organs are laid down, the wall contributes the greater number of cells *directly* to the rudiment in question.

Finally, as presenting a still higher type of organization, we may cite the buds of *Botryllus* and many other Ascidians, in which blood cells are not concerned at all in the development; nor is there here a wandering out of cells from the vesicle to form a shapeless mass, out of which a definite structure is built up later.

We may take the origin of the dorsal tube as an illustration; in *Botryllus*, for instance, the roof of the inner vesicle in the region which will be cut off as the atrium, directly evaginates to form a tubular diverticulum; the posterior connection is lost eventually and the definitive dorsal tube, which is thus bodily pinched off from the inner vesicle, is established. The origin of the pericardium as a diverticulum in *Goodsiria*, according to Ritter (*l. c.*), furnishes another example of the same degree of differentiation.

It is interesting in this connection to call to mind the various modes of origin of the body cavities presented by different species of *Balanoglossus*. Omitting the proboscis cavity on account of absence of sufficient data, Morgan[1] has shown that the remaining body-cavities "may arise as enteric diverticula, as endodermal proliferations, or even arise from mesenchymatous beginnings." This is an exactly parallel series of facts with those which *Botryllus*, *Ecteinascidia*, and *Perophora viridis* exhibit in their bud-development regarding the origin of certain organs. As Morgan emphasises the fact that no sharp lines can be drawn between enterocoels, schizocoels, and blastocoels, so the different methods of formation of those structures in the Ascidian bud, which have been referred to above, are not fundamentally unlike but are merely expressions of varying degrees of differentiation of the inner vesicle.

EXPLANATION OF FIGURES.

FIG. 2.—Portion of inner vesicle on right side in posterior region, cut transversely, showing rudiment of pericardium, *pc. r.*; *a.* and *b.*, nuclei passing into latter; *in. v.*, inner vesicle. (500 Diam.)

FIG. 3.—Frontal section of anterior end of inner vesicle, showing very young rudiment of dorsal tube, *d. t. r.*, cut transversely; *ec.*, ectoderm is also figured; *in. v.*, inner vesicle. (500 Diam.)

FIG. 4.—Transverse section from anterior end of older bud; *gl. r.*, rudiment of ganglion; *d. t.*, dorsal tube; *ec.*, ectoderm; *in. v.*, inner vesicle. (500 Diam.)

FIG. 5.—Transverse section from still older bud, showing origin of sub-neural gland, *s. n. g.*, from ventral wall of dorsal tube, *d. t.*; *gl.*, ganglion. (500 Diam.)

FIG. 6.—Transverse section of portion of inner vesicle from the dorsal side in posterior region, indicating origin of rudiment of the sexual organs, *s. r.*; *in. v.*, inner vesicle; at lower right hand corner of figure, cells are passing out of the wall probably to become cells of the blood. (500 Diam.)

FIG. 7.—Portion of wall of inner vesicle, showing a cell, *a.*, at an early stage of migrating into body-space. (500 Diam.)

Notes on the Cubomedusae. By F. S. CONANT.

In June and July of 1896 while the Marine Biological Laboratory was stationed at Port Henderson, in Kingston Harbor, Jamaica, two species of Cubomedusae were found in unexpected abundance. Of these one was very much like the *Charybdea marsupialis* of the Mediterranean; the other presented characteristics midway between those of the Charybdeidae and the Chirodropidae—the two families into which Haeckel divides the Cubomedusae—so that for it I have erected a new family under the name of the Tripedalidae. The names that have been chosen for the two Jamaica forms are *Charybdea xaymacana* and *Tripedalia cystophora*.

A. SYSTEMATIC.

Haeckel's classification, as given in his "System der Medusen," is as follows:

Cubomedusae (*Haeckel*, 1877).

Acraspeda, with four perradial marginal bodies, which contain an auditory club with endodermal otolith-sac and one or several eyes. Four interradial tentacles or groups of tentacles. Stomach with four wide perradial rectangular pockets, which are separated by four long and narrow interradial septa. They belong to the subumbrella, and are developed from the endoderm of the stomach pockets, so that they project freely into the space of the pockets.

[1] Journ. Morph., Vol. IX, No. 1, 1894.

Family I: Charybdeidae (*Gegenbaur*, 1856).

Cubomedusae with 4 simple interradial tentacles; without marginal lobes in the velarium, but with 8 marginal pockets; without pocket arms in the 4 stomach pockets.

Family II: Chirodropidae (*Haeckel*, 1877).

Cubomedusae with 4 interradial groups of tentacles; with 16 marginal pockets in the marginal lobes of the velarium, and with 8 pocket arms, belonging to the exumbrella, in the 4 stomach pockets.

(This family is represented in American waters by a species of Chiropsalmus found at Beaufort, N. C., and identified by H. V. Wilson as *Ch. quadrumana*. Before Claus's paper on *Charybdea marsupialis* was received at the laboratory, Professor Wilson had gone over essentially the same ground on Chiropsalmus, but with results so similar to those of Claus that when the latter's article came he did not finish for publication the notes and drawings he had made.)

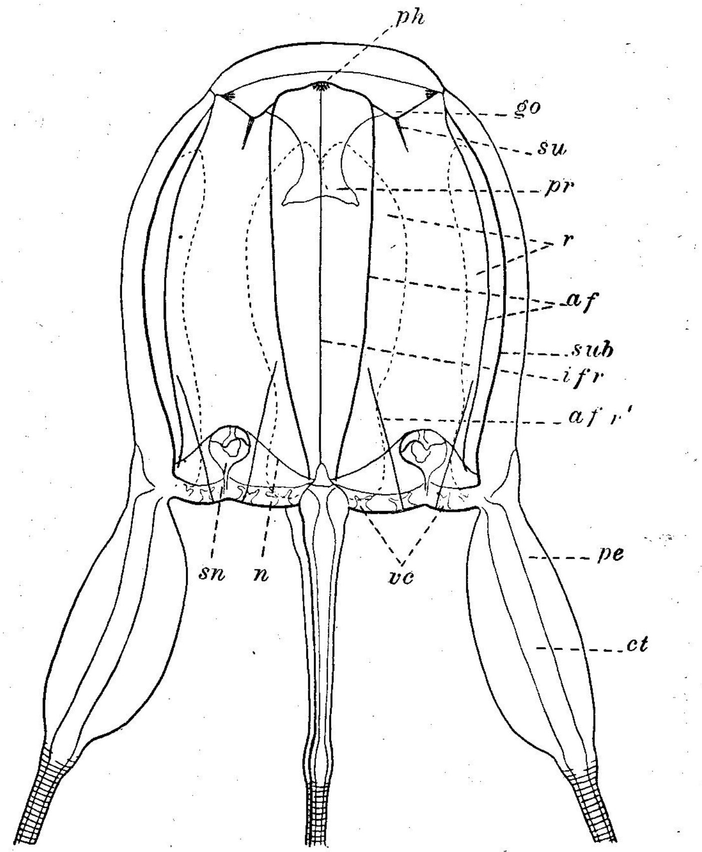

FIG. 8. *Charybdea xaymacana.*

To accommodate the second species found in Kingston Harbor another family must be added to the preceding.

Family III: Tripedalidae (1897).

Cubomedusae with 4 interradial groups of tentacles each group having 3 tentacles carried by 3 distinct pedalia; without marginal lobes in the velarium; with 16 marginal pockets; without pocket arms in the stomach pockets.

Description of *Charybdea xaymacana*. (Fig. 8.)

Genus Charybdea (acc. to Haeckel): Charybdeidae with 4 simple interradial tentacles, with pedalia; with velarium suspended, with velar canals and 4 perradial frenula. Stomach flat and low, without broad suspensoria. Four horizontal groups of gastric filaments, simple or double, tuft or brush-shaped, limited to the interradial corners of the stomach.

Species: *Charybdea xaymacana.*

Bell a four-sided pyramid, with the corners more rounded than angular, yet not so rounded as to make the umbrella bell-shaped. The sides of the pyramid parallel in the lower two-thirds of the bell, in the upper third curving inward to form the truncation; near the top a slight horizontal constriction. Stomach flat and shallow. Proboscis with four oral lobes, hanging down in bell cavity a distance of between one-third and one-half the height of bell; very sensitive and contractile, so that it can even be inverted into the stomach. The four phacelli, epaulette-shaped, springing from a single stalk. Distance of the sensory clubs from the bell margin one-seventh or one-eighth the height of bell. Velarium in breadth about one-seventh the diameter of the bell at its margin. Four velar canals in each quadrant; each canal forked at the ends, at times with more than two branches. Pedalia flat, scalpel-shaped, between one-third and one-half as

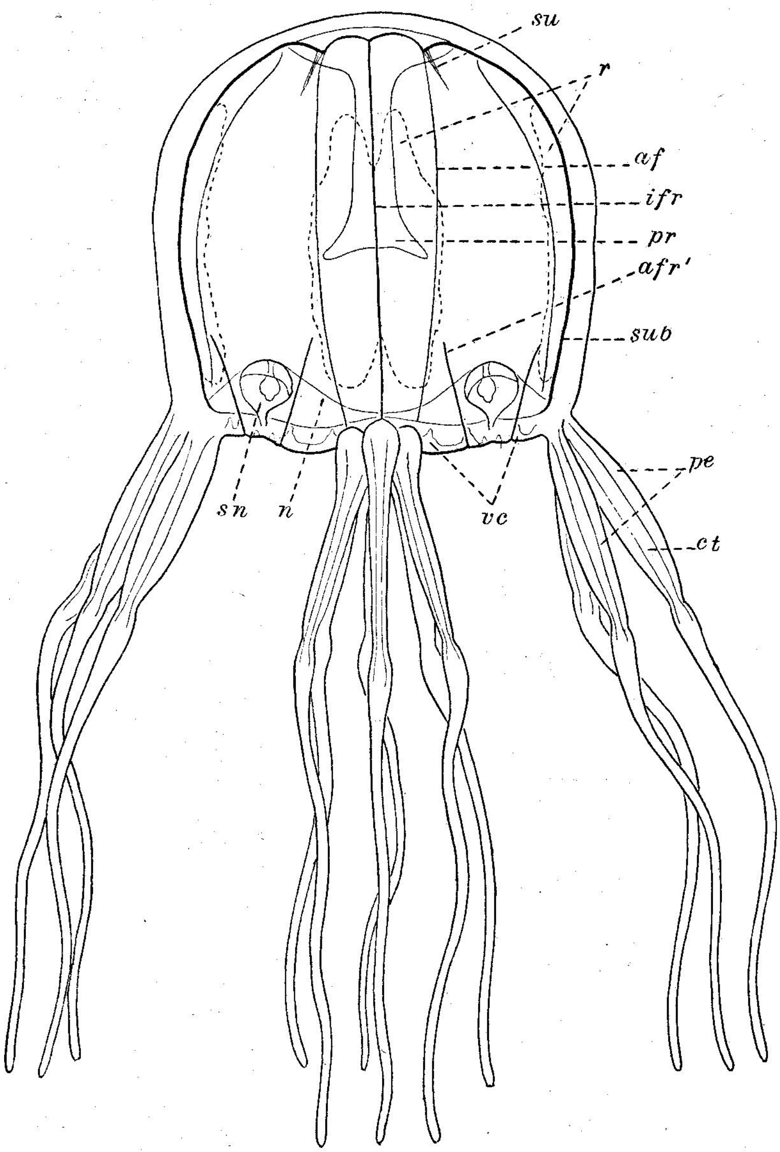

FIG. 9. *Tripedalia cystophora.*

long as the height of bell. The four tentacles, when extended, at least eight times longer than the bell. Sexes separate. Height of bell, 18–23 mm.; breadth, about 15 mm. (individuals with mature reproductive elements). Without pigment. Found at Port Henderson, Kingston Harbor, Jamaica.

As may be seen from the above, *C. xaymacana* differs only a little from the *C. marsupialis* of the Mediterranean. Claus mentions in the latter a more or less well defined assymmetry of the bell which he connects with a supposed occasional attachment by the proboscis to algae. In *C. xaymacana* I never noticed but that the bell was perfectly symmetrical. *C. xaymacana* is about two-thirds the size given by Claus for his examples of *C. marsupialis*, which were not then sexually mature. It has 16 velar canals instead of 24 (32) as given by Haeckel, or 24 as figured by Claus. Difference in size, and in number of velar canals, are essentially the characteristics upon which Haeckel founded his Challenger species, *C. murrayana.*

Description of *Tripedalia cystophora.* (Fig. 9.)

Genus Tripedalia: For the present the characteristics of family and genus must necessarily be for the most part the same. The genus is distinguished by having 12 tentacles, in 4 interradial groups of 3 each; velarium suspended by 4 perradial frenula; canals in the velarium; stomach with relatively well-developed suspensoria; 4 horizontal groups of gastric filaments, each group brush-shaped, limited to the interradial corners of the stomach.

Species: *Tripedalia cystophora.*

Shape of bell almost exactly that of a cube with rounded edges; the roof but little arched. Proboscis with 4 oral lobes; hanging down in the bell cavity generally more than half the depth of the cavity; and at times even to the bell margin. In the gelatine of the proboscis an irregular number (15–22) of sensory organs resembling otocysts, from the presence of which comes the specific name. Phacelli brush-shaped, composed of from 7 to 13 filaments springing from a single stalk in each quadrant, or rarely from two separate stalks in one of the quadrants. Distance of the sensory clubs from the bell margin about $\frac{1}{5}$ or $\frac{1}{4}$ of the height of bell. Breadth of velarium about $\frac{1}{6}$ the diameter of bell at margin; with 6 velar canals on each quadrant; the canals simple, unforked. Pedalia flattened, shaped like a slender knife blade, about half as long as the height of the bell. Tentacles at greatest extension observed, $2\frac{1}{2}$ times the length of pedalia. Sexes separate. Height of bell in largest specimens (reproductive elements mature) 8 or 9 mm. Breadth same as height, or even greater. Color a light yellowish-brown, due in large part to eggs or embryos in the stomach pockets. The reproductive organs especially prominent by reason of their similar color. Found in Kingston Harbor, Jamaica.

It will be seen from the above that Tripedalia possesses two of the characteristics of the Charybdeidae and two of the Chirodropidae. The small size of *T. cystophora* is worthy of note in connection with the fact that of the twenty species of Cubomedusae given by Haeckel in his system only two are smaller than 20 mm. in height and those are the two representatives of Haeckel's genus Procharagma, the prototype form of the Cubomedusae, without pedalia and without velarium. While Tripedalia has both pedalia and velarium, it may be perhaps that its small size, taken in connection with characteristics just about midway between the Charybdeidae and the Chirodropidae, indicate that it is not a recently acquired form of the Cubomedusae.

B. HABITAT.

The Cubomedusae are generally believed to be inhabitants of deep water, which come to the surface only occasionally. Both of the Jamaica species, however, were found at the surface of shallow water near the shore, and only under these circumstances. Whether these were their natural conditions, or whether the two forms were driven by some chance from the deep ocean into the Harbor and there found their surroundings secondarily congenial, so to speak, can be a matter of conjecture only. *C. xaymacana* was taken regularly a few yards off-shore from a strip of sandy beach not ten minutes row from the laboratory at Port Henderson. It was seen only in the morning before the sea-breeze came in to roughen the water and to turn the region of its placid feeding-ground into a dangerous lee-shore. Some of the specimens taken contained in the stomach small fish so disproportionately large in comparison with the stomach that they lay coiled up, head overlapping tail. The name Charybdea, then, meaning a gulf, rapacious, seems to be no misnomer. It is worth mentioning that the digestive juices left the nervous system of the fish intact, so that from the stomach of a Charybdea could be obtained beautiful dissections, or rather macerations, of the brain, cord, and lateral nerves of a small fish.

Charybdea is a strong and active swimmer, and presents a very beautiful appearance in its movements through the water. The quick, vigorous pulsations contrast sharply with the sluggish contractions seen in most Scyphomedusae. When an attempt is made to capture one, it will often escape by going down into deeper water—as, indeed, do other jelly-fish. Escape from observation is all the more easy by reason of the entire absence of pigment, except for the small amount in the sensory clubs. The yellowish or brownish color usually stated as common in the Cubomedusae is nowhere present in *C. xaymacana.*

The environment in which Tripedalia was found is still more unlike that in which Cubomedusae have been taken heretofore. It was obtained in two localities, both of which were cut off from the main body of the Harbor, and so from the ocean, by peninsulas and islands covered with a growth of mangrove. The water was shallow and discolored with organic matter, and the bottom for the most part a black mud. The regions were virtually mangrove swamps. It was under the shelter of the overhanging mangrove boughs, among their half-submerged roots, that the Tripedalia was found thriving in large numbers. Conditions more strikingly unlike those of the pure deep sea could hardly be imagined.

T. cystophora is as quick and vigorous a swimmer as the species of Charybdea. In one case as many as 110 pulsations were counted in a minute. Its brownish-yellow color enables it to escape observation not infrequently in the discolored water.

C. Anatomy.

An abundance of material of both species was preserved in several ways and has furnished subject-matter during the past year for investigation of the adult anatomy of the Cubomedusae. The results have been embodied in a paper whose publication I hope will not be greatly deferred. Meanwhile the mention of one or two points may not be out of place.

The parts to which especial attention was given were the vascular lamellae, or cathammal plates, and the nervous system. The vascular lamellae, being definite areas where the two walls of the gastro-vascular system have come together and fused, are interesting because they show how the present structure of the gastro-vascular system of the Cubomedusae has come about from a simpler, undivided condition. It was hoped that their study might throw definite light on the affinities of the group. The results, however, were unsatisfactory, for while one part of the system of lamellae pointed strongly toward a relationship with such Hydromedusae as, for example, Liriope (Trachomedusae), another part, around the margin of the bell, gave evidence equally as good to the effect that the velarium was formed by the fusion of marginal lobes and that the view which considers it not homologous with the Hydromedusan velum is therefore correct. The question as to the affinities of the Cubomedusae must wait until the development is known.

The nervous system has been described by Claus,[1] and more recently in greater detail by Schewiakoff.[2] With the latter's conclusions as to the structure of retina and vitreous body of the complex eyes on the sensory clubs I am unable to agree. Schewiakoff's conception of the structure is in brief as follows:

a. The retina is made up of two types of cells, pigment and visual, which are figured as alternating regularly. The pigment cells are cone-shaped; the visual are spindle-shaped, with their nuclei lying in the swollen central portion of the spindle, at a lower level than the nuclei of the supporting pigment cells.

b. From the visual cells extend rod-like processes into the vitreous body (which lies between the retina and lens) lying in canals in the vitreous body.

c. In the vitreous body separate cone-shaped streaks of pigment overlie the pigment cells, which do not, however, form part of those cells.

d. Apart from these pigment streaks and the rod-like processes of the visual cells, the vitreous body is structureless, probably a secretion of the pigment cells.

The conclusions reached upon the same points by the study of the two Jamaica species are:

a. There is not good evidence of two distinct types of cells in the retina—cone-shaped pigment cells and spindle-shaped visual cells, with the nuclei of the latter at a lower level than those of the former.

b. The rod-like processes in the vitreous body exist, though not referable to a special type of cell in the retina.

c. The cone-shaped streaks of pigment in the vitreous body belong to the underlying pigment cells, in fact are direct continuations of them; and at their distal ends they are prolonged into fibrous processes lying in canals of the vitreous body exactly like the visual rod-like processes of Schewiakoff.

d. The vitreous body, over and above these "visual fibres" and "pigment streaks," is not a homogeneous secretion, but is composed of prisms of gelatinous, refracting substance, each with a denser central fibre. The size of the cross sections of these prisms corresponds with that of the cross sections of the majority of retinal cells. It is probable, therefore, that they represent the outer ends of retinal cells.

From the above it will be seen that I find in the vitreous body two structures in addition to Schewiakoff's visual processes—namely, similar processes from the "pigment streaks," and the prisms that make up the mass of the body. I am inclined to believe that the retina contains at any rate two and perhaps three kinds of cells, but that these are distinguishable only by that part of them which lies in the vitreous body, and are not distinguishable in the retina as two alternating types, as figured by Schewiakoff.

In another point also I am unable to agree with Schewiakoff. In one region of the sensory club is found a mass of peculiar large, closely-packed, polygonal cells, which he affirms to be ganglion cells as against Claus, who considers them supporting cells. In my sections they show nothing whatever to suggest a resemblance to ganglion cells. No processes could be made out, and the body of the cell consisted of a beautiful cytoplasmic reticulum with thickenings at the nodes of the rather coarse meshes.

The sensory organs in the proboscis of Tripedalia are simple cysts of ciliated epithelium lying in the gelatine. The long cilia support and keep in constant motion an otolith of ragged outline, in which no trace of cellular structure was found. This is the only case, so far as I know, of the occurrence among the medusae of a free, unsuspended otolith in a ciliated sac.

D. Development.

Females of Tripedalia were found with stomach pouches, or pockets, filled with developing ova, so that I am able to offer a few facts preliminarily on the development of the Cubomedusae. The mature eggs pass from the ovaries into the stomach pouches and there develop up to the stage of free-swimming planulae. In with them are found floating masses of cells, showing here and there a nematocyst, whose structure points clearly to an origin from the ovary also. These masses circulate about among the developing ova and serve for protection and apparently also for nutrition, since the cells are found vacuolated in masses from individuals containing well advanced embryos. All the eggs or embryos in one individual are at the same stage of development. Gastrulation was not observed in the living material, but sections show a stage in which central cells lie clearly marked off from a surrounding ring of smaller surface cells, and the probability is that these endodermal cells were formed by delamination. When the spherical mass is beginning to elongate into the ellipsoidal form of the planula a large migration of cells from the surface into the centre takes place, not limited to one pole. The relation of the central cells earlier seen, and of these inwandering cells, to the definitive endoderm was not made out. The young are set free from the parent as ciliated planulae, having pigment spots on the posterior end. The planulae swim about actively on the surface for a day or two, their motion being both translation and rotation. Then they gradually lose the forward motion and rotate on their own axis in one spot. At this point they settle down, and the pigment spots which were on the posterior surface are found to migrate into the interior. In a day or two they bud out two tentacles, and shortly afterwards two more, though young hydras with three and five tentacles were by no means uncommon. In this condition they lived for three weeks in the aquaria without undergoing further development.

Search for scyphistomas in the region where the jelly-fish were found was fruitless. The youngest specimens taken in the tow were of practically the adult structure, so that the important intermediate stages remain unknown. The youngest jelly-fish were interesting, however, in that only the middle tentacle in each group was developed, and that the sensory clubs were situated almost on the margin, and were not yet enclosed in niches.

Reference Letters in Figures.

af—furrow, on inner surface of exumbrella underlying the adradial ridge on the outer surface; *afr'*—furrow on outer surface, setting off the area in which the sensory niche lies; *ct*—canal of the tentacle; *go*—gastric ostium; *ifr*—interradial furrow, on outer surface; *n*—nerve ring, on the subumbrella; *pe*—pedalium; *ph*—phacellus; *pr*—proboscis; *r*—reproductive organ; *sn*—sensory niche; *su*—suspensorium; *sub*—subumbrella; *vc*—velar canals.

[1] Ueber Charybdea marsupialis. Arb. aus d. Zool. Inst. d. Univ. Wien. Bd. II., Heft 2, 1878.

[2] Beitrage zur Kentniss des Acalephenauges. Morph. Jahrb. Bd. XV., Heft 1, 1889.