the two antero-lateral horns not produced in advance, reflected backwards at a divergent angle.

Although, seen separately, the three above varieties would seem to lay claim to separate specific recognition, it will be found that every gradation of form connecting the one with the other occurs among examples from the same locality. At the same time it has been observed that while the normal form of *Ceratium tripos* is most abundant in the vicinity of Bergen, the variety α, *macroceros*, predominates on the west coast of Norway, while the variety β, *arcticum*, occurs most numerously in the more northerly latitude of Spitzbergen. The eminent phosphoric properties attributed to the species by Ehrenberg and Michaelis have not been confirmed by the researches of Claparède and Lachmann. According to Dr. Pringsheim, a species closely resembling *C. tripos* occurs in fresh water in the neighbourhood of Berlin.

The author has recently received from Dr. Wm. J. Gray, F.R.M.S., a sample of "surface skimmings" collected by Count Castracane in the neighbourhood of Fano, in the Adriatic, that is particularly rich in Peridiniidæ, *Ceratium tripos* being the most abundant type, and five other forms, *Ceratium fusus*, *Ceratium divergens*, *Ceratium eugrammum*, *Prorocentrum micans*, and *Dinophysis caudata*, being more or less sparingly represented. Of *C. tripos* the variety *macroceros* is most plentiful, the majority of examples being remarkable for the extreme length and slenderness of their arm-like processes, which in this respect not unfrequently exceed the proportions given at Pl. XXV. Fig. 24. Every gradation from this attenuate variety to the more typical condition, Fig. 33, was encountered, but in no instance the thick-armed variety *arcticum*, whose appendages are apparently specially adapted to preserve the equilibrium of the animalcule in the colder and consequently denser waters of the Arctic seas. An interesting structural feature was elicited in connection with the author's examination of this type. In specimens mounted in the usual manner for future observation the median posterior process was shown to be composed of four longitudinal segments; these under pressure became separated from one another throughout the greater portion or even their entire length, presenting under such conditions the aspect of a fascicle of four rigid, distally divergent setæ. This opportunity of becoming personally acquainted with the typical pelagic representative of the genus *Ceratium* was also utilized by the author for the solution of the moot question concerning the composition of its exceedingly brittle indurated carapace or cuirass. It had been previously suggested by Mr. Charles Stewart, of St. Thomas's Hospital, with reference to the accredited capacity of this element to withstand incineration, that it was probably of a siliceous nature, such opinion being endorsed by the author in an account given in the 'Midland Naturalist' for May 1880, of various marine Infusoria collected off the coast of Cornwall. The views there expressed, based only on unsupported testimony, are now entirely discarded, for, on putting the matter to the test by heating examples on talc over a spirit-lamp, it was found that they speedily shrivelled up, and ultimately disappeared, while the more delicate siliceous diatom-frustules and sponge-spicules scattered beside them remained intact. The possibility of the carapaces of these *Ceratia* being composed of silex was thus disproved, and no grounds are left for supposing that their composition is other than corneous or chitinous, as obtains in the carapaces, loricæ, or capsular elements of all the more familiar infusorial species. Yet additional testimony in support of the view now advocated is afforded by the fact that the remains of several reputed species of *Ceratium*, *C. pyrophorum* and *C. delitiense*, have been obtained as fossils in flints belonging to the cretaceous formation. It is a well-known fact to geologists that silica in its first state of combination is entirely eliminated from these deposits, and is present only in its recombined and concrete form. It may be hence consistently maintained that the *Ceratia* met with in the chalk could not have possessed siliceous tests.

Ceratium furca, Ehr. sp. Pl. XXV. Fig. 31.

Cuirass subtriangular, longitudinally striate, bearing three horn-like processes, the two antero-lateral ones directed straight forwards, not exceeding the body in length; the median posterior process straight and slender, twice the length of the anterior ones. Entire length 1–120″.

Hab.—Salt water. Colour yellow.

Claparède and Lachmann include in this species both the *Peridinium furca* and *P. lineatum* of Ehrenberg. The dimensions of the last-named type are however so much smaller, 1–380″ only, that it seems highly probable that the two are distinct. The present form, according to the last-named authority, is eminently phosphorescent. Although usually regarded as entirely marine, M. Werneck has reported the occurrence of an apparently identical species in fresh water in the vicinity of Salzburg.

Ceratium biceps, C. & L.

Cuirass subtriangular, striate longitudinally, bearing three horn-like processes, neither of which exceed the length of the body, the two anterior ones directed forwards in a straight line, one longer than the other, closely approximated at their bases. Length 1–120″.

HAB.—Salt water: Norwegian coast (C. & L.).

This species most closely approaches *C. furca*, and is not improbably a variation only of that type; provisionally, it may be distinguished from that form by the shorter proportions of the horn-like processes, neither of which exceed the length of the body, and by the close proximity of the two anterior ones, which seem to spring from a common base.

Ceratium fusus, Ehr. sp. PL. XXV. FIG. 40.

Cuirass elongate-fusiform, armed with two horn-like processes only, each of these about three times the length of the body, and produced in the same plane respectively from the anterior and posterior segments of the cuirass; the posterior process usually straight, the anterior one slightly curved. Length 1–120″ to 1–90″.

HAB.—Salt water. Colour yellow; highly phosphorescent.

Identical with Ehrenberg's *Peridinium fusus*. Claparède and Lachmann remark that the customary third horn-like process, though not conspicuously represented, is often present in the form of a short spine or slight protuberance, near the base of the single developed anterior horn. Examples of this species were obtained by the author off Falmouth in July 1879, in connection with the summer excursion of the Birmingham Natural History Society. A distinct ovate endoplast was observed in a crushed, spirit-preserved specimen.

Ceratium candelabrum, Ehr. sp.

Contour of cuirass resembling that of *Ceratium furca;* body depressed, greatly dilated, its surface areolate and cribrate, the equatorial furrow straight, the anterior border oblique; the three horn-like processes produced abruptly from the body portion, the basal horn about twice the length of the body, the two anterior ones unequal, neither of them exceeding one-sixth the length of the basal process, their surfaces ornamented with unevenly developed parallel rows of asperities. Total length 1–120″.

HAB.—Salt water: Adriatic. Colour yellowish-brown.

Ceratium lineatum, Ehr. sp.

Contour of cuirass resembling that of *Ceratium furca* but of smaller size; its surface ornamented with punctate longitudinal striæ, about twelve such striæ being included in the half exposed to view. Total length 1–384″.

HAB.—Sea water: Newfoundland.

Ceratium eugrammum, Ehr. sp.

Contour somewhat resembling that of *C. furca* or *C. lineatum;* surface of cuirass longitudinally striate, the intervals cribrate, not areolate; body conical, tapering gradually into the straight, posterior or basal, horn-like process, which equals the body in length; the two frontal processes of unequal length, both shorter than the body. Total length 1–180″.

HAB.—Salt water: Adriatic, with phosphorescent water.

Examples of this species, having an average length of 1–100," are abundantly contained in the sample of surface skimmings from Fano, in the Adriatic, collected by Count Castracane, and placed at the author's disposal by Dr. Wm. Gray. In some, but not all instances, it was observed that the surfaces of the horn-like processes were distinctly serrated.

Ceratium seta, Ehr. sp.

Cuirass bicornate, resembling *C. fusus,* but longer and more slender; body fusiform, slightly inflated centrally, the anterior portion of this region notched, its posterior one tapering gradually into the basal horn-like process; both horns slender, setaceous, straight, or lunately curved, their extremities truncate, their surfaces roughened or asperate, the front one mostly the longer, often three times the length of the body. Total length 1–120" to 1–72".

HAB.—Salt water: Adriatic, with phosphorescent water.

Ceratium trichoceros, Ehr. sp.

Cuirass with three elongate, setaceous, horn-like processes, the single posterior process straight, truncate, over six times as long as the ovate or subglobose central portion, the two anterior ones recurved, obtusely pointed, exceeding eight times the length of the central body, all distinctly asperate; equatorial groove obliquely directed, parallel with the anterior border of the cuirass; colour yellowish-brown. Length of body, without horns, 1–864"; total length 1–120" to 1–96".

HAB.—Salt water: Adriatic (September).

Excepting for its minute size, this species, briefly characterized by Ehrenberg in the 'Monatsbericht Berliner Akademie' for the year 1859, does not appear to differ materially from the slender-armed variety of *C. tripos* previously recorded.

Ceratium longicorne, Perty. PL. XXV. FIG. 26.

Cuirass bearing four horn-like processes, of which three, one longer median and two shorter antero-lateral ones, are produced from the anterior, and one long median process from the posterior segment; entire surface of cuirass and horn-like processes finely and evenly asperate; a red eye-like pigment-spot frequently developed at the anterior extremity of the body. Length 1–120" to 1–90". HAB.—Fresh water.

This species, while first associated by Perty with the above-named title, was afterwards identified by him with the *Ceratium macroceras* of Schrank, and under which designation it is figured and described in his 'Kleinster Lebensformen,' in the year 1852. That name, however, so closely approaches the previously introduced *C. macroceros* distinctive of the marine three-horned variety so named by Ehrenberg, that the retention of Perty's later title in the present instance has been decided on. A characteristic feature by which this form may be immediately distinguished from every marine or fresh-water representative of the genus *Ceratium* described in this volume, is afforded by the profuse development of the horn-like appendages of the cuirass, no other type as yet encountered possessing more than three such processes. The distribution of the animalcule, as with various other forms of Peridiniidæ, may be described as cosmopolitan. First reported from Germany and the Bernese Alps by Schrank and Perty, a type indistinguishable from it was obtained in the neighbourhood of Calcutta, in September 1859, by Major, now Colonel, Stuart-Wortley, as shown by delineations of the same supplied by him to Mr. Carter, copies of which are in possession of the author. Quite recently again, August 1879, examples according in all essential details with the Bernese and Indian form, have been received by the author through Mr. J. Levick and Mr. Thomas Bolton, from the Olton Reservoir near Birmingham. In the specimens personally examined, it was found that the surfaces of the body and each of the four horn-like prolongations were distinctly asperate. Such ornamentation, although not recorded of the Continental or Indian examples, may have existed, but escaped the notice of their recorders in consequence of the employment of insufficient magnifying power; or, as in the case of *C. tripos*, it may be the outcome only of local influences.

An interesting circumstance connected with the discovery of this type in British waters is connected with the fact that a Rotifer, *Anurea longispina*, also new to this country,* was simultaneously met with, in which long spinous processes, similar in number, proportions, and plan of disposition, are developed from the surface of the carapace. The interesting Entomostracon *Leptodora hyalina*, hitherto unknown to Britain, was likewise derived from the same locality.

Ceratium Kumaonense, Carter. PL. XXV. FIG. 25.

Cuirass subtriangular, with two anterior and one posterior straight and massive horn-like processes; one of the anterior horns axially directed and, together with the posterior one, equalling the body in length; the second or antero-lateral horn produced obliquely, not half the length of the other two; all three of these processes finely and evenly serrated. Colour reddish-brown. Entire length 1–125″.

HAB.—Fresh water.

This species, described by Mr. Carter in the 'Annals and Magazine of Natural History,' vol. vii. 1871, was obtained in the lakes of Kumaon, Hindostan, at an elevation of from 4000 to 6500 feet above the sea-level, occurring there in such abundance that the ordinary blue colour of the water was temporarily turned by their presence to rusty red. From *Ceratium furca*, with which it most nearly corresponds, this type is to be distinguished by the serration and the shorter proportional lengths of the horn-like processes.

GENUS VII. DINOPHYSIS, Ehrenberg.

Animalcules encuirassed, having a transverse annular ciliated furrow close to the posterior extremity, and joining this on the ventral surface a raised longitudinal perpendicular crest consisting of two membranous plates, from the groove between which a single long flagellum takes its origin. Inhabiting salt water.

It was first supposed by Ehrenberg that the animalcules referred by him to this genus were most nearly allied to the Ophrydinæ (*Ophrydium* and *Vaginicola*) though he afterwards assigned them to their true places as here indicated. At the same time the position and character of the cilia and flagellate appendage were not determined or represented by him, although he predicated their existence in consequence of the movements they exhibited. Claparède and Lachmann, to whom we are indebted for a more accurate definition of the genus, and who have added to it many new specific forms, fancifully compare the contour of its representatives to small lidded

* J. Levick on a new Rotifer, 'Midland Naturalist,' October, 1879.

jugs; adopting this simile, the inflated anterior portion is likened to the body of the jug, the narrow discoidal part behind the annular furrow to the lid, and the perpendicular membranous crest to the handle.

Dinophysis atlantica, Ehr.

Cuirass ovate, urceolate; its surface densely shagreened, posterior segment operculum-like, dilated, ventral plates with transverse decurrent linear thickenings. Length 1–432″. HAB.—Salt water: Newfoundland.

Excepting for its larger size this species is described by Ehrenberg * as corresponding closely with *Dinophysis Michaelis.*

Dinophysis acuta, Ehr.

Cuirass ovate, acuminate posteriorly, the anterior margin plane, its surface granulate. Length 1–576″.

HAB.—Salt water: Baltic Sea, near Kiel (Ehr.).

As originally figured and described by Ehrenberg,† the anterior and posterior extremities have been reversed in both this and the succeeding species, *D. Michaelis.*

Dinophysis Michaelis, Ehr.

Cuirass ovate, rounded posteriorly, the anterior border plane, slightly wider; surface granulate. Length 1–576″.

HAB.—Salt water: Baltic Sea, near Kiel (Ehr.).

Dinophysis norvegica, C. & L. PL. XXV. FIG. 42.

Body compressed, pitcher-shaped, rounded anteriorly, the posterior segment reduced to a simple concave plate; the dorsal and anterior margin supplemented by a thin, longitudinally striate and sometimes denticulate, keel-like crest, which tapers off on the ventral side towards the abrupt termination of the raised ventral plates; ventral plates strengthened by three transverse linear thickenings; surface of cuirass coarsely shagreened. Length 1–400″. HAB.—Norwegian coast (Claparède & Lachmann).

Dinophysis ventricosa, C. & L.

Body compressed, pitcher-shaped, ventricose, the anterior extremity frequently pointed, the posterior segment represented by a simple concave plate; no supplementary crest on the dorsal margin; ventral plates with three transverse linear thickenings; surface of the cuirass coarsely shagreened. Length 1–400″.

HAB.—Salt water: Norwegian coast (C. & L.).

Dinophysis acuminata, C. & L. PL. XXV. FIG. 43.

Body compressed, pitcher-shaped, rounded anteriorly, more considerably inflated on the dorsal side, supplemented at the antero-ventral angle with

* 'Monatsbericht Berliner Akademie,' 1854.
† 'Abhandl. d. Akad. Berlin,' 1839 and 1840.

a projecting claw-like point; no dorsal crest; the posterior segment rudimentary, consisting of a very narrow concave plate; ventral plates strengthened by one or two linear thickenings; surface of cuirass finely shagreened. Length 1–550".

HAB.—Salt water: Norwegian coast (Claparède & Lachmann).

Dinophysis rotundata, C. & L.

Body inflated, compressed, transverse annular furrow set further forward than in *D. acuminata*, the posterior segment being in consequence of proportionally larger size, its margin convex; surface of cuirass coarsely shagreened; no keel-like dorsal crest; ventral plates with two transverse linear thickenings. Length 1–500". HAB.—Norwegian coast (C. & L.).

Dinophysis ovata, C. & L. PL. XXV. FIG. 43*a*.

Body ovate, compressed, two closely approximated spine-like processes developed at the anterior extremity, the posterior segment convex, cap-shaped; surface of the cuirass finely shagreened; no keel-like dorsal crest; ventral plates extending along two-thirds of the ventral border, strengthened by two linear thickenings. Length 1–625".

HAB.—Salt water: Norwegian coast (C. & L.).

Dinophysis lævis, C. & L.

Body suborbicular, compressed, surface of cuirass entirely smooth; ventral plates produced throughout almost the entire length of the ventral border, strengthened with three linear thickenings; posterior segment conspicuously developed, its margin slightly convex; no dorsal crest. Length 1–400". HAB.—Salt water: Norwegian coast (C. & L.).

Dinophysis arctica, Mereschk.

Body broadly flask-shaped, inflated and widest anteriorly, contracted posteriorly, scarcely one and a half times as long as broad; ventral crest largely developed, angular, and obliquely truncate anteriorly, traversed by three transverse lines; surface of cuirass finely shagreened throughout. Length 1–600". HAB.—Salt water: White Sea (Mereschkowsky).

This species closely approaches *D. lævis*, but is to be distinguished from that form by its smaller size, the shagreened character of the cuirass, and by the diverse contour of the ventral plates.

Dinophysis caudata, S. K.

Body suburceolate, the region behind the transverse annular furrow consisting of an inflated, urceolate, basal portion and an abruptly narrowed, subcylindrical, ventrally curved, anterior prolongation; a smooth, narrow ridge produced along the dorsal border of the inflated portion of the posterior segment, and on the opposite or ventral margin of the same region two conspicuously developed fin-like ventral plates; ventral plates angular, equalling in breadth one-half of the diameter of the body, traversed by two or three spine-like linear thickenings; the entire surface of the posterior segment distinctly shagreened; the anterior segment concave, operculum-like, dilated, its margins delicately striate in a longitudinal direction. Length 1–212″. HAB.—Salt water: Adriatic.

This species has been obtained sparingly among the material originally collected at Fano, in the Adriatic, by Count Castracane, and recently placed at the author's disposal by Dr. Wm. J. Gray, F.R.M.S. From all the species previously described it may be distinguished by the distinct narrower prolongation of the anterior segment, which is, as it were, added on to the ordinary ventricose body of *D. norvegica* or *D. acuminata*, and contributes substantially to its total length. The ventral plates are also of much larger comparative size, resembling, in connection with the two or three perpendicular spine-like linear thickenings, the elevated dorsal fin of some Acanthophrygian fish. The smooth narrow ridge developed along the dorsal margin of the body is undoubtedly homologous with the elevated crest distinctive of this region in *D. norvegica.*

GENUS VIII. AMPHIDINIUM, C. & L.

Animalcules encuirassed, having a transverse annular, ciliated furrow situated at the posterior extremity, as in the genus *Dinophysis*, the posterior segment being in a similar manner almost entirely atrophied; the longitudinal ventral furrow, out of which the flagellum springs, represented only towards the anterior extremity, and not joining the transverse annular one; no salient ventral plates. Inhabiting salt water.

Amphidinium operculatum, C. & L. PL. XXV. FIGS. 44–46.

Body oval, depressed, the ventral side slightly flattened, the dorsal one convex; posterior segment rudimentary, operculum-like; the larger anterior portion frequently containing a central dark brown structure, possibly the endoplast, with radiating prolongations; surface of cuirass entirely smooth. Length 1–503″. HAB.—Salt water: Norwegian coast (C. & L.).

Claparède and Lachmann found in company with the normal animalcules, as above described, smaller perfectly transparent examples, having in some instances a pyriform, and in others an almost orbicular contour; these they regard as mere younger conditions of this species.

GENUS IX. PROROCENTRUM, Ehrenberg.

Animalcules encuirassed, cuirass consisting of a single continuous piece, not divided as in the preceding genera by a transverse annular furrow; a stiff spine or tooth-like process usually developed at the anterior extremity close to the insertion of the single flagellum. Inhabiting salt water.

Prorocentrum micans, Ehr. PL. XXV. FIGS. 37–39.

Cuirass oval, compressed, pointed posteriorly, the ventral border flattened, the dorsal one convex, the anterior margin truncate, armed near the dorsal angle with a tooth-like process; surface of cuirass apparently smooth in the living state, exhibiting delicate transverse striæ when isolated by maceration; colour bright yellow. Length 1–430″.

HAB.—Salt water.

According to Ehrenberg this species is highly phosphorescent. Claparède and Lachmann have however failed to confirm the observations of the German authority.

Prorocentrum lima, Ehr.

Cuirass ovate, inflated and rounded posteriorly, becoming gradually narrower towards the anterior region; the anterior border slightly emarginate; surface sparsely asperate. Diameter 1–1152″ to 1–864″.

HAB.—Salt water, Adriatic. Colour yellowish-brown.

Doubtful Species.

The minute *Prorocentrum viridis* of Ehrenberg, reported to be of ovate or sub-orbicular form with a rounded posterior and shortly pointed anterior extremity, enclosing green granules, length 1–1100″, inhabiting the Baltic, is insufficiently characterized for identification as a representative of this genus.

GENUS X. DIMASTIGOAULAX, Diesing.

Animalcules free-swimming, encuirassed, traversed by an equatorial ciliated furrow; flagella two in number, issuing from the same point of origin in the equatorial groove; cuirass extended into horn-like prolongations.

Excepting for the presence of the two flagella, the as yet single known representative of this genus corresponds in form and structure with those of *Ceratium*.

Dimastigoaulax cornutum, Ehr. sp. PL. XXV. FIGS. 51 AND 52.

Cuirass compressed, quadrilateral, the dorsal surface convex, the ventral one concave; the anterior segment bearing two nearly straight horn-like processes, and the posterior a single short median one, neither of them exceeding one-half of the diameter of the body; flagella subequal, equalling or surpassing the body in length. Length 1–280″ to 1–140″.

HAB.—Fresh water; colour brown or slightly green.

This species, which is synonymous with the *Peridinium cornutum* of Ehrenberg, *Ceratium hirudinella* of Dujardin, and *Ceratium cornutum* of Claparède and Lachmann, has been selected by Diesing * as the type of the present genus on the strength of the evidence concerning its possession of two flagella, yielded through the investigations of Lieberkuhn and Claparède and Lachmann. It must be at the same time noted that this evidence is by no means conclusive; the last-named authorities, while figuring two flagella in the drawing, as here reproduced, were by no means certain as to their existence, and did not feel justified, under such circumstances, in connecting the species with a new generic title. The *Peridinium Carolinianum*, found by Mr. J. W. Bailey at Grahamsville, South Carolina, and described under the foregoing title in the 'Smithsonian Contributions to Knowledge' for December 1850, is apparently identical with this type.

* "Revision der Prothelminthen," 'Sitz. der Kaiser. Akad. der Wiss. Wien,' 1865.

In addition to his institution of the new genus *Dimastigoaulax* for the reception of the species last described, Diesing, *l. c.*, has further proposed to subdivide the family of the Peridiniidæ as here defined into several other subordinate genera. The definitions submitted not, however, being the outcome of his personal acquaintance with the organisms treated upon, but being based chiefly on the imperfect descriptions of various earlier authorities, are not considered sufficiently reliable for adoption in this treatise. An estimate of Diesing's proposed innovations in this direction may be gathered from the fact that a new genus, *Heteroaulax*, is proposed by him for the reception of the animalcules here included under the titles of *Gymnodinium fuscum*, *Peridinium* (*Glenodinium*) *inerme*, and *Glenodinium acuminata.* That of *Gonyaulax* for *Peridinium spiniferum*, that of *Glenoaulax* for *Gymnodinium* (*Glenodinium*) *æquale*, and that of *Proaulax* for *Gymnodinium corpusculum.* At the same time the ordinary horned and hornless representatives of the two genera *Ceratium* and *Peridinium* are retained under the last-named generic title, while the genus *Glenodinium* is left in the position originally assigned to it by Ehrenberg, the altogether unstable character of the presence of an eye-like pigment-spot being cited as distinguishing it from *Peridinium.*

Fam. II. HETEROMASTIGIDÆ, S. K.

Animalcules free-swimming, bearing one vibratile and one trailing flagellum, these appendages being supplemented by an adoral fringe of cilia ; oral aperture distinct, anteriorly located.

GENUS I. HETEROMASTIX, J.-Clk.

Animalcules naked, free-swimming, ovate or elongate, highly plastic and changeable in form, metabolic ; flagella two in number, inserted close together at the anterior extremity, one directed in advance, locomotive and vibratory, utilized as a tractellum, the other one trailing in the rear, gubernacular or anchorate ; a fringe of cilia extending on the ventral surface from the point of insertion of the flagella towards the posterior extremity ; endoplasm frequently enclosing a coloured eye-like pigment-spot ; oral aperture situated close to the base of the two flagella.

Heteromastix proteiformis, J.-Clk. PL. XXIV. FIGS. 70 AND 71.

Body highly contractile, changeable in form, mostly elongate fusiform or lanceolate, with a more pointed anterior extremity ; flagella long and stout, the anterior one, or tractellum, vibratile, about twice the length of the extended body, the trailing flagellum or gubernaculum about half this length ; supplementary cilia produced along a longitudinal groove which extends backwards on the ventral surface from the insertion of the flagella through about one-half of its entire length ; a red eye-like spot usually present at the anterior extremity. Length of body 1–500″.

HAB.—Fresh water.

This remarkable form, figured and described by Professor H. James-Clark in the Memoirs of the Boston Society of Natural History for the year 1868, is among the most interesting representatives of the Cilio-Flagellate group. With a flexible polymorphic body most closely resembling that of an *Astasia* or *Euglena*, exhibiting likewise the coloured pigment-spot of the latter genus, it possesses the two differentiated flagella, the one trailing and the other extensile and vibratile, of *Anisonema*, *Heteromita*, or *Heteronema.* Superimposed on this we find an anterior adoral fringe of well-developed cilia, the animalcule thus constituted representing an intermediate condition or annectant type between the above-mentioned simpler Flagellata and the more highly organized Ciliata. Upon this accessory ciliated fringe there appears, according to Professor Clark's description, to devolve the chief task of locomotion, the extended and longer anterior flagellum being used more exclusively as a tentative and prehensile organ. As reported by this authority, the animalcule furthermore displays much intelligence in the use of its tactile flagellum, turning and twisting it about, and feeling with it in every direction with as much seeming consciousness as is shown by an elephant in the control of its proboscis. No details concerning the position or existence of a contractile vesicle or endoplast have yet been recorded, nor any data relating to the phenomena of development and reproduction. Professor James-Clark has unfortunately omitted to mention whether the endoplasm of this interesting species is coloured green or transparent. It structural affinities being evidently nearest to *Heteronema*, it might be anticipated, in correlation with their structure, that this element is colourless. At the same time, the development of an anterior eye-like pigment-spot is more commonly associated with the chlorophyllaceous forms.

Fam. III. MALLOMONADIDÆ, S. K.

Animalcules free-swimming, bearing a single long, terminal flagellum; entire cuticular surface covered with long, flexible, setose cilia.

GENUS I. MALLOMONAS, Perty.

Animalcules free-swimming, oval or elliptic, persistent in shape; cuticular surface indurated, clothed with long, non-vibratile, hair-like setæ; a single long vibratile flagellum produced from the anterior extremity; contractile vesicle indistinctly developed. Inhabiting fresh water.

Mallomonas Plosslii, Perty. PL. XXIV. FIGS. 72 AND 73.

Body ovate or elliptical, slightly narrower anteriorly; cuticular surface finely shagreened or crenulate, thickly clothed with fine, hair-like setæ, whose length is less than that of the body; flagellum long and slender, retractile; endoplasm vacuolar, amber colour or greenish yellow; contractile vesicle indistinct, posteriorly located. Length of body 1–1000″ to 1–900″.

HAB.—Marsh water.

Having, in February 1878, obtained an animalcule from marsh-water from Le Marais, Jersey, which is undoubtedly identical with the *Mallomonas Plosslii* of Perty, the author is enabled to furnish a more accurate description and delineation of this singular form than has been hitherto supplied. Turning attention first to the cuticular investment, its indurated character has been clearly demonstrated through the discovery in abundance in the same water of the empty skins, either nearly whole or in fragments with angular fractures, as left after the decay of the living contents. To these cuticular fragments the hair-like setæ were likewise attached, in a more or less perfect state, indicating not only their rigid and durable consistence, but also their original derivation from this cuticle and not from the underlying endoplasm, as was at first suspected by an examination of living examples only. Perty's testimony respecting the apparently crenulated aspect of the peripheral border was fully confirmed and explained by the employment of a high magnifying power, when it was shown that the whole surface of the cuticle is ornamented or shagreened with closely approximated hemispherical elevations, each of which forms a basis of support to the overlying seta. In this respect the cuticular investment of *Mallomonas* exhibits a structure corresponding closely with that of many Holotrichous Ciliata, in which the cilia or setæ spring from similar hemispherical cuticular elevations, the cuticle however, in most instances, remaining soft and plastic. Examined in the living state the animalcules were found to exhibit diverse phases of comportment. Sometimes they remained quiescent, with the flagellum entirely retracted within the perforation or oral cleft at the anterior extremity of the hardened cuticle, while at other times this organ was extended and rapidly undulated or vibrated. In the former of these instances the quiescent animalcule with its extended setæ and retracted flagellum, except for its colour, presents an aspect closely similar to that of the Holotrichous *Cyclidium glaucoma*. On abandoning this quiescent for a motile state, the hitherto erectly extended setæ are, as the animalcule progresses in an even, straightforward course through the water, reflected backwards, as shown at Pl. XXIV. Fig. 73. At first it seemed as though the little creature possessed an active control over these appendages, and could erect or depress them at will. The subsequent determination, however, of the relationship subsisting between the setæ and the indurated cuticle, as already described, precludes such an interpretation, and it is evident that this reflection of the setæ must be accounted for simply by their yielding before the pressure of the water during locomotion.

The interior parenchyma or endoplasm of the specimens examined was found to consist of an apparently homogeneous, clear, greenish-yellow plasma, one or two slowly contracting vacuoles within the same being detected towards the posterior extremity of the body. Other vacuolar spaces, of a non-contractile order, were scattered irregularly throughout its substance. By Perty the animal or vegetable nature of *Mallomonas* was left undecided. Although the inception of food-particles was not witnessed, the evident control exerted by this organism in its movements leaves no doubt as to its true animal nature.

Stein * has attempted to identify *Mallomonas Plosslii* with the disintegrated and metamorphosed zooids of *Synura uvella*. Such an identification, however, in face of the evidence here brought forward, cannot be maintained. *Mallomonas* proper never possesses but a single flagellum, while the characteristic setæ exhibit a uniform size and symmetrical plan of disposition altogether distinct from that pertaining to the metamorphosed zooids of *Uvella*, as figured by this authority.

Supplementary Species.

Fresenius † has figured and described an animalcule which he refers to this form, which on further investigation will probably prove to be a second species. The hair-like setæ in this type are represented as fully equal in length to or longer than the body, and comparatively few, thirty being the greatest number counted by him, while considerably less are given in his figures; the two anterior of these are, however, described as being usually directed forwards, like antennæ, on each side of the flagellum. It is proposed to provisionally distinguish this animalcule by the title of *Mallomonas Fresenii.* A delineation of this species or variety, reproduced from the figures of Fresenius, is given at Pl. XXIV. Fig. 74.

Fam. IV. STEPHANOMONADIDÆ, S. K.

Animalcules free-swimming, bearing a single terminal flagellum, the base of which is embraced by a brush-like fascicle or uninterrupted circular wreath of cilia.

* 'Infusionsthiere,' Abth. iii., 1878.

† 'Beiträge zur Kenntniss mikroskopischer Organismen,' Frankfort, 1858.

Divested of their flagellate appendages, the as yet but little known representatives of this small family group would bear a marked resemblance to such free Peritricha as *Strombidium* and *Halteria*, and it is not improbable that the transition or line of evolution from the Flagellata to the above-named group of the Ciliata is accomplished in this direction.

GENUS I. STEPHANOMONAS, S. K.

Animalcules free-swimming, more or less ovate, bearing a crown or wreath of cilia at the anterior extremity of the body, from the centre of which a single persistent flagellum takes its origin; the remaining surface of the cuticle entirely smooth.

This genus is instituted for the form referred with some doubt by De Fromentel * to the genus *Trichomonas* under the title of *T. locellus;* the symmetrical, crown-like disposal of the cilia and single flagellate appendage at the anterior end of the body serve at once, however, to distinguish it from all the members of that generic group. It is possible that the *Asthmatos ciliaris* of Salisbury is identical with, or closely allied to this same form, though in that type both the flagellum and cilia appear to be much more fugacious in character.

Stephanomonas locellus, From. sp. PL. XXIV. FIG. 69.

Body ovate or pyriform, truncate and slightly narrower anteriorly; about twice as long as broad, the posterior region rounded and inflated; ciliary wreath symmetrical, encircling the anterior border; flagellum thickest towards the base, scarcely exceeding the length of the body; endoplasm transparent, granular. Length 1–800″. HAB.—Fresh water.

This species, as above intimated, is identical with the *Trichomonas locellus* of De Fromentel. The *Trichomonas minima* of the same writer, somewhat resembling the present form, but of apparently considerably smaller size, and in which the central flagellum was not distinctly observed, represents possibly a second species of the genus *Stephanomonas.* De Fromentel's *Trichomonas hirsuta,* with non-vibratile cilia clothing the entire cuticular surface, is apparently more closely related to his own *Trichonema hirsuta*, presently described.

GENUS II. ASTHMATOS, Salisbury.

Animalcules free-swimming, ovate or spherical, bearing a terminal crest or brush-like fascicle of long, vibratile, retractile cilia, which is supplemented by a central, long, extensile flagellum or proboscis-like process; the remaining cuticular surface naked, soft and plastic, permitting the body to assume various outlines.

The aspect of the as yet single known species of this genus, as described and figured by Dr. Salisbury in Hallier's 'Zeitschrift für Parisitenkunde,' Bd. iv. 1873, conforms so closely, when the flagellum or so-called proboscis is retracted, with such Ciliata as *Strombidium* or *Mesodinium*, that it was at first proposed to refer the type to the Peritrichous order. The supplementary appendage named, however, agrees so essentially in nature with that of an ordinary but somewhat thickened flagellum, and the cilia themselves possess in their retractile capacity so distinct and it may be

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* 'Études sur les Microzoaires,' Paris, 1876.

said less permanent a character than is met with among the Peritricha, that its reference to the present intermediate group, sharing the characters of both the Ciliate and Flagellate infusorial orders, seems desirable. Both the central flagellum and surrounding fascicle of cilia would seem to manifest in their capacity of retraction and temporary obliteration a certain correspondence with the similarly retractile flagellum and associated collar of the order of the Discostomata, which has been already briefly referred to, see p. 329, in connection with that group.

Asthmatos ciliaris, Salisbury. PL. XXIV. FIGS. 62–64.

Body usually ovate or subspherical, but plastic and changeable in form; anterior fascicle of cilia brush-like, long and flexible, the length of the constituent cilia, when fully extended, equalling that of the body; flagellate appendage usually central, but sometimes developed toward one side of the anterior border, thick at its base, and gradually tapering to the apical extremity, exceeding the length of the body when fully extended; endoplasm finely granular, enclosing one or more vacuolar spaces or nucleolar bodies. Length 1–1200″.

HAB.—Occurring as a parasitic form in the mucous fluid of the eyes, nose, and throat of the human subject.

This remarkable animalcule is described by its discoverer, Dr. J. H. Salisbury, in the publication above quoted, as constituting the essential cause of certain forms of hay-fever, which he proposes to distinguish as "infusorial catarrh and asthma." This decision is arrived at by him, not through the detection of the animalcule in connection with a single instance only of the above affection, but from its invariable presence in large quantities in as many as sixty cases successfully treated by him, extending over a period of six years, and in all of which instances the recovery of the patient speedily followed the application of remedies causing the death of the animalcules. The diagnosis of the disease, as given by Dr. Salisbury, may be thus abbreviated: The ailment first attacks the mucous surfaces of the eyes and nose, causing a free secretion of tears, and frequently intense paroxysms of sneezing. From the nasal passages the affection extends to the fauces, larynx, trachea, and to the larger and smaller bronchi; burning heat and irritation, accompanied by violent coughing, attend its arrival at the first-named locality, while upon reaching the larger bronchi the symptoms exhibited are very similar to those of "catarrhal fever." Finally invading the smaller bronchi and air-cells, asthmatic symptoms predominate, associated with intense suffering, which is more particularly aggravated by exposure to the night or evening air. Relief was invariably afforded and a speedy cure effected in even the most distressing cases by the frequent inhalation, every hour or two, of a solution of either carbolic acid, tincture ferri chloride, sulphuric, hydrochloric, or nitric acids, the solution in either case being sufficiently weak to avoid irritation during the inhalement. Two grains of quinia sulphate every four hours, or twenty drops of tincture ferri chloride in a glass of water morning, noon, and night, further accelerated the recovery of the patient. The sputa or mucus from the affected parts, examined before and after the first inhalation, demonstrated the presence in the former instance of the animalcules in an actively motile state, while in the latter instance they were mostly dead or motionless, and speedily succumbed to further applications of the remedy. In connection with the more ordinary and milder form of hay-fever, occurring usually during the latter end of May and through June, accompanied by violent sneezing and painful inflammation with the corrosive discharge from the nasal mucous membrane, Professor Helmholtz * has detected the presence within the nasal

* See 'Nature,' May 14th, 1874.

secretion of innumerable vibrio-like bodies, not observable at other times; these were readily destroyed and the hay-fever symptoms cured by administration three times daily, with a nose-douche, of weak solution (1·800) of sulphate of quinine. The best effects were obtained through applying the solution in a tepid form.

The manner in which *Asthmatos ciliaris* reproduces its kind is, in accordance with Dr. Salisbury's account, somewhat remarkable. A single young one at a time is, he relates, developed inside the parent, and is when mature discharged posteriorly through the body-wall of the latter. His woodcut illustration of this liberation of the newly formed animalcule, reproduced at Pl. XXIV. Fig. 64, would seem, however, to represent an instance of ordinary transverse fission similar to that exhibited by *Halteria* or *Strombidium*, and in which the body, becoming elongate, is constricted centrally, the constriction being accompanied by the growth of a new circlet of cilia. The newly produced zooids are described as being much more active than the older ones, rolling from side to side in an oscillating manner, while the movements of the parents are chiefly tremulous or vibratory.

So recently as November 1880, the author's attention has been directed by Dr. Joseph Leidy to a communication concerning this singular organism contributed by him to the 'American Journal of Medical Science,' p. 85, for the year 1879. In this communication the claim of *Asthmatos* for recognition as an independent protozoic structure is not admitted, Dr. Leidy expressing himself satisfied that the so-called animalcules, as first described by Dr. Salisbury, represent merely detached ciliated epithelial cells from the air-passages, more or less modified by the catarrhal affection. This decision he arrives at not merely from an analysis of Dr. Salisbury's description and accompanying figures, but—having been himself affected by an autumn catarrh for many years—through an intimate acquaintance with an apparently identical organism produced abundantly in his own person, which he unhesitatingly identifies with ordinary or more or less deformed ciliated epithelial cells. While the evidence submitted by Dr. Leidy is here accepted as strongly supporting this epithelial interpretation, one or two points connected with Dr. Salisbury's original description of *Asthmatos* leave room for justifiable doubts as to whether or not two distinct organisms have been examined by these respective observers. Thus, the production of young from the parent's body, or, as it is here interpreted, the phenomenon of transverse fission accompanied by the development of a posterior ciliary circlet, recorded by Dr. Salisbury, is altogether at variance with the ordinary comportment of detached epithelial cells; added to which it must be observed that in none of the numerous figures given by Dr. Leidy is any indication given of the so-called proboscis or flagellate appendage which constituted an essential feature of the innumerable examples examined by Salisbury. It may be further mentioned, that reference is made by Dr. Leidy to a communication, entitled 'Rhizopods (*Asthmatos ciliaris*) a cause of Disease,' published by Dr. Ephraim Cutter, of Boston, in the 'Virginia Medical Monthly' for November 1878, and in which this last-named authority having, in company wth Professor P. F. Reinsch of Erlangen, examined numberless examples, arrives at the conclusion that the organism is a Protozoon allied to *Actinophrys*, referring the more precise identification of its nature and position to Dr. Leidy. That infusorial animalcules exist which correspond in all essential points with the isolated cellular elements of ciliated epithelium, is abundantly manifested in such isomorphic types as *Magosphæra planula* and *Lophomonas blattarum*, which forms again, excepting for the presence of the more ordinarily developed flagellate appendage, the *Asthmatos ciliaris* of Dr. Salisbury closely resembles.

Fam. V. TRICHONEMIDÆ, S. K.

Animalcules free-swimming, bearing a single terminal flagellum, the remainder of the cuticular surface more or less completely clothed with cilia.

The members of this group, as typified by the genus *Trichonema* of De Fromentel * may be said to bridge over the gap between the ordinary Flagellata and Holotrichous Ciliata, in the same manner as the *Stephanomonadidæ* connect them with the Peritricha. In the absence of the flagellum the animalcule in question would scarcely be distinguished from a minute *Trachelophyllum* or other representative of the Holotrichous order.

GENUS I. TRICHONEMA, De Fromentel.

Animalcules free-swimming, more or less ovate, elastic and changeable in form, bearing a single flagellum at the anterior extremity; the entire cuticular surface clothed with short cilia; oral aperture distinct, situated at the base of the flagellum.

Trichonema hirsuta, From. PL. XXIV. FIGS. 65 AND 66.

Body when extended subpyriform or ovate, most usually rounded and inflated posteriorly, narrower and attenuate anteriorly, contracting to an almost globular form; endoplasm hyaline, granular; flagellum long and slender, about twice the length of the body, rigid at its base, very flexible and undulating at its distal extremity; cuticular cilia short and apparently non-vibratile; oral orifice represented by an obliquely oval excavation, situated at the base of the flagellum; contractile vesicle posteriorly located. Length 1–800". HAB.—Fresh water.

GENUS II. MITOPHORA, Perty.

Animalcules free-swimming, persistent in shape, elongate-ovate or pyriform, bearing a single terminal flagellum which is supplemented by a lateral or more or less complete peripheral fringe of vibratile cilia.

In the single type referred to this genus by Perty, a considerable range of variation is, in accordance with his accompanying figures, exhibited in the development of the accessory cilia. In some instances these appendages are represented as forming a short lateral fringe only, while in others they constitute an almost complete peripheral series. It would seem, indeed, not altogether improbable that these cilia entirely clothe the cuticular surface as in *Trichonema*, from which generic type it would then be distinguished only by its persistent shape.

Mitophora dubia, Perty. PL. XXIV. FIGS. 67 AND 68.

Body clavate or pyriform, sometimes curved, from two to three times as long as broad; flagellum produced from the thicker of the two extremities, sometimes with a knob-like distal termination; lateral ciliary fringe conspicuous, variably developed; endoplasm enclosing green granules. Length 1–450". HAB.—Fresh water; movements slow and rotatory.

Some uncertainty is attached to the identification of the anterior and posterior regions of this animalcule, Perty correlating with the latter the extremity bearing the flagelliform appendage. In one of his figures, however, a notch-like excavation is indicated close to this organ, and this not improbably represents an imperfectly observed oral aperture.

* 'Études sur les Microzoaires,' Paris, 1876.

APPENDIX TO VOL. I.

THE MYXOMYCETES OR MYCETOZOA.

At pages 41 to 43 and 193 of this volume (published in Parts I. and II., October and November, 1880), the Myxomycetes or Mycetozoa have been somewhat extensively referred to as exhibiting, in accordance with the researches of De Bary and Cienkowski, so close an affinity with the typical Flagellate Infusoria that they cannot be consistently retained in their old place among the Gasteromycetous Fungi, but must be advanced to a position among the Protozoa at no very remote distance from the group Spongida. In the pages of 'Grevillea,' for December 1880, the editor, Dr. M. C. Cooke, has, as a mycologist, lodged a somewhat strong protest against the proposed transfer, arguing that more substantial evidence than a mere citation of these continental authorities is required to prove the animal nature of these organisms. In the 'Popular Science Review' for April 1881,* the author has, in a résumé of the structural and developmental features of the Myxomycetes, fully replied upon all the points raised by Dr. Cooke, and added to the evidence previously adduced the record of a recent personal investigation of the developmental phenomena of several Myxomycetan types, including more especially the *Physarum tussilaginis* of Berkeley and Broom,† originally discovered in this country by Mr. Thomas Brittain of Moss-side, Manchester, and to whom the author is indebted for the receipt of authenticated specimens. The results obtained through the careful cultivation of the spores of this species have so fully confirmed and added to the testimony first submitted by De Bary and Cienkowski, that the author is prepared, even more confidently than hitherto, to support the animal interpretation of their nature and affinities. A brief abstract of the developmental data recorded by the author in connection with this species is herewith reproduced.

The spores in question—primarily enclosed in a depressed sessile sporangium having a delicate membranous wall studded with minute stellate spiculæ ‡—were sown in distilled water on ordinary slides, covered with thin glass, and kept when not under direct examination in a moist chamber. So soon as within seven hours after wetting them, or indeed directly following their deposition on the slide, an examination revealed the companionship of innumerable quiescent *Bacteria*, with a more or less abundant sprinkling of spores other than those of *Physarum*, and of considerably smaller size. The spores specially sown, having a diameter of 1–2000″ to 1–1500″, were found, under high magnification, to consist of an outer wall of considerable thickness, finely echinulate externally, and exhibiting, by transmitted light, a dark amber or chitinous coloration. The protoplasmic contents rarely entirely filled the outer shell, but remained separated from it by a greater or less number of angular interstices. A central spheroidal nucleus, with a contained nucleolus, one or more large refringent corpuscles, and numerous smaller granules, represented the sum-total of the recognizable internal elements. By the end of the second day active life had already dawned upon the scene. Bacteria were swiftly propelling themselves to and fro in all directions; one or two biflagellate monads, *Heteromitæ*, whose development was subsequently traced from certain of the smaller spores above mentioned, glided slowly along, dragging their posterior flagella, "gubernacula," cablewise behind them. Sparsely scattered amongst the spores of the Myxomy-

* "The Myxomycetes or Mycetozoa; Animals or Plants?" by W. Saville Kent, F.L.S., &c., 'Pop. Sci. Rev.,' New Series, vol. v. No. xvii. pl. iii. and iv., 1881.

† 'Ann. Nat. Hist.,' p. 139, Feb. 1856.

‡ 'Pop. Sci. Rev.,' pl. iv. figs. 30–35.

cetan were presently observed isolated hyaline protoplasmic spheres having the same diameter and structure as the contents of the spore-cases, just described. In a little while the exit of one of these hyaline spheres from the echinulate spore-cases was witnessed, and the relationship between the two substantially established.

By the termination of the third day, these protoplasmic spheres had much increased in number, some of them exhibiting feeble amœboid movements. An additional factor had, however, now appeared upon the scene in the form of a vermicular monadiform organism, having a length of 1–1250″ to 1–1000″, and which progressed somewhat clumsily through the water revolving on its longitudinal axis. A spheroidal nucleus, with its enclosed nucleolus, was observable towards the anterior extremity, and a single rhythmically contracting vesicle at the opposite region of the body. The derivation of these monadiform beings, from the extruded protoplasmic spheres, was immediately suspected, and the correctness of this inference soon substantiated. Selecting an isolated and recently extruded sphere, it was carefully watched. For a considerable interval the newly released germ confined its signs of vitality to a feeble expansion and contraction of its peripheral margin, and to the rhythmical pulsations of its contractile vesicle, which, with the spheroidal endoplast, were clearly discernible. As time progressed, alterations in contour were more strongly manifested, though without the germ moving away from the scene of its birth. At length an altogether elongate amœboid, or vermiform aspect predominated, the nucleus or endoplast being shifted to one extremity and the contractile vesicle occupying the other. Then, all at once, a flickering at one end indicated the development of a flagellate appendage, which in a few seconds became distinctly visible. The vibratile motion of this organ soon caused the body to oscillate, and presently lifting it from its hitherto prone position, it was launched into the surrounding water a free-swimming, elongate monad. During the next few days, similar monadiform germs were developed abundantly from the spores in all parts of the field, and the next step in their ontogeny fully certified. It was found, in fact, that the free-swimming condition of the germs was but of brief duration, and subservient, apparently, only to their local distribution. Within a day or two, the monadiform beings once more betook themselves to a repent mode of existence, the flagella being for a while retained, communicating to them a remarkable likeness to the repent flagelliferous animalcules heretofore described under the generic titles of *Mastigamœba* and *Reptomonas*. The flagella being next completely withdrawn, the organisms became undistinguishable from ordinary *Amœbæ*, and continued to creep about the field by broad, ovate extensions of their periphery.

An important point yet remained to be solved. De Bary and Cienkowski had declared that during both their monadiform and subsequent amœboid phases the Myxomycetes ingested and subsisted on solid food. This evidence has been regarded by some writers as extremely doubtful, while by others it has been emphatically denied. A simple experiment, however, soon demonstrated that these two authorities were again completely in the right. Examples, more especially of the repent amœboid units, had been previously observed, whose bodies contained vacuoles more or less completely filled with ingested *Bacteria*, which, being produced in numbers prior to the hatching out of the *Physarum* germs, provided for the Mycetozoa an abundant and ready set feast. The common test of adding pulverized carmine to the water, was speedily followed by its free ingestion by both the natatory monads and the repent amœbiform units, the former incepting it chiefly towards the anterior region of the body, and the latter indifferently at any point of their periphery. As in the case of *Bacteria*, the smaller particles of pigmentary matter, after inception, were usually collected together within spheroidal vacuoles of the endoplasm, and maintained there the same molecular movements they exhibited in their free condition. The larger particles, on the other hand, remained distributed as more or less distinctly isolated fragments. For the next few weeks, these amœboid organisms continued to feed and increase in size, and were fairly started on their way towards the succeeding chapter in their ontogeny, viz. their production, through coalescence, of the comparatively colossal but still amœbiform "plasmodia," out of which the spore-receptacles or sporangia are finally evolved.

The points concerning the development and nutritive phenomena of the Myxomycetes thus verified through personal investigation, are accepted by the author as affording the strongest confirmation of his views previously expressed, to the effect that these organisms have nothing whatever to do with Fungi, but are rightly referable to the Protozoic division of the animal series. Among these. their correlation may be accomplished with the utmost ease, their entire life-cycle, indeed, being precisely parallel in kind, though differing in degree, with what obtains among the ordinary Flagellate Infusoria. A primary flagelliferous phase, an intermediate repent amœboid condition, and a final encysted sporiferous state, these three represent the normal life-cycle of either a Myxomycetan or a simple monadiform animalcule. The only distinction manifested on the part of the Myxomycetes, and that, as just stated, being one only of degree, and not of kind, consists in the fact that the final act, that of encystment, and the resolution of the body into spores, is in this group accomplished by a mass of coalescing or conjugating units, which consequently produce a relatively colossal spore-receptacle or sporangium—the so-called Fungus—while in the case of the typical Flagellata it is an isolated monad, or two or a few conjugated units only, that build up the relatively minute, but otherwise morphologically and physiologically identical reproductive structure.

In every structural detail, and in every successive stage of their life-history, the Myxomycetes or Mycetozoa, from their first exit from the spore until their final resolution into similar reproductive elements, may be consistently correlated with the typical Protozoa, and with them alone. While in their compound aggregation, their production of a horny rete or capillitium, and frequent excretion of spicular elements, a departure is made in the direction of the Sponges, the simply flagellate condition of the spore-derived units, and the capacity possessed by them to ingest food-substances at all parts of their periphery, demonstrate their nearest affinity with the simple Flagellata Pantostomata, and of which they may be accepted as representing the most complex factors.

This decision arrived at by the author concerning the affinities of the Myxomycetes receives additional and highly substantial support in connection with the description, by Surgeon-major D. D. Cunningham, of the life phenomena of certain microscopic organisms developed in the intestinal canal and fæcal evacuations of man, cows, and other animals, recorded in the 'Quarterly Journal of Microscopical Science' for April 1881.* Under the title of *Protomyxomyces coprinarius*, is therein described an organism which, while presenting an infinity of polymorphic expressions, is reducible in a like manner to the three component terms common to the two groups of the Myxomycetes and ordinary monads, and which, indeed, as intelligently recognized by Dr. Cunningham, occupies a position precisely midway between these two series. With the typical Myxomycetes, *Protomyxomyces* agrees in so far as that the usually relatively large sporangium represents the final disintegration into spores of a multitude of closely associated amœboid elements, surrounded by a common membranous envelope studded with organic granules, these amœboid elements having again commenced existence as simple flagellate monads—Dr. Cunningham's so-called "zoospores." From the typical Myxomycetes, on the other hand, *Protomyxomyces* differs in that the amœboid beings thus building up the compound sporangium do not coalesce intimately with one another so as to form a common plasmodium, but, while closely approximated, remain individually distinct, each amœboid unit separating into an independent spore-mass after the manner of the typical Flagellata.

* First published as an Appendix to the "Fifteenth Annual Report of the Sanitary Commission of the Government of India."

END OF VOL. I.