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ference in the canned fish is, however, probably hardly appreciable. The canned salmon from the Columbia, however, bring a better price in the market than those from elsewhere. The canners there generally have had a high regard for the reputation of the river, and have avoided canning fall fish or species other than the quinnat. In the Frazer's river the blue-back is largely canned, and its flesh being a little more watery and perhaps paler, is graded below the quinnat. On Puget sound, various species are canned; in fact, everything with red flesh. The best canners on the Sacramento apparently take equal care with their product with those of the Columbia, but they depend largely on the somewhat inferior fall run. There are, however, sometimes salmon canned in San Francisco, which have been in the city markets, and for some reason remaining unsold, have been sent to the canners; such salmon are unfit for food, and canning them should be prohibited.

The fact that the hump-back salmon runs only on alternate years in Puget sound (1875, 1877, 1879, etc.) is well attested and at present unexplained. Stray individuals only are taken in other years. This species has a distinct "run," in the United States, only in Puget sound, although individuals (called "lost salmon") are occasionally taken in the Columbia and in the Sacramento.

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THE SIPHONOPHORES.

II.—THE ANATOMY AND DEVELOPMENT OF AGALMA (CONTINUED).

BY J. WALTER FEWKES.

THE key to the zoölogical affinities of *Agalma*, the adult structure of which has been given in a previous article,[1] is to be found in its embryology or the development from the egg. To that subject I propose to devote the present article, as it is impossible in the case of this jelly fish, to discuss its morphological relationship from the study of anatomy alone.

In this discussion I shall consider, in the first place, the development of the *Agalma* from the egg, and in the second, the growth of new buds along the axis to form those new parts, the adult forms of which have already been described in some detail. The former division includes the consideration of the changes in form which the colony as a whole passes through in the growth from an egg to an adult like Fig. 1; the latter, the development of each of the different members of the community, or their growth from buds formed on an axis already well developed.

[1] NATURALIST, 1880, p. 617.

I. DEVELOPMENT OF THE EGG.

The new *Agalma* always begins its growth from an egg. I know of no case where any other method of origin than from an egg takes place among Siphonophores. Alexander Agassiz describes in *Agalmopsis cara* a reproduction by a bud from the stem, and says that this bud has a well-developed float before it separates from the stem or axis. In *Agalmopsis picta*, a species closely allied to *Agalmopsis cara*, no such budding of a new colony takes place. In the excellent volume already quoted, entitled "Seaside Studies in Natural History," it is suggested[1] that those organs which I have called "tasters," drop off and develop into new colonies. I consider this supposition improbable as far as any known genus of tubular jelly fishes is concerned. In the genus *Agalma*, as before stated, reproduction is always from the egg.

I was fortunate enough to find in the glass vessel in which the first *Agalma* captured by me was confined, that the water was filled with minute transparent spheres, no larger than the head of a pin. They floated about in the liquid, and were not limited to any definite depth, but when the contents of the glass became quiet, all rose to the surface, and thickly crowded together, covered it like so many small oil-globules. When they had collected in this way, I was able by means of a watch crystal to skim them off, and transfer all into a more convenient receptacle for study.

These little oil-globule-like spheres were originally cast into the water from the female sexual bells, and are eggs, from each one of which grows a new *Agalma*. The female bells are found in grape-like cluster just below the feeding polyps, and appear to take the form of individuals, which have apportioned to themselves the single function of reproduction of new *Agalmata*. They have no stomach nor mouths, but draw their nourishment from the cavity of the axis into which it has been poured by those individuals of the colony, which do all the eating for the *Agalma*. Each bell contains a single egg, and after that egg has been cast, the bell withers up, or is absorbed into the stem, or sometimes before the egg escapes, breaks loose from its connection with the axis, and drops into the water with the contained egg. The last process takes place by a rupture of the pedicle by which the female bell is hung upon the axis of the *Agalma*.

[1] The authors state that they have never seen these "closed Hydræ" drop off, but they suggest that it "seems natural to suppose that they do separate from the parent stock" to found new communities.—*Sea-Side Studies, p. 80.*

The eggs cast into the water are then impregnated by sperm from the male bells. Previously to this event the egg is of course incapable of development, and it is an interesting fact that the male bells of one colony cannot fertilize the eggs from the same. I need not remind the reader how widespread this law is in the plant world. Two sexes are joined in the same *Agalma* colony, but self-fertilization is not possible. The egg cannot be impregnated by the male element from the same *Agalma* as that from which it arises, but is cast into the water, and there fertilized by the males from another *Agalma*. Artificial impregnation of the egg often fails because this principle has not been recognized and followed. Although there are very many known examples, where an animal has the power of casting eggs capable of development before the adult form is reached, nowhere do we find this principle in nature better illustrated than in *Agalma*. Even before the *Agalma* has doffed features called embryonic, from the fact that they are limited to the young, and are not present in the adult, the jelly fish lays eggs, which, strangely enough develop into other *Agalmata*, and eventually into the true adult form, which their parent had not attained to when they were cast. The egg floating in the water after the escape from the female bell is transparent, and has a cell contents, but with no differentiation in any part except the existence near one pole of a more transparent space containing a dot. These structures are called the germinative vesicle, and the germinative dot respectively.

The first changes which I have observed in the egg after impregnation, or contact with the male element, is the formation in the germinative vesicle of a number of radiating lines, which give to it an indistinct likeness to a wheel with radial spokes and a central hub, which is represented by the contained dot. At the same time there separates from this region of the egg two small spherical bodies similar to those cells which in the eggs of some other animals have been given the name of direction cells. The radiated appearance in the germinative vesicle, is what is known as segmentation, and is very peculiar in *Agalma*.[1]

The next important change in the development of the egg after the segmentation above described has taken place, is the disap-

[1] Of the obscure method of segmentation among Physophoridæ much remains yet unknown. The account which I have given of the peculiar radial structure in the germinative vesicle may be of something else than segmentation. See P. E. Muller, Naturhistorisk Tidsskrift, 3 R. 7 B, 1871.

pearance of the germinative vesicle altogether, leaving the egg perfectly homogeneous, and covered with short vibratile hairs or cilia, by the motion of which it is driven through the water. Intermediate changes, too technical to speak of in this account, occur, but I have omitted to mention them. Now opens a long chapter of the developmental history, which includes stage after stage, each different from its predecessor, following one another in rapid succession, all looking, although sometimes indistinctly, to the formation of a new *Agalma*. Of these stages in growth there are three which are characteristic and so distinct, that I have deemed them worthy of special names. They are of great importance in a study of the systematic position of *Agalma*, and are as follows:

1. Primitive larva or primitive medusa (Lizzia stage).
2. Athorybia stage.
3. Young resembling closely the adult, but still retaining embryonic structures, *i.e.*, embryonic tentacles, covering scales, &c.

Between the primitive larva, the Athorybia stage and the adult *Agalma*, there is very little likeness. The third stage, however, has in most particulars a very close resemblance to the adult as figured in my sketch, Fig. 1, and differs from it only in size and in certain minor details. It is indeed very difficult to decide when the adult form of *Agalma* is really reached, for it begins to lay eggs when in an immature condition, as far as adult characters are concerned.

The first change in the egg, after the peculiar process called segmentation which I have already described, is the formation of a stage in which the germinative dot and vesicle disappear. A knowledge of this fact may be of use to one studying the process of development, for unless these structures in the egg of *Agalma* do disappear, the egg will not pass into following stages. Haeckel erroneously states that the germinative dot and vesicle does not disappear in genera closely allied and perhaps identical with *Agalma*.

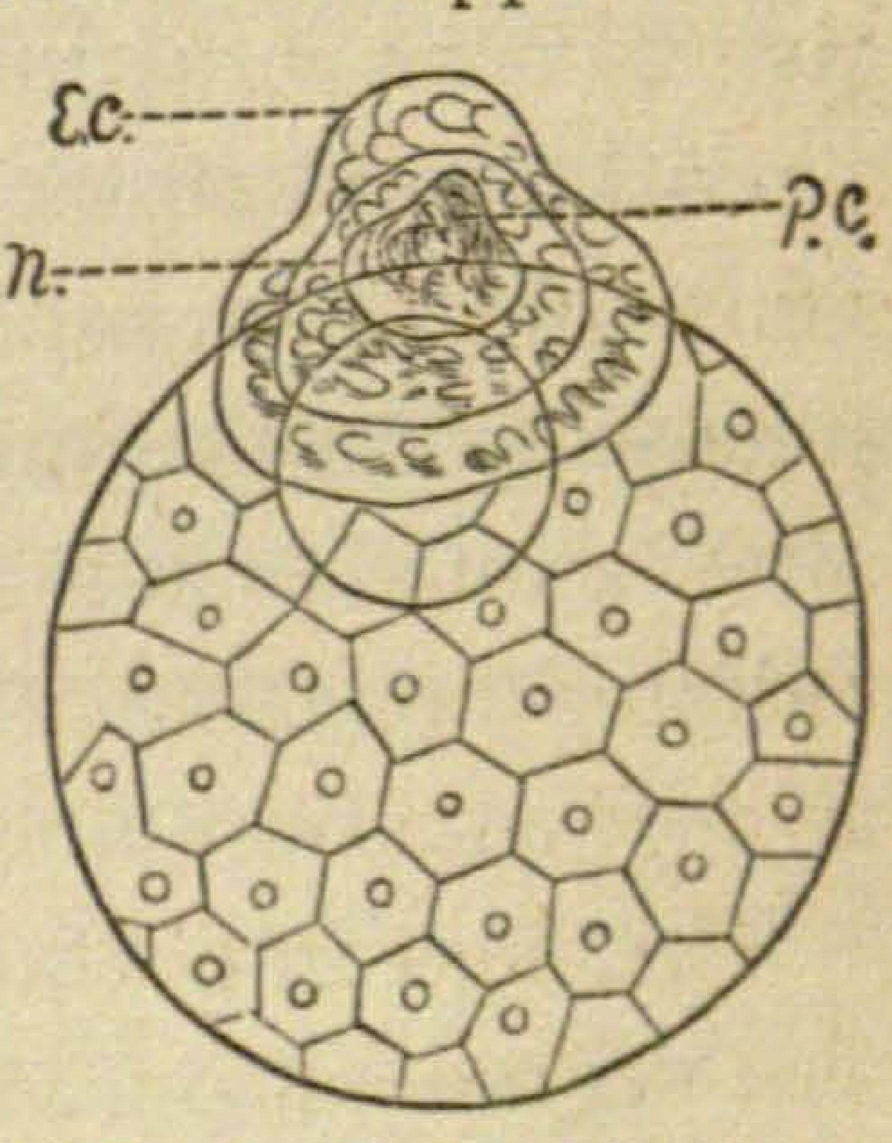

FIG. 7.—Egg of *Agalma* with apical elevation.

The next stage is the planula with the whole surface covered with cilia, which is followed by one in which is formed at one pole an elevation composed of two layers, which also becomes very thickly pigmented. The most superficial of these layers is formed before the more profound. The former is called ectoderm; the latter, endoderm, and between them is a third which eventually becomes very thick, forming the great mass of a helmet-like structure of gelatinous character, which gives the characteristic shape to the primitive larva. This enlarged layer corresponds with that which forms the mass of the bell of an ordinary free medusa.

All these layers are formed at one pole of the egg, and gradually, as their elevation above the surface of the ovum continues, their edges grow down towards the equator of the egg. The limit of this growth is the opposite pole at the other end of a diameter opposite that from which they originated. In subsequent growth the yolk sac itself, in the genus *Agalma*, is transformed into a feeding polyp of peculiar kind. According to Haeckel this transformation does not occur in genera closely allied to that which I have considered. The modified yolk-sac may be detected in later stages of the growth of an *Agalma* by a peculiar network of bright crimson pigment spots covering one side of the polypite into which it is changed.

A continued elevation of the layers, at the pole of the egg, has left below the deeper a small cavity. This cavity is bounded by endoderm on the upper side and by the undifferentiated contents of the egg-sac on the other. The middle layer, which I have said lies between ectoderm and endoderm, increases very rapidly, and the ectoderm keeps pace with this enlargement, yet in an inverse ratio becomes relatively thinner and thinner, until it is reduced to a simple epithelium layer, in which condition it is found in the adult of all the bells, and nectocalyces of the adult *Agalma*.

At the same time that the middle layer is thus enormously increasing in size, the endoderm, which lines the primitive cavity has pushed out into this growing layer and its cavity has elongated into a tube, which at one end opens into what remains of the primitive cavity, and at the other seems to end blindly in the gelatinous substance of the apical enlargement of the embryo. The gelatinous middle layer now thickens so much that it has formed a helmet-like body, the rim of which extends down along the sides of the larva in the form of a free ring separated on all sides except at the apex of the larva from the larva itself.

It may be well, before we go farther, to point out that in this larva, which is the so called primitive larva, we can recognize all the organs of the jelly fish, called Lizzia, one species of which, *L. octopunctata*, is found in the waters of our bays. The helmet-shaped organ of the larva of *Agalma* will be seen to represent the bell of the Lizzia, and the egg from which it has developed the proboscis. The central tube of the helmet of the young *Agalma* is the exact reproduction of the early condition of four tubes in the bell through which the nourishment of the Lizzia circulates, and which are called chymiferous vessels. Tentacles or structures corresponding with these thread-like organs, which arise from the margin of the bell of a Lizzia, do not in fact exist depending from the rim of the helmet-like cap of the primitive larva.

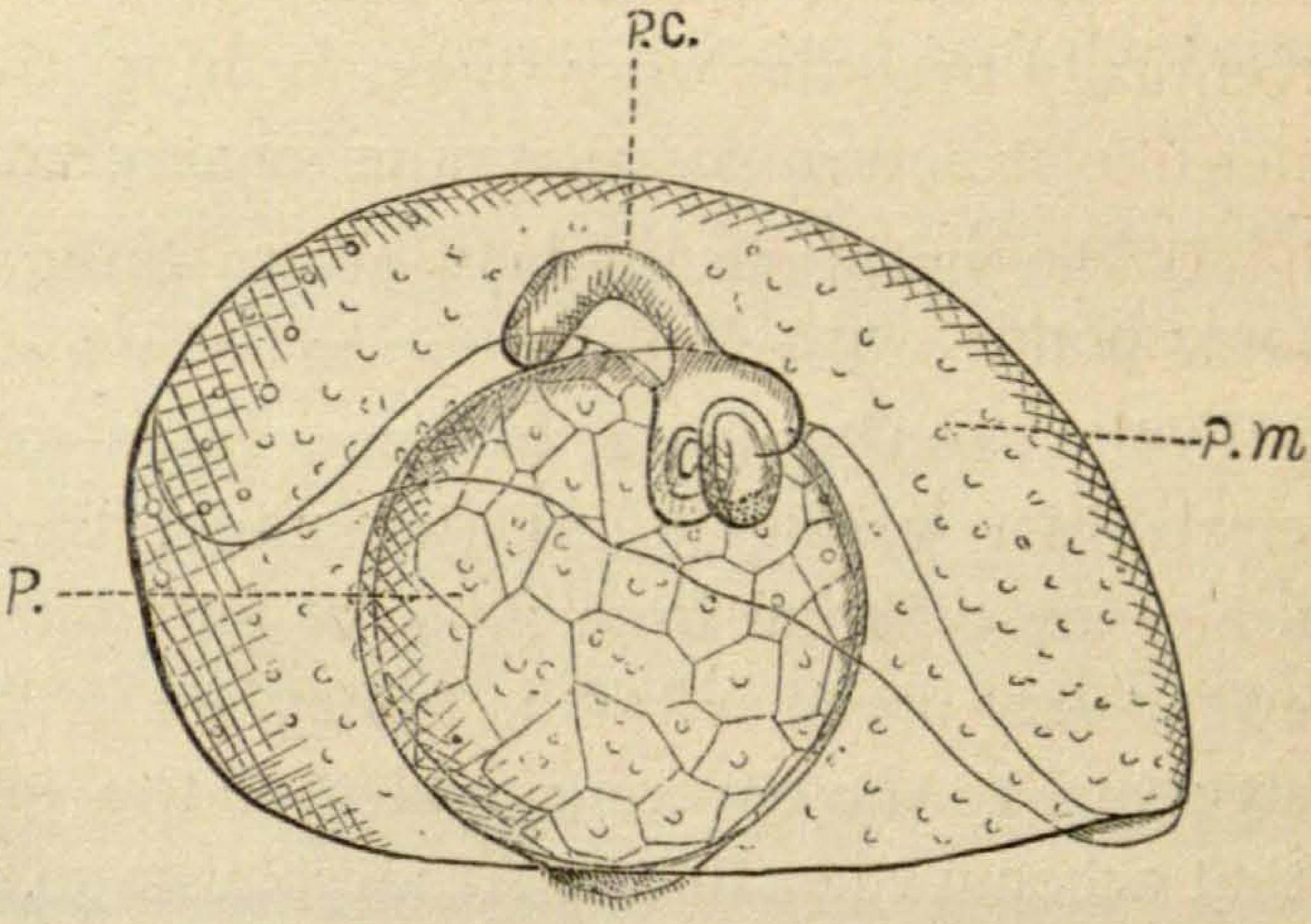

FIG. 8.—Primitive larva of *Agalma*.

The primitive larva or Lizzia stage of the young *Agalma* is well formed at the end of the fourth day after the eggs have left the female bells. Its change into the following or Athorybia stage is very rapid, and in outward appearance very radical. Before considering the details of these changes let me give names to the different parts of the primitive medusa, or Lizzia stage, in order to simplify references in the following pages.

The helmet-shaped bell, fitting over the egg from which it was formed, bears very many resemblances to a covering scale, and under that name it has generally been described. To avoid confusion, I suggest for it the name of primitive covering scale, the meaning of which designation is, I think, self-evident. The tube-like cavity in its center may be known as the primitive tube and the cavity in the eggs itself, from which this tube is differentiated, as the primitive cavity. That part of the larva which corresponds to the proboscis is designated the primitive proboscis.

The Lizzia stage of the young *Agalma* is followed by a second, which from its resemblance to a genus of Siphonophores, called Athorybia, I have called after Claus, the Athorybia larva, or Athorybia stage of *Agalma*. About the same time that the primitive medusa stage is reached, there appears as a bud from the primitive tube a small structure, which later develops into a float.

This body is not the end of the primitive tube enlarged, but is a true bud from it, and as such should be considered in all our studies of its homology.

2. ATHORYBIA STAGE OF THE YOUNG AGALMA.

As the primitive medusa grows older, the primitive covering scale is lost, either by absorption or by a rupture of the connection with the growing larva, and new buds take its place, forming a circlet of covering scales just under the float. These covering scales are different from those of an adult *Agalma*, and have their edges very finely serrated. They are in fact very similar in their structure to the covering scales of the genus Athorybia, and on that account the name of Athorybia stage, seems not inappropriate to apply to this condition of the growing *Agalma*.

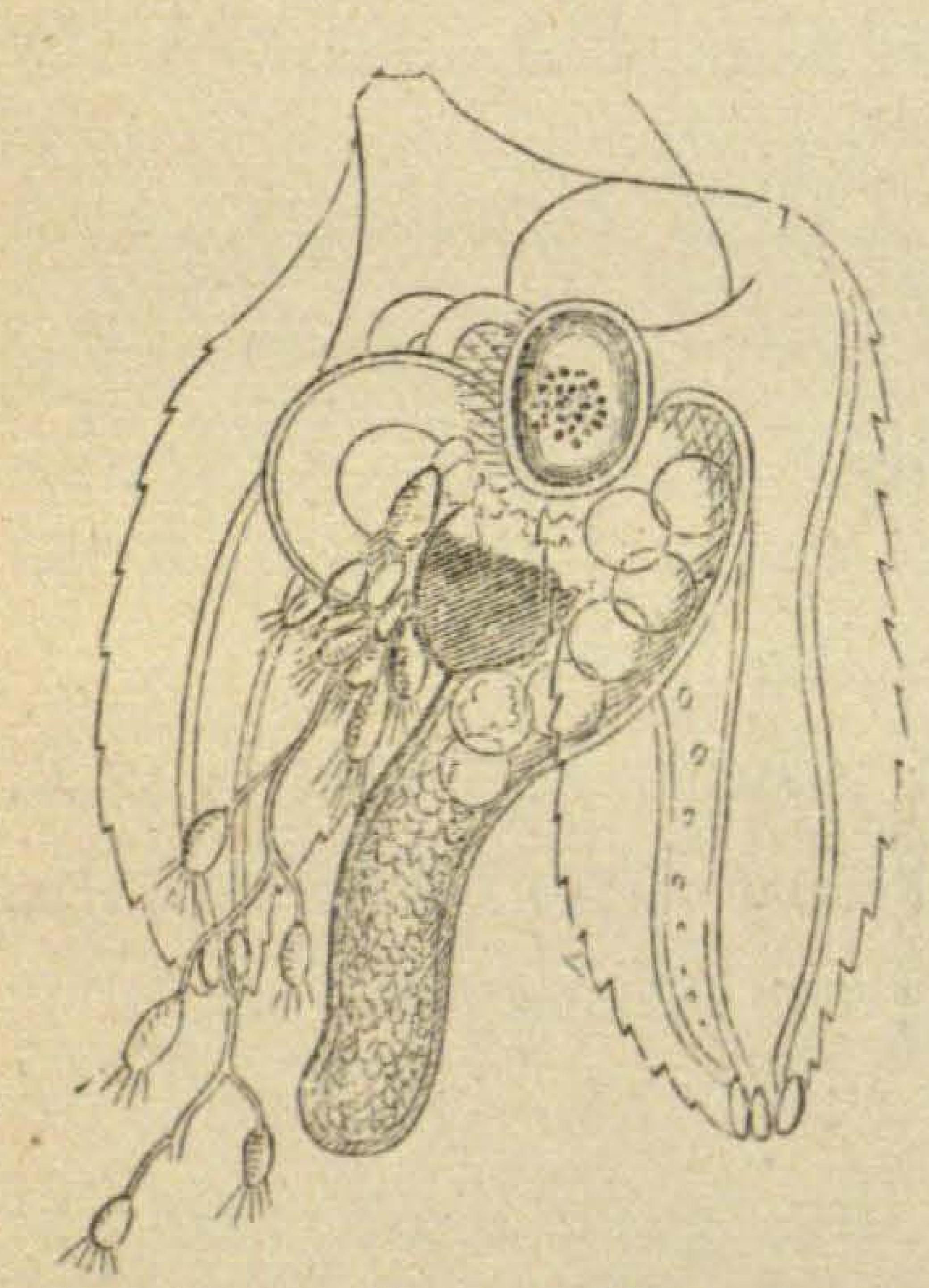

FIG. 9.—Athorybia larva of *Agalma*.

Another peculiarity of this stage is the character of the tentacles, and the knobs which hang as pendants from them. The tentacular knobs of the Athorybia stage never develop into an adult knob like Fig. 4. They are embryonic and are confined to the young larva, more especially to that stage known as the Athorybia larva. On account of their restriction to larval conditions it may be well to speak of them as the larval knobs. They are club-shaped, and from peculiar cells at the distal end there arise structures which resemble stiff hairs. (Fig. 9.)

3. LARVA WHICH RESEMBLES THE ADULT.

(PHYSOPHORA STAGE.)

The Athorybia larva has no swimming bells and no elongated axis or stem, but immediately after that stage is reached an axis begins to form at the same time that buds, producing swimming-bells, make an appearance. A circlet of covering scales of very different outline and destitute of serrated edges, replace those which characterize the Athorybia larva. A new tentacle, with tentacular pendants like the adult, also make an appearance, so that we have a stage in which both kind of pendants, embryonic and adult, are to be seen. I have called this stage of the young *Agalma* the Physophora stage, because at the very end of the stem its cavity is enlarged, and on that enlargement hangs a circle of covering scales not unlike what exist in the genus of Siphonophores, called Physophora. The larva is now in a condition structurally not very distant from the adult. In minor details there are, as has been already pointed out, certain differences, but from this stage on the growth into the adult is direct and without the formation of provisional organs of any kind.

A description of the development from the bud of each kind of characteristic structure found on the stem of the *Agalma*, would take me into details too special for this paper. It is sufficient for our argument as to the nature of the *Agalma*, to state that each and every structure along the stem originates as a simple bud, which can at first hardly be distinguished one from the other,

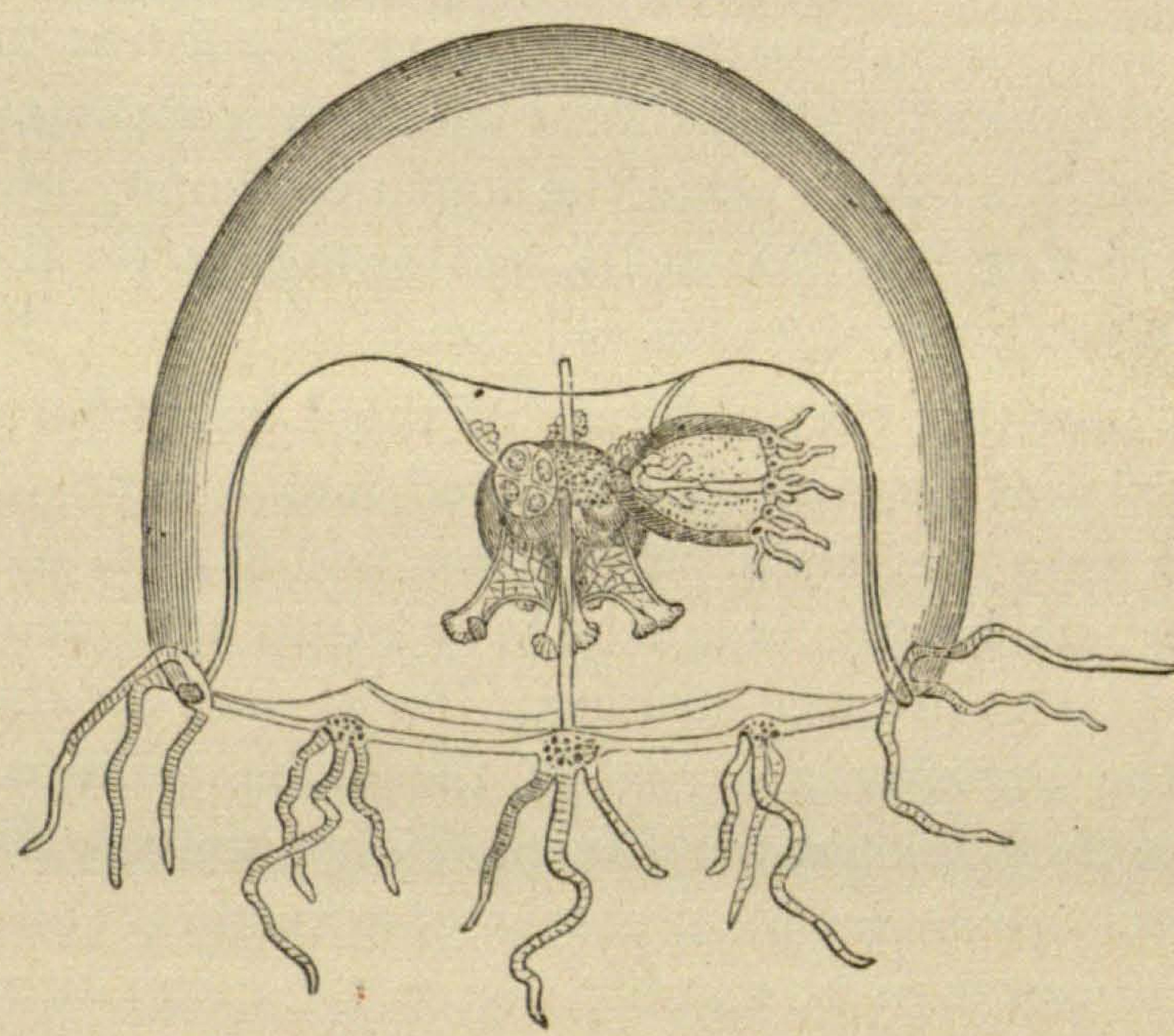

FIG. 10.—*Lizzia octopunctata* (young).

whether they form float, swimming-bell, feeding polyp or covering scale. In their earlier stages they are all alike. The details of the changes by which now a swimming-bell and now a float is formed are not necessary for my argument, and I will not consider them in this place.

I have already, in my former sketch of the anatomy of *Agalma*, made the comparison of the Siphonophore to a little medusa, called Lizzia, found in our waters. That comparison at which McCrady hinted long ago is supported by the embryology which I have just given.

In the primitive medusa, as has been shown, we find a jellyfish with parts identical with those of a Lizzia. All the organs are duplicated in one and the other. What are the changes of form which in subsequent growth so alter the external form as to produce in the one case a Lizzia, such as I figure (Fig. 10), and in the other an *Agalma?*

In the figure of *Lizzia octopunctata* Forbes (*grata* Alex. Agassiz), a species common in Massachusetts bay, several buds can be seen through the bell, forming on what is known as the proboscis. If these buds are closely examined, it will be found that they are young Lizziæ in different stages of growth, and if the proboscis of the largest of these buds be minutely studied, on it will be found buds of still a third generation, grandchildren of the original jelly fish. All these buds whether products of the first or second budding process, eventually break away from the place from which they first formed as buds, and swim away as jelly fishes, the form of which is not unlike the parent from which they sprung. Even before that separation takes place, the impatient young may be seen opening and shutting their bells, and swinging on their fragile stems trying to break themselves loose.

Suppose now that the proboscis of the Lizzia from which the buds formed was very much elongated into a tube. This tube then we liken to the axis of an *Agalma*, and if buds were formed along its whole length, as can be very easily imagined, the likeness would be even more striking. To be sure all the different buds in the *Agalma* are not of the same form or outline. Neither are they alike in the Lizzia. Some are very fully grown while others are in incipient stages of growth. This variety in shape could not then be an objection to the comparison which I have urged.

Each bud which forms along the stem of an *Agalma* is called by some naturalists an individual, from the fact that in early stages they resemble each other so closely, and when fully grown oftentimes certain of them bear such a close likeness to forms of Medusæ, which lead an independent life. I do not consider every bud an individual, but think that in some cases the position on the stem or other causes has so modified them that two or even more buds, as in the case of polypite, and covering scale together make one true individual. A zoöid, as defined by zoölogists, does not seem to be a fitting term to apply to these structures found along the axis of an *Agalma*, unless the term be given the broadest extension. In such a case the distinction between a zoöid and an individual does not seem very great. Through those jelly fishes called the Trachynemidæ, as Circe, there seems to be a close relationship between the hydroid Medusa, Lizzia, and the common Aurelia, Cyanea and other Discophoræ. As therefore I cannot but designate a Pelagia, also a Discophore, as an individual, I must look upon a Circe as the same, and since Lizzia and Circe are closely related, their free Medusæ are likewise morphological individuals. If this is true, and our theory of the likeness between *Agalma* and Lizzia not fanciful, is it proper to call the members of the former colony zoöids, or shall we regard them true individuals?

The solution of this problem as to the exact nature of the members of an *Agalma* colony is most difficult, and, as so many before me, I must leave this speculative part of my subject with the trite remark, that in this animal we have a condition of life where the difference between organ and individual is reduced to a minimum. It is without doubt true that much of the controversy which has been indulged in, as to the exact nature of the different components of the *Agalma*, may reduce itself to a quarrel about terms.

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THE RELATION OF APICULTURE TO SCIENCE.[1]

BY A. J. COOK.

I ONCE heard a well known professor and scientist, than whom there is no better student of American agriculture, remark, that the art of agriculture was founded almost wholly upon empiricism; and that all it had to thank science for, was that the latter explained what had already been determined by the empiric method. Whether this be true or not, the reverse is most certainly true of practical entomology. Economic entomology rests almost wholly upon science. So, too, apiculture, as practiced to-day, owes its very existence to science. Fear deters most people from bee-keeping, unless a desire to study bees, and to know more of the nature and habits of these marvels of nature, impels to that close association with bees, which practical apiculture demands.

For this reason, there is no class of men engaged in manual labor pursuits which possesses the intelligence and enthusiasm which characterize apiarists, or which practices so much that is really sci-

[1] Read before the Entomological Section of the A. A. A. of S.