

JOHNS HOPKINS UNIVERSITY CIRCULARS

Published with the approbation of the Board of Trustees

VOL. X.—No. 88.]

BALTIMORE, MAY, 1891.

[PRICE, 10 CENTS.]

MORPHOLOGICAL NOTES.

FROM THE BIOLOGICAL LABORATORY OF THE JOHNS HOPKINS UNIVERSITY.

EDITED BY WILLIAM K. BROOKS, PH. D., PROFESSOR OF ANIMAL MORPHOLOGY AND DIRECTOR OF THE CHESAPEAKE ZOOLOGICAL LABORATORY.

On the Structure and Development of the Gonophores of a certain Siphonophore belonging to the Order Aulonectae (Haeckel). By W. K. BROOKS and E. G. CONKLIN.

Among the specimens brought by the U. S. Fish Commission Steamer Albatross (1887-88) from the Pacific and left with us to be studied was a single specimen of a Siphonophore, which is probably identical with the genus *Rodalia*, described by Haeckel in his "Challenger" Report. The interest in this form is the greater since Haeckel regards it as so unlike all other Siphonophores as to necessitate its being placed in an entirely new order, which he calls the Aulonectae, or Siphonophores with an Aulophore. But a few specimens, and those badly broken, have ever been obtained, and this fact has led Claus,¹ among others,² to doubt whether Haeckel was justified in describing these few fragmentary specimens as the type of a new order. The specimen here described was taken off the Galapagos Islands, in latitude 0° 46' south, longitude 89° 42' west, and like all the previously described specimens of this group, is badly mutilated, though in an excellent histological condition.

The present paper has to do merely with the structure and development of the gonophores of the specimen mentioned, an account of the remaining organs being reserved for a future communication.

Haeckel says of the gynophores, or female gonophores:³ "The female gonophores are much more varied in shape and composition than the androphores. They are easily distinguished from them by their more rounded (usually pear-shaped) form and their longer stalks. There occur the following remarkable variations:

"A. *Monovone Gynophores*. Each female medusome develops only a single large ovum."

(1.) "The gynophore develops a single very large ovum surrounded by a double envelope; the inner envelope is the thin manubrial wall containing a smaller or larger blind spadicine cavity, sometimes a network of irregular spadicine canals; the outer envelope is the umbrella of the medusoid person, with four narrow radial canals and a small distal ring canal connecting the latter; this is probably the normal and most frequent form of the ripe gynophore."

(2.) "The same form but with four blind radial canals (reduced in the distal half)."

(3.) "The same form (as 1 and 2) but with eight equidistant, regular, radial canals." Fig. 12, Pl. II.

(4.) "The same form (as 1 to 3) but with a variable number (five to ten) of irregular, branched and anastomosing spadicine canals."

(5.) "The same form (as 1 to 4) but without radial canals in the reduced umbrella."

"B. *Polyovone Gynophores*. Each female medusome develops an ovary, composed of a variable number of ovules placed in the wall of the modified manubrium. The umbrella seems to be usually reduced, very thin walled without radial canals; often it has disappeared."

(1.) "The gynophore is a medusome with rudimentary umbrella; the spadicine canal (or the original gastric cavity of the medusa) is central, straight, and runs in the axis of the manubrium (Pl. II, Figs. 9 and 10); the ovules are regularly disposed around it."

(2.) "The gynophore is a medusome with rudimentary umbrella; the spadicine canal is eccentric, curved and runs on one side of the manubrium; it embraces the ovary as a crescent-shaped or semicircular blind canal."

(3.) "The gynophore is a simple sporosac, the manubrium without umbrella; the ovules are arranged equally around the central spadicine canal."

(4.) "The gynophore is a compound sporosac, without umbrella; two or three (rarely more, sometimes only one) buds developing from off the outside of the primary manubrium (Pl. II, Fig. 11). The buds or the secondary sporosacs, contain either a single large ovum or a group of several small ovules; they have usually a long pedicel, and its canal arises from the base of the primary spadix. The different remarkable modifications of gonophores here enumerated exhibited in the adult spirit specimens examined, showed no regular distribution, but occurred in very variable number and association. A further accurate research on living and well preserved specimens is required to make out their mutual relations and significance."

Although a careful search was made for them, the androphores or male gonophores mentioned by Haeckel were not observed. It seems impossible that they could have been overlooked, since they were carefully looked for both in sections and in surface views of a large number of gonodendra; and while female gonophores were found in every stage of development and in great abundance, not a trace of an androphore could be found. The writers therefore conclude that the specimens examined bear female gonophores only. Professor Haeckel's description of the androphores occupies but twelve lines, and he gives but three figures of them, all surface views and very unsatisfactory. It would therefore seem possible, at least, that Pro-

¹ C. Claus, "On the Organism of the Siphonophora," etc. Ann. and Mag. Nat. Hist., Vol. 4, and Arb. Zool. Inst., Wein, Bd. 8.

² J. Walter Fewkes, "On Angelopsis," etc. Ann. and Mag. Nat. Hist., Vol. 4.

³ "Challenger" Report on Siphonophora, p. 295.

fessor Haeckel mistook for male gonophores some long, spindle-shaped gynophores filled with yolk, but into which the egg nucleus had not yet passed, or from which it had been forced out by pressure (several such gonophores were seen). It seems proper here to mention the fact that an examination of the sexual organs of forty or fifty specimens of *Physalia* has shown that they were all males. The structures described by Haeckel as the female gonophores of *Physalia* are not gonophores, but swimbells, as is shown by an examination of living expanded specimens.

Concerning the female gonophores we are able to speak with certainty. Since the present investigation has shown that the so-called "Polyovone Gynophores" show no trace of medusoid structure, and are therefore strictly speaking not gonophores at all, but merely pouches containing ova, the term "polyovone gynophore" has been replaced throughout this paper by the term "egg-pouch." The so-called "Monovone Gynophores" are true gonophores, and are known throughout this paper merely as female gonophores. The remarkable varieties of "Monovone" and "Polyovone Gynophores," mentioned by Haeckel, were not observed at all, and it seems probable that at least many of these varieties were merely different stages in the development of the female gonophores.

The structure of the mature gonophore is so complicated that it will best be understood if the development of the gonophore be traced from its simple beginnings to its final complex form. The earliest stage shown is in Fig. 6, in which a small bud, *A*, is represented as arising from the distal end of a large egg pouch, *B*, which also bears a well developed gonophore containing an egg. The egg pouch itself communicates with the digestive cavity of the stem or gonostyle, *S*. The ectoderm has disappeared over most of the external surface of the bud. The latter is merely a protuberance blind at its distal end, opening into the egg-pouch at its proximal end and lined with endoderm, which is continuous with that which lines the egg-pouch and the digestive cavity.

The next stage is shown in Fig. 1. As before, the gonophore arises from an egg-pouch; however, in this case there are no clearly marked ova in the latter, though it and the stem of the gonophore are filled with yolk, *Y*. The egg-pouch is connected with the stem of the gonodendron near the point where the pedicel, *P*, of the gonophore arises, but at a slightly lower level than that represented in the figure. The invagination at the end of the bud is caused by the pushing in of a solid mass of ectoderm, *BN*; this is the bell nucleus ("glockenkern"), and the cavity of the invagination, filled with the mass of ectoderm, represents the umbrella cavity.

Fig. 2 shows a stage still more advanced. The egg pouch is connected to the stem at a different level from that shown in the figure. The egg cells in the pouch are quite numerous and in all stages of development. It is clearly seen from the sections that the egg cells are endoderm cells which have grown in size, protruding from the simple layer of endoderm which originally lined the egg pouch into the cavity of the latter. In many cases the egg cells in growing have torn the endoderm cells from the supporting lamella and have carried them up along their sides, so that the endoderm cells come to lie between the large egg spheres. Usually the egg cells are found in their original position in the endoderm layer, *i. e.* on the supporting lamella; some, however, have separated from the lamella and are free in the cavity of the egg pouch or in that of the pedicel, *P*, of the gonophore. In the specimen figured two egg cells lie in the cavity of the pedicel below the invaginated endoderm, while one has crowded into the narrow space between the two layers of cathammal endoderm, *K. En.*, on the side of the bell cavity. The ectoderm in the bell cavity, which in the previous stage was a solid mass, now lines the cavity down to the bottom of the invagination, where it turns up on each side and unites with the ectodermal mass which fills the mouth of the invagination. The endoderm and supporting lamella also bend outward at the bottom of the invagination. This feature varies greatly in different individuals; in some it is scarcely seen at all, in others it is quite marked. There can be little doubt that the structure represents the manubrium or proboscis of the ancestral medusa.

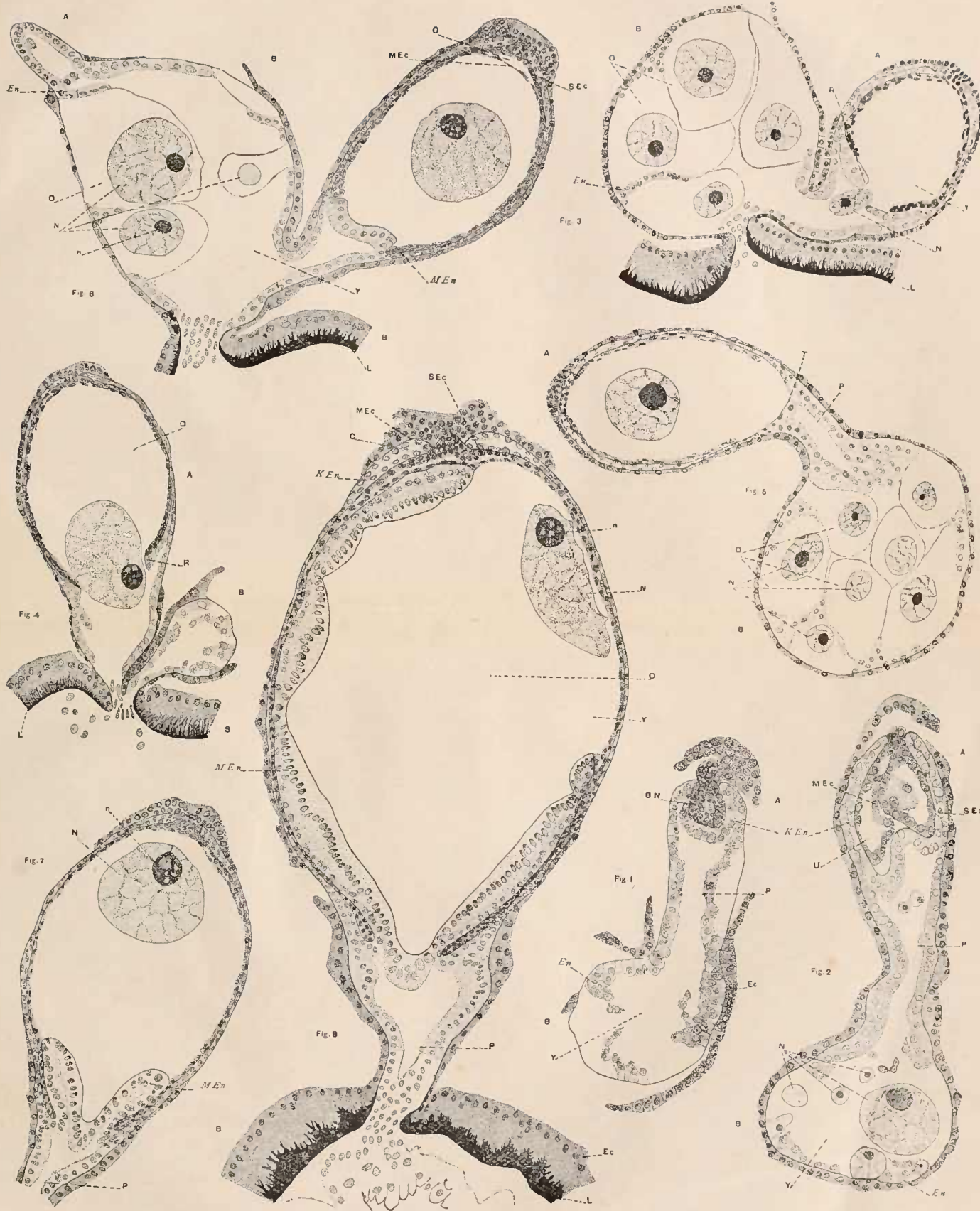
The next stage in the development of the gonophore, and the one most interesting, namely, that of the migration of the egg from the egg pouch into its final position, was the stage most difficult to obtain. On careful search, however, several such stages were found. Fig. 3 shows an egg from the egg pouch just breaking through the endoderm and supporting lamella. The mass of yolk still fills the pedicel while the distal part of the egg, *Y*, has pushed into its final resting place, carrying the ectoderm of the manu-

brium before it and flattening it out against the ectoderm of the subumbrella. There is a wide break, *R*, in the endoderm and supporting lamella through which the nucleus of the egg is just entering. Gradually, however, as the egg gets into its permanent position this break closes and we reach the condition shown in Fig. 5. The egg is now in its permanent position and the endoderm and lamella are closing in behind it, *T*, to shut it off from the pedicel and egg pouch. A second smaller egg is shown just at the break, which, if one may judge from other similar cases, will be broken down and absorbed by the larger egg now in position.

Fig. 4, a stage corresponding to Fig. 3, is nevertheless different from it, in that the gonophore does not arise out of the egg pouch but from the stem of the gonodendron. However, from the same opening in the stem a small egg pouch, *B*, arises. In this case it is impossible to say whether the egg originated in the small egg pouch and then migrated into its present position in the gonophore, or whether it originated above or below its present level and then migrated through the stem to its present position. We have in no case been able to find an egg originating in the stem or in any other place than the egg pouch, and we consider it extremely improbable that they do arise in any other position. Nor have we been able to find any egg migrating through the stem, so that in the case of Fig. 4 it is probable that the egg did originate in the adjacent egg pouch and then migrated into its present position. The condition of the egg pouch in this case indicates that it is undergoing degeneration, and considering the fact that the egg pouch is present in all cases where the gonophore is young, and that as this becomes more and more developed the egg pouch becomes smaller or is absent altogether, we hold it probable that the eggs not only originate in the egg pouch and afterward migrate into the gonophore, where alone they mature, but that the egg pouch also furnishes nutriment to the egg in the gonophore, and that as the latter grows larger the former is absorbed by it.

In Fig. 6 the gonophore is still further developed. The edges of the ruptured endoderm and lamella which, in the previous figure, had closely approached and had almost shut off the egg from the egg pouch and the digestive cavity, have now grown together, completely closing the break by which the egg entered. The egg does not completely fill the gonophore, a small cavity, *U*, being left at its distal end, which is the remnant of the umbrella cavity. At this point the two layers of the ectoderm immediately surrounding the egg are separated; the inner layer (nearest the egg), *M. Ec.*, is the ectoderm of the manubrium, the outer layer, *S. Ec.*, is the ectoderm of the subumbrella; outside this are two layers of endoderm, the cathammal lamellae, closely pressed together, and in which no remnant of radiating canals may be found, but which do show traces of a ring canal at the distal end of the gonophore where the endoderm folds on itself. Covering the outside of the gonophore and filling the mouth of the bell is a layer of ectoderm which is continuous with that covering the stem. In fact, all the ectoderm of the gonophore is in one continuous layer, as appears in the figures. This layer was at first invaginated (primary bell invagination), and then subsequently evaginated by the pushing in of the egg. In the same way the endoderm is in one continuous layer. The endoderm of the stem, gonostyle and egg pouch being continued through the pedicel of the gonophore, and along its side to its distal end, and there folded back on itself by the primary invagination. The endoderm just below the egg and separating it from the pedicel shows a slight upward protuberance, *M. En.*, on each side. This represents the manubrial endoderm, and is the beginning of a fold of endoderm which pushes up on all sides of the egg and nearly surrounds it, leaving only a small place where the egg still remains in contact with the ectoderm. Fig. 7, *M. En.*, shows these endoderm folds more largely developed than in Fig. 6; there is a slight cavity (continuous with the digestive cavity) running up between the folds.

Fig. 8 is a gonophore almost mature, though many reach a size two or three times as great as this. The endoderm folds have grown up far around the egg, and the cavity which they enclosed in the former stage is no longer seen. At their distal ends the folds are imperfectly cleft into a number of finger-like processes which arise from the proximal part of the folds as the fingers do from the hand, only in this case, to carry out the simile, the fingers are connected by a web; the egg is surrounded by these as a ball which is held in the hand is surrounded by the palm and fingers. In the figure the folds are constricted in several places, which is due to the fact that several of these finger-like processes are cut across in the section. These endoderm folds and finger-like processes have a marked glandular appearance; and there can be no doubt that the cells of these endoderm



Conklin, del.

folds secrete yolk which is passed into the egg. No egg pouch is present, it having probably been absorbed. The nucleus occupies the position which it has in all the mature eggs, viz., immediately beneath the ectoderm.

The development of the egg pouches was not observed minutely, though it is evident that they arise as mere diverticula of the stem; they have but a single layer of ectoderm and of endoderm, which is continuous with that of the stem. Haeckel represents the eggs of the egg pouch ("Polyovone Gynophore") as constituting a single layer next the supporting lamella, the eggs being everywhere covered by a continuous layer of endoderm, and separated from each other by endoderm cells. This work has shown that the eggs are not covered with a layer of endoderm, but that they form a part of the endoderm layer; and if the eggs are separated from each other by cells, they are endoderm cells which have been torn from the lamella by the growth of the egg.

In Fig. 2, several stages in the development of some of the endoderm cells into egg cells can be seen. It may be that the germ cells migrate along the stem, as Weismann has observed in many cases, and finally take a position in the layer of endoderm lining the egg pouches, but nothing was observed to indicate that this does take place, and to all appearance the cells which are destined to become egg cells are not different from the other endoderm cells. So far as observed no eggs come to maturity in the egg pouches; they are either passed on into the gonophore or are broken down to nourish the egg which does pass into the gonophore. Usually but one gonophore arises from an egg pouch, though in a few cases two or even more arise from the same pouch.

To sum up: The egg pouch must be regarded as a part of the stem where the growth of the egg cells may take place while the gonophore is developing. As soon as the gonophore is formed one of the eggs, already quite large, passes into it, where it lies between the ectoderm and endoderm of the manubrium. Then by the disintegration of the egg cells remaining in the egg pouch, and by the formation of large endoderm folds which have a secretory function, the egg is rapidly nourished and grows to a very large size. The whole contrivance is to secure as rapid a development of the sexual cells as possible, such as has been so excellently shown by Weismann for very many Hydromedusae and Siphonophores.

The fact that only female gonophores have been found on this "Albatross" specimen, and the probability that the specimens examined by Haeckel were females (since, as we have seen, the evidence that male gonophores were present is very slight), suggests that the male may be widely different in form. And it is highly probable that the female of *Physulia* is so different from the male, which alone has been found, that if ever described, it has probably been classed as a wholly different genus.

EXPLANATION OF FIGURES.

All the figures represent longitudinal sections through the gonophores, and were drawn with the camera lucida, under a magnifying power of about 250 diameters. The space occupied by the yolk, Y, of the ovum, O, is left unshaded.

REFERENCE LETTERS.

A.—Gonophore.	n.—Nucleolus.
B.—Egg Pouch.	O.—Ova.
B N.—Bell Nucleus.	P.—Pedicel.
C.—Circular Canal.	R.—Rupture of Endoderm and Lamella.
Ec.—Ectoderm.	S.—Stem or Gonostyle.
En.—Endoderm.	S Ec.—Subumbrellar Ectoderm.
K En.—Cathammal Endoderm.	T.—Reunion of Ruptured Endoderm and Lamella.
L.—Supporting Lamella.	U.—Umbrella Cavity.
M Ec.—Manubrial Ectoderm.	Y.—Yolk.
M En.—Manubrial Endoderm.	
N.—Egg Nucleus.	

Preliminary Note on the Embryology of *Crepidula fornicata* and of *Urosalpinx cinerea*. By E. G. CONKLIN.

Crepidula fornicata.

The time and manner in which *Crepidula* lays its eggs has been described by Dr. McMurich.¹

The cleavage follows the type found in *Fusus*, *Planorbis*, *Neritina*, etc. The first furrow is, with regard to the future embryo, a median longitudinal one, and divides the ovum into exactly equal right and left halves. (The

method of determining the relation of the first furrow to the embryo cannot be explained without several figures). The second furrow is at right angles to the first and transverse to the long axis of the embryo, and it divides the egg into four equal macromeres.² Of these, two meet in the centre in a line which Rabl² has called the "cross furrow;" the other two are acute toward the centre and do not meet each other. By the position of the macromeres with regard to the "cross furrow," the first and second cleavage furrows may easily be distinguished, e. g., if the egg be viewed from the formative pole and so that one of the cleavage furrows is in the line of vision, the macromere to the right of this furrow and farthest from the observer will be acute at its centre if the furrow in the line of vision be the second cleavage furrow; it will be obtuse, i. e., will meet the opposite macromeres in the "cross furrow" if the furrow in the line of vision be the first cleavage furrow. Of course the reverse would hold true if the egg were viewed from the vegetative pole. The examination of many hundreds of eggs has shown that the position of the macromeres in relation to the "cross furrow" and to the first and second cleavage planes is a constant one, and that the first and second furrows may always be distinguished in the way mentioned. The macromeres as distinguished from the micromeres do not again divide until late in the course of segmentation, and as they do not change their relative position it becomes very easy to orient all the future furrows and cells with reference to the first two furrows.³ The polar bodies which are at the centre of the ectodermal area also mark the centre of the dorsal surface of the embryo, while the blastopore closes and the definitive mouth appears almost directly opposite them. Until after the formation of the blastopore the chief axis is the one drawn from the centre of the ectodermal to the centre of the endodermal area; with regard to this axis the egg is for some time radially symmetrical; the chief axis of the embryo (the antero-posterior) is at right angles to the chief axis of the egg. At an early period there is a trace of a segmentation cavity, which however is soon obliterated. The formation of micromeres proceeds with wonderful regularity, following the law formulated by Rabl,³ new micromeres always being formed in fours either by being cut off from the four macromeres or by the division of four micromeres already formed. When twenty-four micromeres have been formed one of the macromeres, which later developments show to be on the posterior side of the ovum and to the left of the median line, divides into a larger ventral and a smaller dorsal moiety. The smaller cell, which, unlike the ectoderm cells, contains yolk, moves to the right until it comes to lie at the posterior end of the median furrow between the two posterior macromeres; it very soon divides into a right and a left half, and at a later stage these two cells give rise to two mesoblastic bands which extend forward over the right and left sides of the dorsal surface.

Save for these mesoblasts the radial symmetry at the stage with thirty-six micromeres is perfect. At this stage twelve of the micromeres form a cross with three cells in each arm, the crossing of the arms being exactly at the centre of the ectodermal area. Two of the arms lie in the antero-posterior axis, two in the transverse axis; one arm is anterior, one posterior, one right and one left. In the next stage the radial symmetry is no longer perfect, since three arms of the cross lengthen so as to contain four cells each, while the posterior arm does not lengthen until later. However, with this exception, the radial symmetry is preserved until fifty-two micromeres are formed; at this stage the posterior arm lengthens by one cell and the three other arms split longitudinally. At the same time each of the macromeres, except the one mentioned above as giving rise to the mesoblast, divides as did the later into a larger and a smaller moiety. The three smaller cells take positions on the periphery of the egg in the furrows separating the macromeres, one at each end of the transverse furrow and one at the anterior end of the longitudinal furrow.

In normal eggs there is not a trace of an invagination at the ectodermal pole, such as has been described for *Neritina* and *Fulga*, though eggs which were developing abnormally often showed such an invagination together with other irregularities, e. g., the spreading apart of the macromeres and the formation of large yolk containing cells at the periphery of the ectodermal area instead of the small protoplasmic ectoderm cells which are usually formed.

The gastrula is formed by typical epibole. On all sides the ectoderm

¹ A contribution to the Embryology of the Marine Prosobranchs. Studies from Biol. Lab., J. H. U., Vol. 3.

² Carl Rabl, Ueber die Entwicklung der Tellerschnecke. Morph. Jahrbuch, Bd. 5.

³ Loc. cit.

cells grow around toward the ventral side at an equal rate; thus the blastopore is formed in the middle of the ventral side. The mesoblasts are carried around with the ectoderm to the ventral side, where they lie at the posterior edge of the blastopore. The mesoblastic bands are soon separated from the mesoblasts; the latter continue to proliferate mesoderm, which extends forward in the lips of the blastopore.

The cross above mentioned resembles very much an arrangement of cells figured by Blochmann¹ for *Neritina*, the terminal cells in the transverse arms of which are called by him velar cells. In *Crepidula* it seems that no part of the transverse arms forms the velum. However, the cells of the posterior arm grow very large, the nuclei are vesicular and stain lightly, and the cells become covered by fine cilia, which protrude through a thin cuticula; though at first these ciliated cells lie wholly on the posterior side of the ovum, they move forward in the course of development until they come to lie on the anterior side, and as they increase enormously in size, though they seldom divide, it comes about that they cover the anterior part of the dorsal area, extend around over the anterior end of the embryo and down over its sides. These cells finally form the walls of a large head vesicle.

The velum appears first on the ventral side, just anterior to the mouth, and consists at first of a single row of cells. Later it is composed of several rows, some of which are adoral, and at least a single row runs posterior to the mouth. It is not completed dorsally until much later, though soon after the definitive mouth is formed the velum splits on each side of the embryo, and about half way between the ventral and dorsal surfaces, into an anterior and posterior branch; the later continues up over the dorsal surface just posterior to the large ciliated cells; the anterior branch, which is the chief one, turns forward over the sides of the head vesicle, and quite late in development the two arms of the anterior branch meet and fuse on the mid line just in front of the ventral part of the preoral velum. Thus two large velar lobes are formed, one on each side. The posterior branch of the velum appears to be the postoral ciliated band, the anterior branch the preoral; from the corners of the mouth to the middle of the sides of the embryo the two are fused, while ventrally they are separated by the mouth and dorsally by the whole diameter of the head vesicle. A postoral band of cilia has been described as present in the veligers of several gastropods, and among these *Crepidula*,² but I am not aware that any one has hitherto found the two separated dorsally. The velum does not become ciliated until quite late in development, though the embryo swims about in the pouch by means of the cilia of the large ciliated cells which form the head vesicle.

The shell gland appears on the dorsal surface immediately posterior to the second or transverse furrow as a prominence of ectoderm cells. In the place of this prominence an invagination afterward appears; the margin of the invagination extends rapidly and a thin cuticle, the first indication of the shell, is secreted by the invaginated cells. As development proceeds the shell becomes asymmetrical, developing more rapidly on the left side than on the right.

The foot arises as a single median protuberance just posterior to the mouth. While it shows no trace of a double origin, it occupies a region along which the blastopore closed, so that really the foot may be considered as having arisen on both sides of the blastopore, though the lips of the latter have fused before the former appears. Running from the mouth backward over the median surface of the foot is a row of large ciliated cells resembling those on the dorsal area.

At the posterior end of the embryo three or four large ciliated anal cells appear, and just ventral to these the distal end of the intestine is pressed against the ectoderm. The proctodeal invagination does not occur until late in development. The intestine is a tube with a distinct lumen, its walls being formed of small cells free from yolk. In the course of development its central end, where it opens into the cavity between the yolk spheres is carried anteriorly and to the right. Throughout its whole length the intestine is pressed closely against the ectoderm.

The supra-oesophageal ganglia appear as proliferation of the ectoderm on each side of and dorsal to the mouth; the eyes are formed in connection with these ganglia as involutions of ectoderm. The ganglia of the two sides are connected by a commissure, and from the centre of the latter a nerve

runs forward to the centre of the apical plate, where there is a ciliated depression in the ectoderm, which I believe is a sense organ. A commissure connects the supra-oesophageal ganglion of each side with the otocysts. The latter are formed by involution of the ectoderm of the foot, and the pedal ganglion is formed by delamination from the ectoderm at the sides of the foot.

Urosalpinx cinerea.

The breeding habits of *Urosalpinx* have been fully described by Professor Brooks.³ The segmentation is almost identical with that described by Professor Brooks⁴ for the oyster, and closely resembles the segmentation of *Nassa*, as described by Bobretzky.⁵ The chief difference between the segmentation in *Urosalpinx* and *Crepidula* consists in the fact that while the four macromeres of *Crepidula* are equal in size, the four macromeres of *Urosalpinx* are very unequal, one being very much larger than the other three. Two furrows appear simultaneously and seem to divide the ovum into one large sphere and two smaller ones. Really, however, one of the smaller spheres is not completely separated from the larger one, and soon after fuses with it. This smaller sphere is merely a constricted portion of the larger sphere and contains the nucleus. Thus it is seen that of the two furrows mentioned, but one is a true cleavage furrow and it divides the egg into a larger and a smaller moiety. At the next stage the smaller moiety divides into two equal parts, and at the same time two protuberances, each containing a nucleus, are pushed out from the larger moiety. One of these protuberances is cut off to form a macromere equal in size with the two smaller ones; the other protuberance is a part of the larger macromere and again fuses with it. There have thus been formed by two vertical furrows comparable to the first and second cleavage furrows of *Crepidula*, three smaller and one larger macromere.

The antero-posterior axis of the embryo is no longer coincident with the first cleavage furrow as it is in *Crepidula*, but in order to preserve bilateral symmetry the axis is shifted to one side, so that it passes through the centre of the larger macromere and through the middle one of the three smaller spheres. This new axis crosses the first furrow at an angle of about 45°, and the "cross furrow" is in this case a true cross furrow, being transverse to the long axis of the embryo.

The micromeres are formed very much as in *Crepidula*. The ectoderm extends posteriorly over the large sphere much more rapidly than it does anteriorly over the three smaller spheres, and the blastopore closes almost directly opposite the formative pole and at a point where the four macromeres meet in the centre. At this point the definitive mouth afterward appears.

Owing to great difficulty in cutting sections of the *Urosalpinx* egg its development was not carried farther.

¹ F. Blochmann, Deber die Entwicklung der *Neritina fluviatilis*. Zeit. wiss. Zool., Bd. 36.

² McMinrich. J. H. U. Circulars, No. 44, 1885.

³ Preliminary observations on the development of the Marine Prosobranchs. Studies from the Biological Laboratory, J. H. U., Vol. I.

⁴ The Embryology of the Oyster. Studies from the Biological Laboratory, J. H. U., Vol. I.

⁵ N. Bobretzky. Studien über die Embryonale Entwicklung der Gasteropoden. Archiv. f. Mik. Anat., Bd. 13.