THE EMBRYOLOGY OF STOMOTOCA APICATA.

INTRODUCTION.

The material for this research was secured, and the observations on the living forms were made, during the summers of 1903 and 1904 while I was occupying a table at the United States Fisheries Laboratory at Beaufort, North Carolina. Stomotoca is not very abundant in the harbor at Beaufort. I found it there as early as the middle of June. It is most plentiful during July and early in August. A few specimens may also be taken until early in September. The eggs were obtained from medusae captured between July 10 and August 5. The adult animals could not be secured in large numbers; and, owing to the fact that each female lays only a few eggs the material for embryological study was limited. Therefore the greater part of the work the results of which are embodied in this paper was done with living material. All the drawings, with the exception of those of sections were made from camera sketches of the living

forms. Blastul[illegible] ulae ranging in age from fiv[illegible] twenty-seven hours were fixed and sectioned for the study of the various stages in the formation of the [illegible]derm and the other features of development which make their appearance during this period.

I wish to acknowledge my obligations to the Honorable George M. Bowers, Commissioner of Fisheries for the privileges afforded me at the Fisheries Laboratory; and also to thank Dr. Caswell Grave, Director of the Laboratory for help and suggestions. The work was finished in the Biological Laboratory of the Johns Hopkins University. For the interest shown and for kind suggestions offered during my work I am very grateful to Professor W. K. Brooks.

DISCUSSION.

The eggs are discharged at about five o'clock in the morning. The ectodermal epithelium of the ovaries becomes ruptured, in fact broken down; and by the movements due to the muscular contractions of the manubrium the eggs are set free into the cavity of the sub-umbrella. Then by the rhythmic contractions of the bell they are forced out of the bell cavity into the water outside. While the eggs are being

laid the medusa remains at one spot, unless disturbed, and keeps up a continuous and rhythmic contraction and expansion of the bell and proboscis. Thus as the eggs are liberated, one, two, or three at a time, they are almost immediately passed out with the ejection of the water from the bell cavity. This process of dehiscence lasts for a few minutes during which the medusa remains at the bottom of the aquarium. All the mature eggs are discharged without intermission in the process, unless the medusa is disturbed. In that case it frequently swims to another part of the aquarium and in a short time commences to discharge the eggs again. The eggs in the ovaries of Stomotoca apicata are usually all deposited at one time. Occasionally a few immature ones are left in the ovaries after the process of dehiscence. Whether these immature and are laid at a later time, or whether they are reabsorbed I am not able to decide.

As stated above, the eggs are laid at about five A. M. On several occasions I observed the process of dehiscence and found that the time was always practically the same. Some medusae were watched all night, July 14. At five o'clock in the morning they began to lay their eggs. They all began

at about the same time and all the eggs were discharged within fifteen or twenty minutes. The time when the medusae are captured and put into the aquarium does not seem to have any influence on the period of dehiscence. I have taken them in the tow at nearly all hours of day and night, and never had them to deposit their eggs except at 5 o'clock in the morning.

THE EGG.

The egg of Stomotoca griseata is spherical and measures .14 of a millimeter in diameter. It is devoid of a vitelline membrane and the cytoplasm is rather dense and only semi-transparent; however it is not as dense as the egg of Stomotoca pyrosoma, which is extremely opaque and of a chalky-white color, and also slightly larger. The color of the egg of Stomotoca griseata is a bluish-white.

A point of interest may be mentioned in this connection. On one occasion, having taken a number of Stomotoca in the tow at night, they were picked out and put into a dish of clear sea-water with the intention of allowing them to lay, and using the eggs for study the next morning. It happened that both species of Stomotoca that are found at Beaufort

were represented. There were mature females of both species that deposited their eggs the next morning at the regular period; Stomotoca rugosa has the same time for dehiscence as Stomotoca apicata. Only the eggs of the latter species developed; there being no males of Stomotoca rugosa. The next day when the two species were in the same dish, and both discharged their eggs, only the eggs of Stomotoca rugosa segmented and developed. In this case there were no mature males of Stomotoca apicata. These facts aroused my interest and on several later occasions I placed the two species together with the intention of getting them to interbreed, but did not succeed and therefore I am led to the conclusion that they will not cross even though they are species of the same genus. To my knowledge no other experiments have been made in attempting to cross different species of this group of animals, and I did not have the opportunity to try with any other species than the above named after my attention had been called to the fact that they did not cross when accidentaly placed in a dish together.

POLAR BODIES.

Soon after the egg is deposited the first polar body

is given off. A few minutes later the second polar body is formed. They remain near the egg for some time; frequently until after the second or third segmentation. The polar bodies are not held by a cone of rays, as the egg is devoid of such a structure; neither are there any protoplasmic connections visible with a magnification of 212 diameters. Yet for a time they seem to be held near the egg by some means of attraction. The first polar body may segment once or twice. Usually about the time of the second cleavage the polar bodies either disintegrate or pass out into the water and are lost.

FERTILIZATION.

Very little concerning fertilization could be made out on account of the character of the eggs. The ova and spermatozoa are discharged into the water and there fertilization takes place. It is impossible to follow the nuclear changes which take place during maturation; or the union of the male and female pronuclei in the living egg because of the opacity of the cytoplasm, and material could not be secured in sufficient abundance in the various phases for the preservation

the different stages for sections. There is no visible fertilization-membrane given off after the penetration of the spermatozoa.

CLEAVAGE.

Cleavage is total, equal and nearly regular, especially in the early stages. The divisions occur at short intervals, and the blastomeres soon move away from the center of the egg, thus forming a gradually enlarging segmentation cavity. The cells continue to divide and arrange themselves into a single layer around the blastocoele to form a true blastula. The egg is not divided into an animal and a vegetative pole as the deutoplasm and protoplasm are distributed evenly in all parts. But as is customary and for convenience of description I will call the part of the ovum from which the polar bodies are given off the upper pole, and the part of the egg opposite the lower pole.

The first cleavage occurs a short time after the polar bodies are ejected. The plane of division is vertical; the segmentation-furrow begins at the upper pole and gradually deepens until the egg is cut into two equal parts. The egg,

viewed from above, at first shows a nearly circular depression which very soon spreads laterally and begins to grow down. This first furrow is wide and leaves the blastomeres separated some distance from each other as it progresses downward, as is seen by looking at the egg from the side (Figs. 4 and 5). This furrow remains open until the egg is almost separated into two parts; the blastomeres being connected simply by a narrow protoplasmic film at the lower pole. Protoplasmic currents can frequently be seen in this connecting thread. Bunting ('98) describes and figures in Hydractinia a protoplasmic thread in the two cell stage in which she also notes protoplasmic movements. The connecting film in Stomotoca griseata is not so clear and definite in outline as she shows it in her figure of Hydractinia. The two cells gradually come in close proximity and in a short time the connection of protoplasm at the lower pole is broken and the resultant two-cell stage is formed (Fig. 6).

The second plane of division is also meridional and at right angles to the first. This cleavage takes place about fifteen minutes after the first division. These second segmentation furrows start at the centre and move out toward the periphery. During their progress outward there are to be seen globular or oval spaces at their outer extremities. These spaces are large enough to cause openings that extend through the egg as shown in Figure 7. During this cleavage there is a shifting or rotation of the blastomeres from right to left. The second segmentation furrows usually start opposite each other at a point in the centre of the first cleavage furrow, and then are carried apart by the rotation. Or the rotation may have started before the second segmentation began; in that case the second cleavage planes are some distance apart as soon as they make their appearance. Figure 7 shows an egg in the process of division in which rotation has taken place. During the progress of the second segmentation, the egg has in-

quartic a flattened appearance as seen in the figure just mentioned.

In this stage protoplasmic films or bridges, also, frequently exist for a time after the segmentation is practically complete. They finally are absorbed by the blastomeres which round up forming the completed four-celled stage as shown in Figure 8.

The third cleavage plane is equatorial and divides the egg into eight equal blastomeres; four of which are situated at the upper pole and four at the lower pole of the egg as seen in Figure 9. This is the condition when the ~~condition~~ is regular, and might be described as two four-celled stages of half size superimposed one upon the other, and then the upper set rotated to the left. While the formation of the eight-celled stage was always nearly the same in the eggs that I followed, after the division was completed, the blastomeres did not always retain the same relative positions. Sometimes there occured a separation of the cells at one side of the equatorial furrow and the blastomeres rolled

such a curve as that in the curve sheet. In these this separation and unrolling of the blastomeres was less definite and the final arrangement was such as shown in Figure 10.

The irregularity in the relative position of the blastomeres with the eight called stage and is more or less characteristic of all later stages up to the formation of the blastula. But, while there is diversity of arrangement of the blastomeres, nevertheless I am led to believe that the division of the individual cells is regular and takes place just as though the blastomeres always had the same relative position.

The fourth segmentation falls a little short of time. Figure 11 shows a sixteen-cell stage which is really regular, but the cleavage cavity has already been formed within the group of blastomeres and they are thus somewhat forced from the central position. In this stage the cells appear as if in three layers, the [illegible]

[illegible] is [illegible] with the ovary. The eggs in it are difficult to [illegible] with accuracy the degree to the cells. Figure 15 shows a later stage in which the segmentation of the cells is more regular than in those actually met with in eggs of the same age.

As at first before, the divisions in each stage at short intervals. Within two hours after the eggs were laid they had undergone the process of maturation and fertilization, and had passed beyond the sixty-four celled stage. The cells continue to divide with the same rapidity, while within the segmentation cavity is also gradually enlarging. Figure 16 shows a stage in which the cells are no longer distributed around the segmentation cavity. The blastomeres finally become very numerous and small, and arrange themselves around the blastocoele in a single cellular layer, and form a true blastula.

DIFFERENTIATION.

The blastula [illegible]

[illegible] the unsegmented egg. The [illegible] are [illegible] blastula, they were measured [illegible] .1[illegible] mm. in length and .0[illegible] mm. in their largest transverse diameter. The egg before cleavage measured, as stated before, .1[illegible] mm. in diameter. The blastomeres in the blastula stage have become very numerous and small, and are arranged in a single layer of epithelial cells. When the larva is about eight or ten hours old, these peripheral cells develop cilia; probably each cell has one cilium. With the development of the cilia movement commences. At first the motion is slight, but as the cilia become more numerous, the blastula is enabled by the ciliary movements to leave the bottom of the dish in which it was heretofore lying and to swim about in the water [illegible] — [illegible] which is characteristic of hydroid blastulae and planulae. The [illegible] of the blastula is [illegible] may be [illegible]. [illegible]

l[illegible]

possible to determine. It is reasonable, however, to infer that there may be no fixed relation in the larva to the product, for it is well known that normal embryos of small size will develop from fragments of eggs.

BLASTULA.

The blastula gradually elongates and becomes narrower during larval life, which is usually about three times as long as broad as a blastula. From measurements taken of living blastulæ the average size is about .55 mm. in length and .2 mm. in the short diameter. These measurements are not constant, the larva becoming somewhat longer at an older age. The anterior end is also slightly larger than the posterior, but the difference is not as great as in the blastula. During the blastula stage the larva swims near the bottom of the dish; when it attains the blastula stage it rises and swims at or near the surface of the water for a shorter or longer time. In observations made about thirty-two hours after the eggs were fertilized,

A few hours later the ciliated ectoderm cells gradually settle down to the bottom again and finally the ciliated covering cells, due to the loss of the cilia. [illegible] a period of varying length the ciliated ectoderm cells of the [illegible] elongate at the posterior end. About forty-eight hours after the eggs are laid the larvæ reaches the stage of development in which attachment takes place. In preparation for attachment the cercule settles to the bottom, loses its cilia and becomes sessile.

METAMORPHOSIS OF THE CERCULE.

The formation of the ectoderm in Lepidonotus squamatus is similar in appearance with those cells in which the segmentation of the egg is unequal, giving rise to macromeres and micromeres; and in which the ectoderm is formed by a process of the micromeres overgrowing the macromeres by the process of epibole. In direct contrast to this the cleavage is equal and the formation of ectoderm the blastula cells have divided in such a

[illegible] are situated [illegible] with [illegible] between the periphery of the blastula (figures 1f and 1g, two sections of blastulae five and eight and one half hours old respectively). Thus, in their position, all the cells which result from the segmentation of the egg strictly may properly be regarded as forming ectoderm; and indeed already at this stage of development be designated as such, it is better to use the term ectoderm before the appearance of an inner germ layer. The cells of the blastocoele are columnar in shape and at first all are relatively of the same height; but finally those cells at the vegetal pole become somewhat taller than the rest. This is the region where the endoderm will be budded off.

FORMATION OF THE ENDODERM.

In Stomatopa the formation of the endoderm takes place by unipolar ingression, or the "myxotrope" method. The latter term was used by Metschnikoff in contradistinction

ulum = Eigenti . . . . ultur = Kulturgebiet, the . . . . hs istinguish . . . differ . . . es, na-
lv: 1. . . . ay-Zelle ir . . . ich teils durch transverse Zweiteilung der Blasto-
derm- oder Furchungs . . . f. 2. . . ult . . . clar impression, which takes . . . al cilia (Cirrus cir). 3. . . accondary de-
lamination, which occurs where a . . . ula structure exists, as in Cyclops, the ectoderm . . . t of the hyaloid calyx.
4. . . . me delamination, in which the endoderm cells originate in part through transverse division or impression; e. g., . . . , through subsequent differentiation of a secondary delamination. This last mode of the formation of the . . . , as in the Ctenophore, occurs in polygonic; and in the tangential . . . hod both of multiple delamination . . . e shell. In the unipolar impression, an "Eyrest cell" . . . ecies the ectoderm is reminded to a . . . materially small area at the . . . ation of the blastula. This is the cell that is called . . . in the species we . . .

...ssible time.

About the time the blastula has ... ciliated ... forms a gut, usually eight to ten hours after fertilization, the cells at the posterior end of the larva become ... what taller than those in the other regions; and from these cells relatively large, ... The formation of the endoderm in the ... is, in some ways, similar to that described by Kowalevsky in his "Entwicklungsgeschichte einiger einfacher Tiere," for Amphioxus, lytic pipe, ... Metschnikoff (Embryologie). ... cells ... given off from the lower end of the blastula and are pushed into the blastocoele. ... cells may be budded off. Gradually more cells are given off, and these first ... divide; ... by the continuation of this process ... an invagination of the blastula ... filled solidly from the posterior to the ... end. ... which ...

[illegible] process; a [illegible] through [illegible] the endodermal tissue [illegible] be entire cavity.

According to Strasburger, in this second type of unipolar impression or "hypostase," the endodermal tissue [illegible] as a result of radial division of the cells into the blastocoele, and not by a transverse division of the endodermal cells-- the inner parts not [illegible] endoderm cells [illegible] outer parts by giving off radial cells. In figure 66, Plate 5 Strasburger shows a cell in the process of transverse division; [illegible] the [illegible] of situated that one can easily see that they may have arisen by transverse division of a single endodermal cell. These features are [illegible] in his figure 71 of the same species by [illegible] the cell in the process of transverse division. This he seems to regard as an exception, and elsewhere that on the [illegible] the endodermal cells increase by [illegible] division [illegible].

study of
t wi [illegible] for [illegible] portion of the embryo [illegible]
[illegible] to be [illegible] and [illegible] by [illegible] side-
in which the [illegible] lie. However, I am inclined to think
that the [illegible] will arise by a transverse division of
the cell [illegible], as [illegible] shown in the accom-
panying [illegible] of Cyclia pisidioides. Figure 1 is drawn from
the only section I was able to secure that [illegible] exhibited
showing the beginning of the formation of the endoderm, and
that was [illegible] somewhat oblique, requires some [illegible]. A
portion of a little older stage and drawn with [illegible] magni-
fication is shown in Figure 1c. Here there are three cells
that appear to have just divided by transverse division.
Further proof which causes me to think that the endodermal
cells arise by transverse division of the original ecto-
derm cells is the fact that the ectoderm cells in this
region are noticeably no wider than those in other parts of
the blastula. This would not be the case if the longi-
tudinal division occurred; for [illegible] all cells would

PLATE IA.

[illegible] the larva is about twenty-four hours old [illegible] about the time that the epidermal tissue begins to regress itself into the definite larval epithelial layer, a definite regression in the epidermal tissue. The interstitial cells now role their processes here and there by growing in between the bases of the epidermal cells. These latter cells which henceforth were straight cylindrical structures with their sides parallel to each other, now become more irregular; some assume conical form, others spindle shapes according to the pressure of the neighboring cells. After, about this time, or a little later, small vesicular refractive bodies make their appearance usually in the interstitial cells, especially in the end organ cells also. These small vesicle bodies do not only not leave the cytoplasm, and [illegible] to be situated [illegible] between the epidermal cells at the surface. [illegible] developed into [illegible].

a bulbet that is at first [illegible] -
shaped and thus divergent from any tentacle.
The mouth is now invaded, as split begins through the
two germ layers, at the apex of the young hydranth by the
centripetal budding of tentacle buds. About a day later
very tentacles appear. These primary tentacles alter-
nate with the primary ones. The secondary tentacles buds
do not all appear simultaneously; but one usually adds one
to the set a time until there is a complete cycle of tentacles in -
serted and the hydranth has ten tentacles in all. Such
hydranths may have fewer tentacles with six, seven, eight, nine or
ten tentacles according to the stage of development.
Ten seems to be the number of tentacles in the fully
developed hydranth polyp. The oldest polyps in I pool
grew very old but their number; and they seem to be immune to
the hydra, which kills young polyps. I have now seen all
stages of the living animals, on which had come to me,
involved, as having only ten tentacles. In my other

[illegible] i [illegible] later [illegible] and [illegible] ought that [illegible] species. The primary and secondary tentacles arise from the same level so that they may be said to constitute one whorl. The five primary tentacles, however, are longer and projected forward; while the secondaries are shorter and extend backward. The tentacles are well armed with thread cells which are arranged around the tentacles in clusters at short distances from each other, from one end of the tentacle to the other. These groups of thread cells become closer together as the distal end of the tentacle is approached.

A third distinctive character is seen [illegible] in the devel[illegible] of the hy[illegible]. It adheres [illegible] stem. It does not extend the entire length of the stem; but stops a little distance below the whorl of tentacles. In Figure 31 a polyp is shown in which the [illegible] con[illegible] tracted [illegible] shown [illegible]

[illegible] Y.

[illegible] laid at [illegible], [illegible] the [illegible] the ovaries. They [illegible] to be the [illegible] of the epithelial layer of the ovaries.

The eggs are spherical and measure [illegible] in diameter. It is not known what colour they are when laid, and none is published. The cytoplasm is large and opaque.

Maturation takes place after the eggs are laid; and fertilization takes place very soon. Details of fertilization could not be made out because of opacity of eggs.

The [illegible] is small, round and nearly purple, especially in the old stages. The cytoplasm is clear and homogeneous, and contains [illegible] yolk globules, [illegible] the new-laid eggs. The egg-membrane envelops a very loosely adherent clear cavity.

The [illegible] of the fertilization membrane [illegible], which [illegible] with [illegible] of the [illegible] is [illegible].

[illegible]

[illegible].

This work on the ecology of Turritopsis nutricula was begun at the suggestion of Dr. [illegible]. The material was collected and the observations on the living medusae were made during the summers of 1903 and 1904, while I occupied a table at the United States Fisheries Laboratory at Beaufort, North Carolina. Turritopsis is one of the most common medusae in the harbor during the summer. In the two years that I was there they became abundant in the beginning of July and remained more or less plentiful until I left Beaufort September 15. While the medusae could be collected in fairly large numbers, many of them were in poor; they lay only a little [illegible] number of eggs. However, the material was preserved and stained for the study of such facts as could not be made out from the living forms. The work was finished in the biological laboratory of the Johns Hopkins

University.

DEVELOPMENT OF THE OVARIAN EGG.

The ova develop in the ectodermal layer of the germinal epithelium. The germinal epithelium becomes very much thickened in these regions; these enlarged areas are the ovaria. The primitive ovarian cells when first differentiated are larger than the epithelial cells of other parts. Their protoplasm is coarser and of a finely granular character. The nuclei are less hyaline in appearance; and the nucleolus stains deeply. The primitive ova are first distinguished from the rest of the ovarian cells by the increase in the size of the protoplasm and the clearing of the nucleus. The latter becomes very large in proportion to the rest of the cell; and acquires a vesicular appearance. The nuclei have irregularities, and a network of chromatin is scattered throughout the germinal vesicle.

The ovaria are given by the proliferation of the germinal epithelium. In addition to these there are

[illegible] in the [illegible]. It [illegible] -
[illegible] early [illegible] [illegible] by [illegible] -
[illegible] in the [illegible] [illegible]. These are [illegible] stain
very [illegible]. They first [illegible] around the [illegible] vesicle.
As they [illegible] more numerous by the continual formation of
new ones, they are pushed out through the cytoplasm toward
the periphery. The formation of the yolk spheres goes on until
the ovum is closely crowded with them except for a narrow
[illegible] zone, in which the cytoplasm retains its homogeneous and finely granular character and forms the ectoplasm
of the mature egg. Figures 1 to 6 inclusive show different
stages in the development of the ovarian ova and the formation
and elevation of the yolk granules. Some idea of the extent
to which the cytoplasm becomes crowded with these bodies of
[illegible] can be formed from figure 6, which is drawn from
a [illegible] mature ovum. In the fully developed egg the layer
[illegible] is [illegible] than is represented in this figure.

They [illegible] first [illegible] around the nucleus. The

The ovarian walls are all more or less flattened. Their nuclei are about the same size as the nuclei of the primitive germ cells, but are less dense. The nucleoli are conspicuous and stain readily. In general the cells of the epithelium of the ovary are similar, except they are not so much flattened, to the cells in other parts of the ectodermal layer of the subumbrella. The eggs in the ovary lie next to the mesoglea, that is, there is no ectodermal tissue between them and the supporting layer. The ovarian eggs are irregular in shape due to their being crowded together; but when liberated they become spherical.

DEHISCENCE.

The eggs are imbedded in the ectodermal layer of the manubrium. As the eggs grow and increase in size the epithelium of the ovary becomes more and more distended. When they have reached maturity the outer ectodermal tissue of the ovary is under considerable tension. Finally when the time for dehiscence arrives, the outer wall of the ovary is ruptured by the aid of the muscular contractions of the manubrium

[illegible] all of the eggs passed into the ovisac [illegible]. The process of egg laying is very similar to that described for the tree.

The number of eggs deposited by a single female squid varies considerably. It is usually between twenty and thirty five. On one occasion an exceptionally large female was taken in the bay; her ovaries were seen to be crowded with eggs. She was put into a spherical dish of sea water for the purpose of counting how many of eggs that she would lay. The count was made at the time the eggs were deposited; and the number was found to be fifty-six, which is unusually large. I have only three counts but this was the only time that the number exceeded fifty. As a rule it is from twenty to thirty-five, only rarely is it as high as fifty. These numbers seem remarkably small when we consider the enormous number of eggs that are laid by many of the other animals of the ocean; the number often reaching many millions, as a case in point of the Echinodermata and Cephalopoda.

It is a most curious fact that these animals are

always so very regular in the time for depositing their eggs, which is from five to six A. M. During the two summers that I studied Turritopsis at the sea-shore, great numbers were collected and kept in aquaria. On many occasions I arose early in the morning to observe the act of spawning,- one time they were watched through the entire night,- and always the act of egg laying was seen to commence at about five o'clock or a few minutes after. Very rarely did it take place as late as six o'clock; and on no occasion was the phenomenon observed more than a few minutes before 5 A. M.

This precise periodicity is not confined to Turritopsis, but seems to be quite prevalent among the medusae in general. In Staurophora laciata, Staurophora rugosa and a species of Eucheilota I find that the eggs are deposited also at a fixed hour, namely, 5 to 5.30 A. M. Professor Brooks found that Liriope and Eutima spawn at about 4 P. M. In Gonionema Perkins found the time to be from 7 to 8 P. M. Bunting found the period of dehiscence for Hydractinia to be about 10 P. M. While Mereschkowsky says that the eggs of

Bonnia are laid early in the morning. Stechnikoff also gives the time of spawning of 14 species.

Regular breeding habits have also been found to exist among other marine animals, and may be more general than has been suspected. Wilson in his work on the development of Renilla found that the eggs of that form were always laid at about 6 A. M. In a single case only, he says, the spawning took place as early as 5.30 and it was never observed to occur later than seven o'clock. The pelagic Crustacean, Lucifer, Professor Brooks observed to deposit its eggs at 9 to 10 P. M.

Bunting found that by placing Hydractinia in ice and keeping them at a lower temperature she was able to delay the time of egg laying. On restoring the animals to the normal temperature, the eggs were laid after a short period of time. Perkins found that the periodicity of spawning in Gonionemus is definitely affected by the use of light. By placing his colonies in a dark place for an hour and then putting them in the daylight twice the normal egg laying again took place.

While I did not keep any experiments on Turritopsis with regard to temperature of light, yet the changes of temperature from day to day had no noticeable effect on the time at which they discharged their eggs, that is, it occured at the same hour on warm days and cool days. In like manner the fact that the aquarium in which the medusae were contained was kept before a lighted lamp all night had no effect on the time of spawning the next morning, which took place at the fixed period.

THE EGG.

The egg of Turritopsis is spherical and is devoid of color when first laid and none is subsequently formed. Its size it is quite small and can easily be overlooked. If the water is free from sediment and the dish containing the eggs is held upon a piece of black paper the eggs are visible to the naked eye. They measure .1/6 of a millimeter in diameter. They are one of the smaller of the medusa eggs. Sketch itself gives the measurements of the eye of Turritopsis.

species of Leuckartiara; the [illegible] which measures .85 [illegible] .
[illegible] 1.5 [illegible]. During preparations having the smallest [illegible]
Polyxenia albescens the largest egg of the species included in his list. The egg of Eurystoma sig is in fact slightly larger than that of Lathea fasciculata according to the measurements of Etzenhöfer.

In the substance of the egg two parts are distinguishable; an outer layer of clear protoplasm which consists of visibly formative yolk composed of protoplasm with very fine granules; and a central mass of endoplasm which is coarse and opaque and filled with large, dark granules of nutritive yolk. From the fact that the endoplasm is crowded with these coarse yolk granules of nutritive material the egg is very opaque and the germinal vesicle is not to be seen from the exterior. Thus the changes which take place during maturation and fertilization, and the nuclear phenomena of segmentation, as well as the formation of the endoderm cannot be followed in the living egg. For this reason

the egg of Eurrit_sig is not as suitable for study as the
l s, as the beautifully transparent eggs of Liriope a
Eutima for instance, which allow all the changes that take
place within the egg during development to be followed easily.

The specific gravity of the eggs is greater than that
sea-water and consequently they sink to the bottom of
the aquarium as soon as they are discharged from the cavity
of the umbrella. In opacity the egg of Eurrit_sig is inter-
mediate between the egg of Sto stoma pu oga, which is extre-
ly dense and of a chalky white color, and the egg of Sto_o-
toca cyanea which is semi-transparent and of a pale bluish-
white by reflected light. In color the egg of Eurrit_sig
is yellowish white.

THE ADULT AND ITS HABITS.

Because of the scarcity of the eggs satisfactory obser-
vations on the breeding habits of the species could not be
made. Individuals were kept for three months, except for those changes which

take place on the outside. A few minutes after the egg is laid the first polar body is given off at the upper pole of the egg. The second polar globule follows after a very short interval. These structures are of an ephemeral nature and soon disintegrate or pass out into the water and are lost. Nothing can be made out of their internal structure or ~~and~~ of the arrangement of the chromatin with the low magnification which one is obliged to use in the study of the living egg. However I was fortunate enough to get sections of the early stages of preserved eggs which show the polar bodies in the process of being extruded. The germinal vesicle moves to the periphery of the egg, then a part of its substance is divided off and extruded as the first polar body. In Figure 7, which is a section of an egg that was preserved a few minutes after it had been laid, the second polar body is just being given off. It contains several granules of chromatin scattered [illegible] e [illegible].

[illegible], [illegible] little distance

. but in this hal in some [illegible] the
[illegible] of attachment, the two str[illegible] together
[illegible] ring in the centre of the clear zone.
[illegible]. The mode of attachment of the polar bodies to the
surface of the egg is not quite clear, as the egg is distinct
from a membrane. It is possible that some of the clear
liquid part of the protoplasm may exude from the substance
of the egg as the polar bodies are extruded and be the means
of holding them to the surface of the egg over the insertion.

As can be seen in the figure, the germinal vesicle
during the extrusion of the polar bodies is situated at the
[illegible] pole of the egg; however, about half of its bulk extends
beyond the general contour of the egg's surface. The [illegible]
material in the ground around the nucleus with the same density
as in other parts of the egg. After the second polar body
has been given off, the female nucleus moves back into
the germinal area [illegible]. Here it is met by the male
nucleus and fusion of the two takes place. In the [illegible] is

ova [illegible] the entrance of the spermatozoon or [illegible] could not be decided. But I am inclined to think that [illegible] is capable of penetrating the egg at any point; and that when it has once entered the substance of the egg, the male and female pronuclei are brought together by the attraction existing between the two.

It was impossible to see the discharge of the spermatozoa from the males; neither did I see them enter the eggs. But, as stated before, the eggs are so opaque that the internal phenomena of fertilization could not be followed in the living specimens. The reason to believe that the eggs are discharged at about the same time that the females lay their eggs. Fertilization takes place in the water immediately following extrusion, and segmentation begins in a very short time.

SPERMATIA.

Spermatia is to all appearances exceedingly small. While [illegible] is a slight difference in the size of the [illegible]

at [illegible] this is [illegible] that [illegible] will
have [illegible] value in [illegible]; that is, they [illegible]
living [illegible] living [illegible]. There is
evidence [illegible] observations [illegible] living eggs, [illegible]
[illegible] study of sections [illegible] proved [illegible] that [illegible]
[illegible] blastomeres can be localized [illegible] distinct
parts of the future embryo. During the first two or three
cell cycles the process is usually quite regular, but beyond
the eight cell stage the segmentation becomes very irregular
or erratic; almost if not fully as regrettable as that de-
scribed and figured by Hertwig [illegible] and
to which he says: "Between the attempts of the blastom-
bisected [illegible] there is clearly in the duration of the
cycle of the four cells the most considerable [illegible] exhi-
bited in individual cells of [illegible] which have [illegible]
[illegible]. It is not strange that with the partial [illegible]
cur [illegible] exhibiting as yet [illegible] in the [illegible]
[illegible], [illegible], [illegible] should [illegible]

[illegible] as [illegible] very [illegible] expressed [illegible] [illegible] [illegible] figures illustrating this paper as abnormal [illegible] the degree of being pathological. And [illegible] it seemed [illegible] [illegible] first observed; and as pointed out in the earlier paper, the first batch of eggs were discarded as having 'gone bad.' "

When I first began the study of the development of Fundulus eggs, the irregularities of segmentation struck me as very peculiar and I was at first inclined to think that they were abnormal. After I allowed the eggs time to progress I discovered that they developed into normal glomuli and thus was forced to conclude that this strange and irregular cleavage must after all be normal for the species. On several occasions the attention of a number of other observers who were working in the same research laboratory was called to this phenomenon, as they also expressed surprise and remarked that they had never seen segmentation presenting such an irregular structure.

Stockard (1909) describes and gives a few figures of a very similar condition in segmentation in [illegible] eggs.

de [illegible]ys: "[illegible] beschrieben[illegible] neuerer [illegible] [illegible] in de[illegible] des vierten Furchungs-stadium constatirt werden musste, so scheint [illegible] bei [illegible] eine gewisse Regelmässigkeit zu finden. [illegible]end in dieser Beziehung verhält sich [illegible], [illegible] bei dieser Gruppe die kaum mit einander vereinigten Blasto-meren durchaus unregelmässig und ordnungslos nebeneinander liegen. — — — Das Abweichende in der Embryonalentwickelung der [illegible] hält noch nicht [illegible] auf. Die Furchung setzt sich in unregelmässigster Weise fort und führt zur Bildung unförmlicher Zellenhaufen, in deren Innern [illegible] eine Furchungshöhle [illegible] nicht. [illegible] [illegible] eine ganz [illegible] Gestalt an, deren Ursache zum Theil darin liegt, dass sie sich durch Theilung v[illegible], [illegible] habe ich [illegible] isolirte Blastula-stadien beobachtet, so kann ich an dessen Existenz nicht zweifeln." [illegible] Tu[illegible], [illegible], [illegible] cleavages [illegible]

[illegible] may be seen at times in these cytoplasmic filaments. Their function does not seem to be clearly known; but it, very probably, is associated with a readjustment of cytoplasm and the establishment of an equilibrium between the different blastomeres.

Hertwig in his paper on "The early development of [illegible] tigrella" discusses the occurrence of nucleoli, threads, and bridges; and reviews briefly the observations of a number of other investigators in regard to these phenomena, and the cytoplasmic activities which they have seen to take place in the eggs of a number of animals widely separated morphologically. No definite conclusions are reached as to the functions of these various phenomena, but it is generally thought that they are associated with certain intrinsic changes within the cytoplasm.

These protoplasmic corrugations are usually confined to the equator only. They are present not only in the two-cell stage, but in several of the following stages as well. In the four-cell stage [illegible] the egg divides [illegible]

less readily recognized.

The second cleavage occurs [illegible] v- iv [illegible] ty minutes after the first. The plane of division is also meridional and at right angles to the first segmentation. It begins at the centre of the egg next to the furrow of the first cleavage and slowly extends out toward the periphery. When the division is completed the four blastomeres undergo a slight rotation from right to left; and in the centre of the egg between the cells there is, at times, to be seen a small open space or segmentation cavity which may extend through the entire egg as shown in figure 12.

After a length of time equal to that which occurs between the first and second divisions, the third cleavage furrow appears. This plane of division is equatorial and divides the egg into eight blastomeres. The segmentation is [illegible] in that the quartets of cells are situated one over the other and [illegible] more or less spherical whole, as is the usual arrangement in eggs in which segmentation [illegible]

is equal [illegible] . This arrangement of the blastomeres, however, is of very short duration, for soon a separation takes place between the cells of the lower quartet and two of them roll away from the plane of separation in one direction; the other two moving out in the opposite direction. In this migration the blastomeres move through an angle of 45 degrees or more, and finally come to lie in such a position as to form a semicircular plate as shown in Figures 13 and 14. The separation and rotation of the cells of one quartet seems to be constant in its occurrence; but the final arrangement of the blastomeres is not always as regular and definite as that shown in the figures. At times they are more loosely and irregularly connected, and may assume relative positions similar to that shown by Metschnikoff for Geonia annata in Figure 14, Plate 1, of his "Embryologische Studien." In the case of the blastomeres are so arranged that the individuals, with these exceptions, touch only one of their fellows, thus

resembling a string of beads somewhat coiled.

With this separation and rolling apart, the regularity in arrangement of the cells in the segmenting egg is lost, and the stages from this point on become more and more irregular with each successive division up to the time when the readjustment takes place which is the beginning of the formation of the free-swimming embryo.

It is possible to distinguish, during these early cleavage stages, a layer of ectosarc around each individual blastomere. Later as the cells increase in number and become smaller, the ectosarc covering becomes less conspicuous and finally is lost from sight entirely.

After an interval of about one half an hour, the fourth segmentation begins. The divisions of the different cells no longer take place simultaneously; some occur a few minutes before others, but all are completed within a comparatively short time. So far as the cleavage itself is concerned, it is still equal and regular, but the arrangement of the blastomeres is no longer regular as it was before. They apparently

follow no law of symmetry, and may be of any description. Figures 15, 16 and 17 show three different forms which the cells of the sixteen cell stage acquire, and various other arrangements of the blastomeres were seen while studying the living eggs which could not be figured for want of space. However the three figures are sufficient to show that the general form of the egg in this stage may be very different. In Figure 15 it is possible to imagine a direct relationship to a preceding form just a little more irregular than is shown in Figure 14. In a form as represented in Figure 16 the descent of the different cells from the individual blastomeres of the eight cell stage is less easily recognised. Figure 17 shows an egg in which all sixteen blastomeres are spread out to form a flat plate one cell thick in the form of a quadrangle. One can easily conceive how this arrangement can have resulted from a regular eight cell stage in which the rotation of the cells of the one quarter was greater than that shown in Figure

15. The flat, arrested outline of the cells at this stage suggests the idea that the egg may have been subjected to pressure. ~~And~~ This might have been the case if the eggs had been squashed on a slide under a cover glass; but there is no evidence that pressure was the cause of this plate-like arrangement, for these forms were occasionally found among a variety of other forms while studying the living eggs in a small preparation dish in sea-water with a two-thirds objective. As the eggs present a number of different forms when subjected to the same external conditions, it seems that the cause of these differences must be sought in the nature of the egg itself rather than in any surrounding influences.

The later cleavages follow at intervals of about the same duration as in the preceding stages. The irregularities of arrangement of the blastomeres increase as the cells become more numerous. On account of the smallness of the blastomeres and the extreme opacity of the egg, it becomes impossible to follow the segmentation in detail any further.

Figures 19 - 21 show a few of the later stages of comparatively very regular form. Figure 21 represents an egg in which the blastomeres are arranged in two main groups held together by a narrow isthmus of only one cell in thickness. Some eggs were separated into three or four thickened clusters that were joined together by small masses of connecting cells. In others there were smaller groups of blastomeres projecting out from the general mass of cells, thus giving the whole somewhat of an ameboid appearance. The term amoeba-like seems to most clearly represent the shape which some of these late segmentation stages assume, for if a simple outline of these remarkable and grotesque forms is drawn it has a general resemblance to an amoeba with thick blunt pseudopods. Whether these irregularities in the shape of the egg during late segmentation, and the tendency of the cells to arrange themselves into more or less distinct lobes is due to an amoeboid property of the cytoplasm of the egg, or to a tendency to multiply by division during cleavage, as was suggested by Wetzel [illegible] for Cearia gu-

[illegible], there is [illegible] cells. It may be possible that both of these factors act in determining the shape of the segmenting mass of cells. And doubtless the membraneless character of the egg plays a part in these phenomena.

BLASTULA.

When segmentation is complete a solid embryo is formed which may at first be called a morula. Small spaces occur sometimes between the blastomeres during the different cleavage stages, but they are sooner or later obliterated by the crowding together of the cells. A central cleavage cavity which is later transformed into a blastocoele is not formed; consequently a true blastula does not exist in the development of Turritopsis. In this respect it differs very markedly from Clavatella and the majority of hydromedusae of which the development has been studied, in which a definite blastocoele is formed that becomes filled

finally with the ciliated ectoderm cells. When the larva is about six to eight hours old, the very irregular shape, which the segmenting ova has assumed, becomes less marked. Gradually the cells have rearranged; the lobes and processes which previously were so conspicuous are now drawn into the main mass of cells, and the egg is transformed into an oval embryo. This process of rounding up lasts from two to four hours. The cells of the embryo now develop cilia, and the larva begins to move. At first the movements are feeble, but soon the larva is able to leave the bottom of the aquarium and swim free in the water. Eggs that are laid at five to six o'clock in the morning develop to the free-swimming stage by four in the afternoon. The larva swims with its broad end forward and has a spiral or corkscrew motion, which propels it onward. This method of swimming is common to many marine larvae. When the embryo reaches this stage the cells become very numerous and small. At last by the cilia are developed at

[illegible] figure it resembles a young [illegible], [illegible] instead [illegible] in [illegible].
[illegible] [illegible] [illegible] [illegible], [illegible] anything [illegible]. The [illegible] [illegible] [illegible] [illegible]; [illegible] have evidently [illegible] from the [illegible].

[illegible] [illegible] this [illegible] [illegible], but [illegible] [illegible] [illegible]. [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]. As it becomes older it grows still longer. Figure 34 shows a larva of thirty hours. It has now the [illegible] [illegible]; and is [illegible]. The [illegible] [illegible], [illegible] for some time during the [illegible] condition of the larva it swims near the bottom of the aquarium. But as it grows longer and slimmer it rises in the water and soon is at or near the surface. The length

The time during which the embryo remains in the free-swimming planula stage is variable; but as a rule by the time it is about forty-eight hours old, it begins to sink toward the bottom of the aquarium, and to swim less rapidly. After the spiral swimming movements are lost, the planula is capable of gliding along the bottom of the dish for some time. Finally the motion ceases altogether and the larva loses its cilia and is ready for attachment. This stage of development is reached under favorable conditions about forty-eight to fifty hours after the eggs have been laid.

The planula is very opaque, and thus it is impossible to make out anything about its internal structure in studying the living forms. Specimens in various stages of development were preserved and sectioned for the study of cellular structure. The description of this structure will be given in connection with the formation of the germ layers.

Brooks describes and figures the embryological investigation

at the posterior end of the planula. He says: "An invi planula i in easy to make out the posterior end, an ectodermal invagination, which looks very much like the mouth of an invagination gastrula, but this resemblance is misleading, for the careful study of a similar structur in the planula of Lutina shows that the invagination has no connection with the digestive cavity, but is an ectodermal gland for the attachment of the planula." From my observations I am inclined to regard this structure, which he describes, as a variation rather than a normal feature. It seems to be an abnormal occurence which is found only rarely. Among the many specimens which I studied both in life and from preserved material, such an invagination was met with only on one occasion. There it was at the anterior end of the planula instead of the posterior. These ~~features~~ structures are clearly abnormal features of the developing Turritopsis planula.

EXPERIMENTAL.

The very irregular character of the segmenting egg and the loose connection of the blastomeres; and their tendency to separate into more or less definite lobes and protuberances, as has been described in the section on segmentation suggested the problem: What would be the effect of dividing the eggs during the comparatively early stages of cleavage? With this question in mind a few experiments were tried. The eggs were divided during several stages of segmentation. The best method for separating the cells was found to be by placing the eggs on a clean glass plate moistened with sea-water. Then with a finely pointed needle or with a very delicate scalpel the blastomeres could be cut or torn apart without being crushed. After they were divided, they were flooded from the glass plate by water from a pipette into a dish of sea-water and watched in their development. The advantage of separating the eggs on a glass plate is that they can be held steadily by suction, while

not rotate as readily while being cut apart. Eggs were divided during different stages of cleavage from two to six hours old. They were then placed under conditions as nearly like those under which the eggs had divided developed as possible. Unfortunately, as these experiments were incidental and incomplete, no eggs were divided during the two-cell stage and their cleavage followed in detail. Some eggs that were laid between five and six in the morning were divided at 10.45 A. M. More than one half of the fragments continued to develop and by six o'clock in the evening had reached the free-swimming stage. They were retarded a little in their development; whole eggs usually arrive at this stage at about four to four-thirty. They were slightly smaller than embryos from whole eggs, but apparently just as active and normal, except in size. By the next morning they had reached the elongated planula stage and were in good condition, swimming at the surface of the water.

[illegible] ti[illegible] were divided. These [illegible] results in development. The [illegible] embryos and the study of their minute structure [impos]sible during life; and because of scarcity of material none could be reserved to study their histology from sections. However these few incomplete experiments show that fragments of the egg of _Turritopsis_ are capable of developing into apparently entire and normal embryos of slightly smaller size.

Hargitt artificially divided some Pennaria eggs during the first cleavage and figures a number of resulting segmentation stages, which are very similar to those of whole eggs. He says: "As will be seen, each of the resulting halves behaves in a manner indistinguishable from that of normal eggs. These half embryos were followed through the [illegible] process of cleavage and through the later stages [illegible] into planulae and polyps, [illegible] in every respect,

size [illegible], the process was entirely normal."

To my knowledge Haeckel was the first to publish the statement that halves of hydromedusan eggs would develop into normal embryos. For some time naturalists in general were inclined to doubt the fact; but since the work of Boveri, Herwig brothers, Roux, Driesch, Wilson, Morgan, Loeb and others on the fragments of eggs, the development of embryos, abnormal and normal, from the portions of eggs is a question no longer to be doubted.

FORMATION OF THE ECTODERM.

In the development of the egg of Eurystomias the germinal layers are not differentiated by process of epiboly, delamination or cellular ingression. During segmentation the blastomeres do not separate and arrange themselves around a segmentation cavity which later is transformed into a blastocoele. Thus instead of having here a coeloblastula, we find that cleavage results in the formation of a solid

oval oviger devoid of [illegible], and [illegible] solid
a morula stage. The cells of the segmenting egg are al
alike in structure and nearly equal in size; so that they are
not distinguishable into nutritive cells and formative
cells, which is the case in forms where a definite de-
lamination takes place, as is so beautifully shown in
Lipiza and Gonyaulax, and in species where cellular ingres-
sion occurs as in Sterechinus and Clytia for example. Fig-
ures 75 to 78 illustrate the uniformity of the cells, and
the solid character of the egg during segmentation. In
figure 77 a space exists between the blastomeres near one
end of the egg, but this is not to be regarded as a true
cleavage cavity. The next figure shows three of these false
cleavage cavities. They occur only occasionally. As
stated before most of the eggs are entirely solid.

About the time the irregular mass of segmenting blast -
omeres is metamorphosed into the oval embryo, the cell bou-
daries are lost and a short time and a syncytium is formed.
This syncytial structure is composed of small granules em

a number of nuclei are scattered through the protoplasm. The nuclei near the surface are numerous near the periphery; and their cell walls begin to appear as shown in figure 33. These cells are to become the ectoderm, which is soon separated from the inner structureless mass by the development of the mesoglea. Now the ectoderm forms a distinct layer, composed of columnar cells all of which are at first similar in structure and lie parallel to each other as shown in figure 34. The differentiation of the ectoderm cells takes place later.

The formation of the germinal layers in Turritopsis is different from that which has generally been described for the development of Hydromedusae. In the majority of those previously studied the differentiation took place either by delamination or by cellular immigration, unipolar or multipolar. These methods have been well described and figured by Metschnikoff for a number of species.

In Aglaura and Geryonia there is found, according to Metschnikoff, a solid so-called morula stage destitute

of the cleavage cavity, the superficial cells of which are converted into the ectodermal layer, while those within represent the endoderm. Here the two layers are formed directly without the formation of a syncytial structure.

In Pudoricium and Terpsis according to Hargitt's description a condition somewhat similar to that of Turritopsis is found. He says: "Indeed in both Pudoricium and Terpsis, not to mention other cases, cleavage would seem to result primarily in the formation of a more or less characteristic syncytium, the subsequent development of the germ layers taking place by a gradual differentiation of the syncytial elements, first and naturally the [illegible], and later, often very much later, the endoderm."

The syncytial character in Turritopsis is acquired under favorable conditions, when the eggs are only a few hours old; at the time that the irregular mass of segmenting cells is metamorphosed into the oval embryo. For I am inclined to think that the formation of the syncytium

and the borders of the larval integument. The length of the [illegible] which [illegible] is evidently progressively short, as each cell cycle and the larva begins to swim. Meanwhile the peripheral region of the syncytium has been transformed into a distinct layer of epidermal cells, separated from the inner mass of tissue, still structureless in character, by the development of the basement.

From the fact that a syncytium, or plasmodium-like structure is formed, it is impossible to localize any of the blastomeres of the segmenting egg which will form special parts of the future embryo. Even those cells which are at the surface at the completion of segmentation cannot be regarded as exhibiting mosaicism, for in the breaking down of the cell boundaries, the activities of the syncytium, and the migration of the cells it is quite impossible to say what change of position may take place.

[illegible].

The formation of the endoderm in Turritopsis nutricula may be carried to any of the schemes of the development of the body regions which have been sketched by Metschnikoff. He distinguishes three principal methods for the development of the inner germ layer: first, delamination, a process in which the segmenting blastomeres divide in a plane nearly parallel to the surface; and the inner cells or cells become primitive entoderm, while the outer cells remain as primitive ectoderm. Second, multipolar ingression, in which cells migrate into the blastocoele from different portions of the peripheral cell layer, and are transformed into endodermal tissue directly. This may be described several subordinate types. Third, unipolar migration, as given in the preceding account that the primitive entoderm cells are given off at one pole only; at the [illegible] pole.

In Turritopsis nutricula, as in many [illegible] em-

[illegible] connective tissue [illegible] F[illegible] [illegible]
[illegible] hese [illegible] [illegible] [illegible]
[illegible] yolk [illegible] [illegible] [illegible]. [illegible]
[illegible] ould is formed much later than ectoderm. [illegible]
after the gastrula embryo is developed cell boundaries
begin to appear in the syncytium in the interior of the larva.
The cells thus formed are primitive endodermal cells, and
are crowded together without any definite arrangement for
a number of hours. Stages in which the cell walls are appearing are shown in Figures 74 to 76. When the embryo
is about forty-eight to sixty hours old, the time at which
attachment takes place, a fissure appears in the middle
of the mass of endodermal tissue. This is the beginning
of the coelenteric cavity. This separation begins near
the anterior part and grows toward the posterior end. The
coelenteron gradually increases in size, and at the same
time the endodermal cells begin to be arranged; gradually become arranged parallel to each other with their long

against the coelom or over a definite integumentary layer.

Goette has observed in Bombinator that during the course of cell multiplication the cell boundaries become indistinct and that the peripheral and central cells are altogether identical. But his opinion differs from Lwoff's, according to his description of the formation of the primitive stem, in that it is not carried out by a multiplication of cells in the interior of the primitive rib; while in Lwoff's the whole stem results directly from segmentation without any recognizable division of cells.

The formation of the endoderm in Lymnaea stagnalis corresponds to what all the others which have previously been described; and which in the main are to serve as models of the structural methods established by Lwoff. The material employed in the [illegible] by

[illegible]

all [illegible] illustrate [illegible] in various [illegible]

division. [illegible] in cells where amitosis takes [illegible]

[illegible] all [illegible] have been [illegible]

[illegible] than in cells where division is less

active. It may be that [illegible] degenera-

tion and the phenomena of direct cell division are associated with each other. Or it may be that the view of Flemming and Ziegler, that amitosis is connected with a high specialization of the cell or is the forerunner of degeneration, applies in this case. This latter conception seems plausable, for we find amitosis to be most abundant shortly before the cell boundaries disappear and the embryo is transformed into the syncytium.

For a number of years it has been known that amitosis is common in follicle cells, digestive epithelial cells, supporting cells, etc.; but generally it was not supposed to take place in early embryonic development. Within the last few years however a number of observers have discovered this

when mature in the developmental stages mentioned in 2.

ATTACHMENT.

Under favorable conditions that is, in about fifty hours all the planulae that appear to have attached have done so. In no case has the planula settled on the hot or, less often, the cold spot recently its swimming organ. The manner of attachment in Eudendrium is like that of Stauridium, but that usually described in hydroid development. Instead of settling down on the anterior end of the planula according to the method which occurs in Eudendrium, and which has been accepted as typical and used in descriptions of the embryology of the Hydromedusae in text-books, the planula bearers attached at its side by nearly its whole length, and is transformed into a unit. The hollow hypostome emerges from the opposite end of the planula as in those which attach themselves by the anterior end,

[illegible] that is given off from the mouth, usually about the middle.

Metschnikoff observed the fact that the blastula is transformed into a gastrula, lays down a hydrocoelic; and gives a brief account of the larva in his paper on "The Life-History of Sutina"(1886). Metschnikoff describes and figures for Mitrocoma the fact that the larva becomes attached by its side and is almost wholly enclosed in the formation of the hydrocoele, while the first hydranth grows out of it by a kind of budding (Embryologische Studien, 1 88).

In general the attachment of the blastula is similar in Eucopidæ to the method which is followed by Clavatæ, but the former does not directly produce secondary hydrocoele. In Obelia about the time the hydranth bud is formed, or even before, the root branches appear usually to one of the secondary radii; in Eucopidæ this branching usually takes place, at least during the first few days of the de-

v[illegible]nt of the hydranth.

[illegible]ocyst [illegible]scribes and [illegible]igures in the [illegible]rvule [illegible]ut[illegible]s [illegible]n ectodermal adhesive gland. It occurs [illegible]etwe[illegible]n the ectoderm and the digestive cavity are fused, and [illegible]s the appearance of the mouth, or as considered [illegible]nvaginated at the small end of the planula. In Turritopsis no such special organ of attachment is found. The larva [illegible]mbolly becomes fixed by a secretion extruded from the ectoderm cells along the whole length of its body.

DIVISION OF THE HYDRANTH.

Shortly after the larva becomes attached a bud develops, usually at about the centre of the west, which is the beginning of the first hydranth. Soon small projections appear near around the distal part of the bud; these will later form the first circle of tentacles. At this time the mouth has yet to be formed. A figure only in this stage of development is shown in Fig. 2 [illegible]. The hydranth bud continues to grow [illegible]ally and at its base a second whorl of ten-

tentacle buds is formed some distance below the first whorl of tentacles. When the polyp is from twenty to twenty-four hours old, or about $\frac{2}{3}$ to $\frac{1}{2}$ forty-two hours after the egg is laid, it is ready to develop the third whorl of tentacles. Thus the tentacles nearest the apex of the hydranth are the oldest and largest. The circles are indefinite, that is the tentacles of a whorl do not all arise from the same level; so that in the advanced hydriform they have rather the appearance of being scattered than arranged in circles. The tentacles when fully developed are stout and filiform; and are capable of much extension and contraction. Figures 27 to 31 illustrate various stages in the early development of the hydranth; the youngest here about fifty hours and the most matured some seventy hours old. Figure 32 shows a form in which the polyp arises from near the end of the hydrorhiza. This is exceptional. A hydranth with the third circle of tentacles is shown in figure 31; the tentacles of the first whorl have become considerably elongated. The hydrocoulus now becomes larger and more slender; and the hydranth assumes a fusi-

[illegible] body.

The [illegible] that I [illegible] from [illegible] at the [illegible] of three days were in the main features like the hydranths of the adult colony found and figured by Professor Brooks, except that they had not yet developed any tentacles. In his description he says: "The upright stems of the hydrocaulus, from 5 mm. to 10 mm. high, bore large terminal hydranths, as well as smaller ones which were scattered irregularly along the stem on short stalks. The large fusiform body of the hydranth carries from eighteen to twenty thin, short, filiform tentacles, which are arranged in three or more indefinite whorls. The medusa buds originate around the stem just below the hydranths, and they are the solves combined on short stems. The manubrium is not annulated, and it forms a large cylindrical sheath around the main stem, and the short branches which carry the lateral hydranths and the young medusae, while the latter are inverted [illegible]

[illegible] sheath of the ster is thickly covered with slender setae. It terminates clavately by a short collar duct below each hydrorhiza. The young hydranths and the reduced ones have no cilia above the collar, but they soon become entirely sheathed in perisarc by the growth of the stem. The male yellowish-red hydranths are very similar to those of Dubinia (Allman) and the hydroid is so similar to Pandeolaria lobata (Clarke) described by Clarke, that they undoubtedly belong to the same genus."

SUMMARY.

1. The eyes of Eurystomella bothi are of the ocellus type of the vertebrate eye; and their retinae are composed only of rod-like sensory cells; and their retinae are densely packed with large well granules.

2. Pelagic larvae take place at a definite time, and have to pass out of the body.

3. The egg is a large [illegible]

[illegible] outer layer [illegible] [illegible]

[illegible] spherical, which is [illegible] and opaque and [illegible] large, deep [illegible] brown.

4. Maturation and fertilization take place in the [illegible] often the eggs are deposited. It is [illegible] [illegible] stage in the living eggs because of their opacity.

5. Cleavage is total and nearly equal. The first three divisions are fairly regular; but during the later segmentation the arrangement of the blastomeres becomes very irregular and erratic. At the completion of segmentation a solid morula stage is formed, in which the cell boundaries are lost for a time giving rise to a syncytium.

6. Parts of eggs which are divided during the cleavage stages continue to develop and free larvae which are normal in every respect except size.

7. The outer cell is formed by the reappearance of cell walls at the periphery of the syncytium mass; and is separated from the interior part by the formation of the blastocoel.

. The segregation of the ectoderm cells from the typical method described by Stockard. It takes place in the layer 1 to form the primitive cells of issue 1 in the interior of the embryo after the separation of the ectoderm by segregation. These cells first appear they are crowded together without any definite arrangement; finally they come to form the distinct endoderm layer.

.. During the late segmentation there is evidence that some of the nuclei divide mitotically.

10. The cytula becomes attached on the side by nearly its entire length, and is transformed into a mat.

11. The first hypoblast develops from a bud which is given about by cells of the primary teloblasts.

1 . The teloblast develops in its finite cells. Each [illegible] teloblast. The cells are next to the initial [illegible]. In the fully [illegible] hypoblast, have the [illegible] their position with [illegible] in [illegible].

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