EARLY STAGES IN THE DEVELOPMENT OF CYMATOGASTER.* By CARL H. EIGENMANN.

The investigation of which this is an abstract has been conducted with various intermissions since December 1888. I present here simply the result. The proof for any one of the propositions would take up more than the time allotted for all of them. The details with all necessary figures will be published during the year by the U. S. Fish Commission.

A large per cent. of the California fishes bring forth their young alive. The members of one family of these fishes, the *Scorpænidæ*, bring forth many thousands of young in a very immature condition. The members of the other family, the *Embiotocidæ*, bring forth comparatively few young, 3–80, but these are sometimes an inch or two in length and resemble the parent as much as the new born mammal resembles its parent. It is this family which is of great interest and to which I devoted most of my time. After examining many of the species just before and during gestation I selected *Cymatogaster* for a special study, because the peculiarities have become most marked in this species. The results are as follows:

1. Copulation takes place in July. This statement is based on the fact that the testes of the male are very much enlarged at this time and on the fact that the ovaries from now on are filled with spermatozoons. The act of copulation has not been observed.

2. The secondary sexual differences are considerable—among them may be mentioned a small gland or bag on either side of the anal of the male. From it extends a papilla forward to beyond the anterior margin of the fin.

3. The spermatozoa have a long rod-shaped head in place of the globular one usual in fishes.

4. The spermatozoa remain dormant in the ovary till December when they become exceedingly active.

5. The eggs mature and are fertilized between November 1st and February 1st, the largest fishes maturing the eggs earliest, the next in size a little later and the smallest individuals last.

6. Those spermatozoa not utilized in fertilization remain in the ovary for several weeks longer. They are finally eaten by the larvæ when the digestive tract of the latter has been sufficiently developed.

7. During the early stages of gestation the females remain in shallow

* I have hitherto referred to this fish as *Micrometrus*. A re-examination of the literature bearing on the subject proves that this name is not available.

water; males are then rarely seen. Later they become scarce but near the time the young are freed and shortly afterwards they are again found in shallow water.

8. The largest ovarian eggs measure about .3 mm. in diameter. During the process of maturation the egg contents shrink to a diameter of .2 mm. or to less than one-third of its maximum size.

9. The egg of this fish, *Cymatogaster aggregatus*, is 130 times smaller than the normal fish egg which has an average diameter of 1 mm.

10. This small size is largely if not entirely due to the non-formation of deutoplasm.

11. The egg is fertilized while still in the follicle. Some sections show the extrusion of the second polar globule and the presence of the male pronucleus in an egg still surrounded by the cells of the follicle. The latter have begun to degenerate.

12. The development begins after the egg has been freed from the follicle. Eggs with one, two, four, eight and sixteen cells as well as many later stages were found free in the ovary.

13. Neither the developing eggs nor the young are in later stages at any time connected with the parent nor is the position of these in relation to the ovarian structures a fixed one.

14. The duration of gestation is probably five months and the number of young from three to twenty according to the size of the parent. In less than a year after birth the young are with young.

15. The food of the young is supplied by the epithelium of the ovary. The cells enlarge and become clear, when they collapse, their contents are emptied into the lumen of the ovary and the framework of the cells soon follows. When the intestine begins its work the spermatozoa serve as part of the food. The ovary at no time was observed to contain more fluids than the peritoneal cavity. (In other species considerable fluid is sometimes present.) Before the development of the alimentary tract the ovariarn fluid is probably appropriated by a process of intercellular digestion on the part of the epidermal cells.

16. The yolk is a waning structure and can scarcely be taken into consideration in accounting for the growth of early stages.

17. During the whole of gestation respiration is carried on by the osmotic action between the general surface and the closely applied ovarian structures. When the alimentary tract is opened a current is kept flowing through it and aeration is, in all probability, effected by the ali-

mentary tract. In later stages the fins become highly vascular and doubtless serve both for purposes of aeration and food absorption.

18. There is present in the entodermic pole of the developing egg a body the like of which has not been observed in any other egg It consists of a mass of protoplasm imbedded in the yolk. It is dissolved near the time of the closing of the blastopore. Mr. J. W. Hubbard, one of my students, has connected its history with that of the yolk nucleus which is a conspicuous structure in the ovaries of adult fishes in egg from 20 μ up to maturity. It is a general extrusion from the nucleus of the young ovum and probably represents the histogenetic or somatic portion of the nucleus and this in part at least corresponds to the macronucleus of ciliate infusoria.

19. Before segmentation begins the whole of the germ is separated from the deutoplasm. The first cleavage plane extends entirely through the germ to the yolk before the second cleavage begins.

20. A segmentation cavity is not formed during segmentation but appears later by a separation of the ectoderm and entoderm.

21. The third cleavage plane is not parallel with the first as is usual in fishes, but is semi-equatorial. This has nothing to do with the horizontal cleavage claimed to have been seen by Hoffman and by Brook. It is taken to be a pseudoreversion to primitive methods of segmentation with the reservation that this condition is not perfectly homologous with the third segmentation of the frog or *Branchiostoma*, and would not be had the yolk entirely disappeared.

22. The periblast is formed from a few of the marginal cells. Like the yolk it is a waning structure. Only about 12-cells are ever formed. They take no part whatever in the formation of the embryo. All of them persist as long as a trace of the yolk is left. It, with the final part of the yolk, is absorbed by the blood of the sinus venosus. The liver has nothing to do with its final absorption as Wilson has claimed but simply mechanically encloses the nuclei above and behind.

23. During an early stage of segmentation some of the marginal cells of the blastoderm creep over the yolk till they nearly if not entirely cover it.

24. Before gastrulation the yolk sinks into the mass of the blastoderm the cells of which re-arrange themselves about it and nearly enclose it.

25. The gastrula is finally formed by a process of delamination of en-

toderm from ectoderm and is completely diplastic and symmetrical, the blastofore closing at the entodermic pole of the egg.

26. Before any other organs become evident the sex cells become conspicuous. Their fate I have discussed elsewhere.

27. The earliest stages of the formation of the embryo have not been clearly made out with the material at hand. It is, however, certain that in one of the figures published by me in the "Journal of Morphology," I mistook the tail for the head. The conditions are extremely similar to those found in the mammalian embryos, except that the central cavity is filled with yolk instead of fluid.

28. The mesoderm is formed by a process of delamination from the entoderm. It is formed as two sheets and over the whole of the entoderm exclusive of the axial line.

29. The young fish is freed from its membrane in a very immature condition. It completely encircles the yolk; in fact the head and the tail overlap. It is incapable of motion at this time and indeed the cells which will form the muscles have scarcely become differentiated. The hatching process is due to the growth of the embryo and not to its activity as is usually the case. The fin folds do not appear till much later.

30. Kupffer's vesicle appears very early and is very large. It consists when fully formed of a dome-shaped roof over a large cavity surrounded on the sides by entoderm. It at first rests on the yolk but soon the yolk is forced down and presents a deep impression just beneath the vesicle. Later the vesicle is divided into three distinct cavities. The upper dome-shaped portion persists for some time and probably represents part of the neurenteric canal. The middle portion remains for some time as an enlarged part of the intestine. The lowest portion is the cavity formed in the yolk. It has acquired a roof by the ingrowth of the entoderm cells to form the floor of the intestine. This cavity usually remains for a considerable time.

31. The entoderm at first extends over the entire yolk. It later becomes restricted to a comparatively narrow strip along the axial line.

32. The floor of the alimentary canal is formed by the ingrowth below of the marginal cells of the entoderm. The ingrowth progresses from in front back. A lumen is not formed at once. The lumen is formed in the hind gut and in the gill region at the same time and gives abundant evidence that the alimentary tract is bilateral. The middle anterior part remains a solid mass of cells after the lumen has appeared both in front and behind this tract.

33. The anterior opening of the alimentary canal to the exterior is through the gill slit in larvæ 1 mm. in length, *i. e.* long before the mouth is formed. The first food enters through this gill slit. The food current before the fish can swallow is kept up by a very highly ciliated gullet which extends from behind the gill region to near the hind gut.

34. The mouth does not appear till the larva has increased 3 mm., *i. e.* to a length of about 4 mm., and during all this time the hyobranchial gill slit functions as mouth. There is here found a condition similar to the one supposed by Dohrn to explain the replacement of the annelid mouth by a gill mouth.

35. Just in front of the notochord and near the region of the hyobranchial slit a strand of hypoblast cells extends up from the median portion of the alimentary tract to above the notochord. This strand of hypoblast cells lies in the region where Dohrn supposes the annelid œsophagus to have disappeared.

36. The hind gut soon becomes enormously enlarged and later a large number of long villi are developed.

37. The larvæ retain as an ancestral trait a large yolk sack, the yolk being quite minute. The sack is largely taken up by the large pericardium through which the long tubular heart extends from below and behind, upward and forward.

38. In conclusion: The fish in almost all its stages has become highly specialized. Many stages resemble very closely primitive conditions but the conditions can probably in but few cases be looked upon as a simple reversion. Its development has, on the other hand, become extremely ichthyized and its egg stands at the end of the chain of eggs in which the *Branchiostoma* egg, the *Elasmobranch* egg and the *normal fish* egg form links.

On birds in Western Texas and Southern New Mexico. By A. W. Butler.

Some remarks regarding the embryology of Amphiuma. By O. P. Hay.