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XIX.

On Certain Medusæ from New England. By J. WALTER FEWKES.

THE following paper is intended as a contribution to our knowledge of New England jelly-fishes. It deals for the most part with animals of this group from the northern waters of the coast of Maine, and from Grand Manan.* During a vacation visit of a month's time at the latter locality, in the summer of 1886, the author collected several new and highly interesting medusæ.† Incidentally, in studies of animals of other groups in the summer of 1885, some observations were made on Eastport medusæ.

* While the waters of the Gulf Stream justly attract the attention of naturalists interested in the study of our pelagic fauna, there is much yet to be done with the dip-net in the cold waters of the Bay of Fundy and the coasts of Nova Scotia and New Brunswick.

† Mention is made in these pages of those medusæ only which were collected by the author, and no attempt is made to include all those mentioned by others.

It is next to impossible to make out a complete faunal list of the medusæ of any locality, except after years of study. From the nature of their life, stragglers and sporadic swarms of rare medusæ appear in localities where the medusan fauna has been well studied. For ten years I have kept watch of the medusæ which appear in Narragansett Bay in summer months, and a season rarely passes in which some jelly-fish new to the known fauna is not observed. Sometimes specimens of some new genus will appear in such abundance that it seems impossible that we could have missed seeing them if they had appeared in other summers. In some years the water near the Newport Laboratory is filled with Pleurobrachiæ, while in others stragglers only appear. In the past summer the most common acaleph in Narragansett Bay was Dactylometra, hundreds of specimens of which were seen, and yet in former summers we rarely have observed more than a half-dozen in the course of a summer.

In the light of these facts it seems preposterous to attempt a monograph of the medusæ of the Bay of Fundy with the limited material collected on the short visits which I have been able to make to these waters.

I have had in mind since that time a new visit to these localities to gather materials for the publication of a monographic paper on the medusæ of the Bay of Fundy, but have been unable to make the necessary collecting trips for its completion. It is now thought best to publish some of the more interesting observations which have already been made, as aids to those who may make a more exhaustive local study of these animals, or as a preliminary to a more extensive examination of animals of this group from these localities.

While the majority of the medusæ here mentioned are from Eastport, Maine, and Grand Manan, New Brunswick, a description of a new genus, Hydrichthys, from Newport, R. I., is added.* This strange genus is parasitic in its hydroid stage on the sides of an osseous fish, and besides the unique parasitism presents us the anomalous condition of an attached hydroid closely related to the well-known Velella and Porpita. The form of Nanomia, the anatomy of Callinema, and the peculiarities of the various other medusæ here mentioned from the vicinity of Grand Manan, show how characteristically boreal this medusan fauna is, and how much it differs from that of Narragansett Bay. They show how rich the field is for an extended research in this region in this kind of marine study.†

The short visit which was made to Grand Manan, and the collecting trips to Eastport in 1885 and 1886, have shown me that the medusan fauna of the Bay of Fundy and Passamaquoddy Bay, near these places, is very characteristic. It differs markedly from that of Newport, and is distinctly boreal in its affinities. While this paper was in preparation the author has had occasion to study the medusan fauna of the Arctic Ocean, and to publish notices of jelly-fishes collected by Lieutenant Ray and General Greely in high latitudes. It has been noticed in carrying on this work simultaneously that there is a marked similarity in the fauna of the Arctic and that of the Bay of Fundy, and it may be said that the

* This curiously modified hydroid was captured during the summer session (1887) of the Newport Marine Laboratory.

† The author would here add a notice of his own experience to that of others as to the advantages of Grand Manan for marine zoölogical work. While many, perhaps a majority, of those who have studied zoölogy in this place, have spoken of its many advantages for dredging and shore collecting, few have tried surface fishing in these waters. I had been led to suppose from certain sources, that revelations with the Müller net would be small in these localities, but I find Grand Manan and Eastport among the best localities which I have visited on the New England coast for the collection of pelagic and "surface animals" with the dip-net.

relationship is closer between the jelly-fishes of these distant localities than between those of Narragansett Bay and the Bay of Fundy. The cause of this similarity may readily suggest itself to one who examines the direction of the currents of water which bathe the New England coast. The cold currents setting down from the Arctic have brought with them an assemblage of medusan genera of a facies in marked contrast with that of those brought into Narragansett Bay by warmer waters. This assemblage partakes of the characters of the Arctic, where the current has its birth. While it is true that some of the northern and boreal genera of medusæ occasionally round Cape Cod and appear even in numbers in the bays to the south of this headland, they show by their rarity, and their dependence upon the prevailing winds at the time, that their home is to the north.*

Among familiar examples we might mention the well-known *Cyanea arctica* and *Aurelia flavidula*. Hardly a summer passes in which both of these genera are not found in Narragansett Bay near the Newport Laboratory, and sometimes the former are in great numbers. I have, however, never seen them at Newport so large or so numerous as those which were taken almost every day at Eastport. Sporadic examples of Turris, Melicertum, and Staurophora are constantly taken in our surface fishing at Newport, but a few days at Eastport showed me a wealth of individuals of these genera which was unknown to me before. This difference in fauna exists also in the Physophores. Nanomia never ventures into Newport waters, and the magnificent Agalma seems to have its habitat on our coast limited to the southward of Cape Cod.

If it were the purpose of this paper to contrast the pelagic medusan faunæ of the Bay of Fundy and Narragansett Bay, many other instances might be mentioned to show how different the jelly-fishes of the two

* While there are many boreal medusæ which straggle into Narragansett Bay, a still larger number of those whose home is in the tropics make their way into our Southern New England waters through the agency of the Gulf Stream. The surface waters of the Gulf Stream are often blown nearer shore than is commonly supposed. I have noticed in the water near the Laboratory a rise in temperature of over ten degrees in a single flood of the tide. The higher temperature of the water is a good sign that we are to expect oceanic animals in our dip-nets, and we are seldom disappointed. The cause of the elevation in temperature is thought to be directly connected with the prevailing wind from the southeast, where the Gulf Stream lies

It is believed that the fact that the differences in the temperature of the water — now warmed by the Gulf Stream, now cooled by other currents — is what gives such a great variety to the marine fauna from Cape Cod southward.

regions really are.* It can hardly be supposed that different physical conditions and environment, as far as the coast line itself is concerned, could have brought about such a great difference and such a restriction in these floating pelagic animals. The great influence in their limitation must be the temperature of the water, and its difference in the two localities.

As strictly related to this line of inquiry is a suggestion in regard to the possible medusan fauna of a region contiguous to the Bay of Fundy. It is a well-known fact that the southern part of the Gulf of St. Lawrence, near Prince Edward's Island, presents us an assemblage of southern genera of Mollusca, surrounded by strictly boreal forms. It would be very interesting to discover what the character of the hydroid and medusan life of this warm area is, and to see if we have, as in the case of the Mollusca, a colony of southern genera protected in their northern home by the higher temperature of the water. I have been unable to visit this locality for study, but I commend the problem to those who engage in marine work on this coast. Unfortunately we know next to nothing of the acalephian fauna of this region of the Gulf of St. Lawrence.

CTENOPHORA.

Mertensia ovum, Mörch.

The common tentaculated Ctenophore at Grand Manan resembles *M. ovum.* It is not rare near Eastport, where I found it in the summer of 1885 in considerable numbers. It was taken in some abundance at Grand Menan in 1886.†

* Tabular lists of medusæ from the Bay of Fundy region and from that of Narragansett Bay are given by A. Agassiz in the "North American Acalephæ." The well-marked contrast which one can easily see in these lists appears even more striking when we add to those of the Bay of Fundy some of the characteristic boreal genera here mentioned.

† Ova of a Ctenophore were found in great abundanee at Grand Manan in July and August, 1886. These were traced into young Mertensiæ, and are possibly of this species. They look unlike the eggs of Pleurobrachia found at Newport. The fact that *Pleurobrachia rhododactyla*, recorded by other observers from Eastport, was not seen by me does not mean that it is not thought to exist there. I have only spoken of jelly-fishes observed, and do not wish this paper to be regarded as a list of medusæ which live in the Bay of Fundy.

Bolina alata, Ag.

This beautiful specimen of Ctenophores was found once, but there is reason to believe that it is common in the Bay of Fundy.

In the few specimens which were seen there were no parasitic Actinians in the body, as is found in the related Mnemiopsis from Newport. Of course, negative evidence of this kind may not mean much, for early in the season at Newport none of the specimens of Mnemiopsis have specimens of Actinians * in their chymiferous tubes or stomachs.

Beroë roseola (Ag.).

Several specimens were found at Grand Manan.

SIPHONOPHORA.

Nanomia cara, A. Ag.

Plates I., II., III.

The only Physophore which was captured at Grand Manan is the interesting medusa called by A. Agassiz † *Nanomia cara*. This jelly-fish, described many years ago, has been repeatedly mentioned in text-books and general works on zoölogy, but since its discovery nothing has been added from direct observation to our knowledge of its anatomy and somewhat exceptional embryology ‡ as made known by A. Agassiz. It was therefore with much enthusiasm that I first saw from the wharf back of the Dominion House at North Head, Grand Manan, many specimens of this beautiful animal swimming in the water. As is well known, many interesting and doubtful details of anatomy remain yet to be made out in regard to this animal, and it was with keen pleasure that the medusa was captured in abundance and placed in aquaria for study.

* It is, however, an interesting fact that I went directly from Eastport and Grand Manan to Newport, and on my arrival there, not more than five days after leaving the northern localities, plenty of Actinians in Mnemiopsis were found. The yearly record of the time of the appearance of this parasite at Newport shows it much earlier in other years than at the time I was at Eastport.

† Proc. Bost. Soc. Nat. Hist., IX. 181; North American Acalephæ, Illust. Cat. Mus. Comp. Zoöl., II. 200–213; Seaside Studies in Natural History, pp. 76–83.

‡ Although nothing has been added to a knowledge of its anatomy and development, the possibility that a closely allied Physophore occurs in the Arctic is commented upon by Moss and by the author. So little is known of the generic characters of the Physophore supposed to be Nanomia from Robeson's Channel and Lady Franklin Bay, that we cannot definitely say they are the same. There seems no good reason to doubt their identity.

As the only figures which we have of Nanomia are of the young, my first care was to obtain a figure (Plate I.) of the adult animal.

The method by which a drawing of the outline of this large Nanomia was made may have an interest to those engaged in the study of the Siphonophores. The outlines of Plate I. were drawn in the following way.

The animal was placed in an upright glass jar, with flat sides, similar to those of glass vessels used for the bath in photography. This glass receptacle was placed in the bright sunlight, on a table between the observer and the window, or some source of light. It was so placed that a well-defined shadow of it was projected on the paper held a few inches back of the animal, on the side of the glass opposite the window. The paper was tacked to a board held upright and firm by simple means, which any one can devise. The shadow of the Nanomia was so clearly defined that even the faintest lines of outline were seen projected on the paper. There are times when a Siphonophore floating in the water keeps almost perfectly quiet for some minutes. This is a good opportunity to trace on the paper the lines of the shadow with a pencil. Although I could not make the whole contour before a new movement of the medusa, it was easy to draw the nectocalyces and sections of the polyp-stem before the animal changed its attitude.

The only trustworthy account which we have of Nanomia is the original description by A. Agassiz.* This observer not only described the first long-stemmed Physophore from American waters, but he also gave the first series of recorded observations on the development of the young of any genus of Siphonophores.

From my own studies of Nanomia I am convinced that the adult of Nanomia has never been figured or described. The reasons for this belief will, I hope, appear as I go on in my account. The description by A. Agassiz was pioneer work in a field where later observations have been extensively made; yet for over fifteen years Nanomia was the only long-stemmed Physophore known from the waters of the United States. His description has been repeatedly copied, and his figure is widely used in general accounts of these animals. It is found necessary to differ from one or two statements made in the original description in regard to Nanomia. These differences are specially noted, and a redescription is not made of those points of anatomy where in the main my account agrees with that already published. The fact that Nanomia more than any other Siphonophore is used in text-books and general descriptions of marine animals published in America to illustrate the general character of the group, would seem an inducement to publish any contributions which might be made in regard to its embryology and anatomy.

It may be well, at the very threshold of my description, to mention the

* The best account of the anatomy and embryology of Nanomia is in "North American Acalephæ." There are other notices of the same animal by the same author, one of the best known of which is in "Seaside Studies," by Mrs. E. C. and A. Agassiz.

reasons which led me to regard the published figures of the adult as the young, and not the adult Nanomia.* One of the most important reasons which have influenced me is the small size and the small number of nectocalyces. While the specimen figured is barely six inches long, specimens of Nanomia were often found at Grand Manan four and five feet in length. While A. Agassiz never found more than four pairs of fully developed nectocalyces, many of the adults had fifteen pairs of these structures.

A more important fact, however, which would seem to indicate that the figure is that of a young animal, is the following. The great number of embryonic tentacular knobs,† or those described on the "first set of polyps," show immaturity; for these knobs are always confined to young or larval forms in related genera, like Agalma, Halistemma, and Stephanomia. The adult permanent knobs, or "corkscrew-shaped tentacles," are all immature. The adult form of these knobs is not attained in any of those of Nanomia yet figured.

In order to facilitate the reader in a comparison of my description with that in the "North American Acalephæ," the following table is introduced. The terms in the first column are from the published account, those in the second are made use of in the present description :

First set of polyps	Embryonic polypite with embryonic tentacular knobs.
Second kind of polyps	Undeveloped permanent polypites with undeveloped permanent knobs.
Third kind of polyps	Hydrocyst, taster.
Fourth kind of appendage (p. 206)	Undeveloped hydrocyst, taster.

The largest specimen captured measured, when extended, over four feet; when retracted, its length was three feet. The specimen which is figured, of life size (Plate I.), was one of the most convenient for study, but not one of the largest. It may safely be said that hundreds of specimens of the size represented were taken just off the wharf near the Dominion House at North Head, Grand Manan.

The adult animals, as they float extended in the water, can readily be distinguished by a practised eye from the southern Physophore, *Agalma elegans*. The whole external appearance of the two genera is different. The tentacles of Nanomia are carried in a different way from those of Agalma, and are not drawn to the polypites in the same clumps, while the tentacle itself is more often thrown into festoon-like folds, as shown in the figure. It is needless

* North American Acalephæ, Illust. Cat. Mus. Comp. Zoöl., No. 2, p. 201, Fig. 332.

† On many of the small specimens of Nanomia from Grand Manan, embryonic knobs (Plate II. Fig. 8) were found. These closely resemble the knobs figured by A. Agassiz. They were not found in adults as far as observed.

to say that Nanomia is no less graceful than the beautiful "sea necklace," Agalma, in all the motions of tentacles and tentacular knobs.

Axis. — The axis of Nanomia is long, highly flexible, muscular, dotted with reddish pigment spots. It is divided into two regions, which may be known as the nectostem (*ns*) and the polyp-stem (*ps*). The length of the latter is several times that of the former. The polyp-stem appears to be more easily bent than the nectostem, but this appearance is brought about by the rigidity imparted to the latter by the close approximation and form of the nectocalyces. It is needless to say that the axis, as in all Physophores, is hollow throughout, and that from it most of the appendages of the colony have arisen.

Float. — The float (*f*) resembles that of other Physophores. It is a small sac enclosed in an enlargement of the axis, and has reddish pigment in its outer walls. The contents seem to be a bubble of air or gas, as in other Siphonophores. The longer axis of the float does not coincide with that of the axis of the Nanomia, but is bent at a small angle.

Nectocalyces. — The nectocalyces (*nc*) are biserial in their arrangement, with bell openings pointing in opposite directions. Their close approximation imparts to the stem (nectostem) a rigid character, which however disappears when their connection with it is once broken. The rows of nectocalyces are transparent, gelatinous, almost invisible as the animal swims in the water. Near the float there is a small cluster of undeveloped bells, the full grown being more distant from the float than the less developed. The specimen figured has thirteen pairs of well developed nectocalyces. Each nectocalyx is bell-shaped, fastened to the axis at the apex, and has two lateral horns or spurs, shown in the figure in profile, which interlock with corresponding spurs from the opposite side of the axis.

The structure of the bell and its tubes is well described by A. Agassiz. The bell is rounded, with small circular orifice, slightly closed by a thin velum. The bell cavity is spacious. The chymiferous tubes are four in number, in addition to a marginal vessel and a single tube communicating, through the point of union of the bell and stem, with the cavity of the axis of the animal.

The fact that the nectocalyx is slightly flattened on the upper and lower sides, and the existence of a corresponding bulge on the remaining sides has brought it about that, while the radial tubes of the nectocalyx of the former spheromeres is regular and straight, passing from common junction directly to bell rim, those of the two lateral spheromeres are tortuous, forming a single loop, as shown in the figure (Plate III. Fig. 2). This character is by no means peculiar to Nanomia, but is an interesting fact in the asymmetrical development of the bell.

Hydrophyllia. — The bracts, covering scales, or hydrophyllia (*hph*) are colorless, transparent bodies, covering the bases of the appendages to the polyp-stem. Each hydrophyllium is irregularly rectangular to triangular in shape. Two adjacent sides of the rectangle are so elongated that a triangular shape is given to these bodies. The free and distal angle diagonally opposite the angle of attachment is rounded and very obtuse ; the angle of attachment is more acute.

A tube extends from the point of attachment diagonally to the opposite angle of the covering scale, where it ends blindly. This tube is undivided, unbranched, with entire edges.

Polypites. — The polypites (*p*) are flask-shaped bodies, attached by a short peduncle to the polyp-stem. Their free end is open, forming a mouth. The rim of this orifice, or the lips, are without appendages. The basal peduncle is short, and of somewhat smaller diameter than the polypite itself. Near the base the polypite bears a "Wimperwülst," or ferule-like thickening of the walls.* At that point reddish pigment is found, and buds which are immature tentacular knobs arise. The tentacles also originate at that point. The polypites are regularly distributed along the polyp-stem, dividing the stem into sections or regions, which may be known as inter-polyp regions. The oral extremity of the polypite, except when it is retracted, extends beyond the hydrophyllia. The opening of the mouth sometimes expands, by which the lips become trumpet-shaped. The rim of the mouth is entire. Fragments of food were seen inside the polypite. Rows of large cellular bodies, in parallel lines, extend along the inner wall of the polypite. These are possibly hepatic in function.

Tentacles. — The tentacles (*ta*) are long, filamentous bodies, arising from the base of the polypite. They are highly contractile, and generally, when the animal is at rest, extended. Each polypite has a single tentacle. There are two kinds of tentacles, one of which bears tentacular knobs, the other being destitute of the same.† The former, which are the tentacles proper, are those which arise from the polypites ; the latter, the filaments of the hydrocyst, which have no tentacular appendages.

The peculiar festoon-like way in which the tentacles are often carried, is noticed by A. Agassiz. This habit is marked in the genus, and is more common in Nanomia than in the southern genus Agalma. Although I have studied all the Mediterranean species of Physophores alive, I recall none where this habit is so well marked as in Nanomia.

Tentacular Knobs. — The adult tentacular knobs (Plate II. Fig. 9) of Nanomia resemble those of Agalmopsis, Fewkes.‡ The various parts which enter

* This increase in size of the polypite at the "Wimperwülst" is largely owing to the increased development of the middle layer of the body.

† The tentacles which are destitute of tentacular knobs do not arise from polypites, but from the hydrocysts.

In the growth of the tentacles the tentacles do not first form, and then the tentacular knobs bud from it, but the knobs first form on the "Wimperwülst," and then the tentacle is pushed out, bearing these bodies, already imperfectly formed.

‡ One form of Agalmopsis, Sars, *Stephanomia pictum*, Metsch., *Halistemma tergestinum*, Claus, *Agalmopsis fragile*, Fewkes. These various aliases of Agalmopsis are mentioned, lest confusion be introduced by the above statement.

into the formation of the tentacular knob are the peduncle, the involucrum, the sacculus, and the terminal filament.

The terminal filament (*ft*) is long, thread-like, single, arising from the distal end of the sacculus. In its walls are imbedded many lasso-cells, or nematocysts. The sacculus is closely coiled in several turns. It is a large reddish body, armed with batteries of lasso-cells, and crossed by prominent lines.

The involucrum (*inv*) forms a cap over the sacculus.* It is bell-shaped, with entire edges, the sacculus (*sac*) arising from the inner central point. The whole tentacular knot hangs from the tentacle by the peduncle.

Tasters.† — Among the most interesting and it would seem exceptional structures in the genus Nanomia are those organs which are known as tasters (*ht*). The most marked peculiarity in their anatomy is the existence of an "oil globule" (*og*) near their base.

The tasters hang from the polyp-stem midway between the polypites. A single adult and many half-developed tasters occur between each pair of polypites. Individual tasters are small, slender, flask-shaped bodies, resembling immature polypites. They arise directly from the stem and are destitute of a basal peduncle. The distal extremity is closed.

Each taster bears near its attachment a prominent red body of spherical shape, known as the "oil globule." The taster has a single long tentacle (*h ta*), destitute of lateral appendages. In the water in which Nanomia was kept alive, several tasters which had separated from the main stem were found floating about near the surface. These were not seen to grow into colonies of Nanomiæ, but gradually became opaque and decayed, never in those studied growing into new colonies.

Gonophores. — A. Agassiz supposed that separate male or female colonies of Nanomia were found. He considered that some colonies of this genus are all males, while others are all females. My observations differ in this respect from his. The adult Nanomia, like the genus Agalma, has male and female bells on one and the same colony.

The sexual bells (*g*) of Nanomia are found near the base of the tasters, where they form botryoidal clusters. These clusters occur on all parts of the polyp-stem wherever hydrocysts are found. The interior of the male bells in many cases has a milk-white color, while the female bells are always transparent. Each male gonophore is bell-shaped and fastened to the base of the cluster by a short flexible peduncle. The walls of the bell are thin, with four-radial tubes joined to a marginal canal. The peduncle is penetrated by a

* The name sacculus has been given to the coiled red structure which forms the larger part of the knob by others. It seems more natural simply to interchange the terms, so that what is now called the involucum may be known as the sacculus, and *vice versa*.

† The term "taster," used to designate these structures, is open to some objections, but is regarded as one of the best which has been suggested to apply to these peculiar organs in the Physophores.

vessel which connects this radial system of tubes with the cavity of the axis of the colony. The bell margin has a marked velum and is destitute of tentacles. The sperm is found in the inflated proboscis, which fills almost the whole bell-cavity. This receptacle is in older male bells, and in those especially which are found near the extremity of the polyp-stem, of a milk-white color. The spermatozoa have a rounded head and small vibratile tail. The clusters of female bells which occur with the male have a similar attachment, and are also campanulate, resembling those of Agalma. Each bell carries a single ovum. Individual eggs and bells voluntarily separate from the attachment to the colony, and the latter live for some time free in the water. The ova of Nanomia can easily be seen by the unaided eye, as they float about in the water in which a parent Nanomia is captive.

A method of collecting the ova is to allow the Nanomia to remain quiet for some time in a glass jar. This jar contained about three gallons of water, and was so placed on a table that one could see through its sides, the window or source of light being on the opposite side of the jar. In this way the ova could readily be distinguished in the water, and after a few hours they rise to the surface. When they are seen floating at different depths in the water, it is possible to pick them out one by one with a pipette. When the ova rise to the surface it is more convenient to skim them off by means of a watch-crystal, or some similar shallow receptacle.

Development. — The development of the older larvæ of Nanomia, after the formation of the float, has been well described by A. Agassiz in his account of the animal, to which reference has already been made. He considers that there are two methods of development, one from the egg, and the other by budding from the parent colony. His figures are mostly from stages which he regards as formed by the latter method, and are of larvæ after the float has already formed.

It is certainly an exceptional method of growth of new colonies of Siphonophores to find the young budding from the parent, and new observations are desirable to determine the details of such growth. There is no known genus which resembles Nanomia in this respect, and all other genera, whose embryology is at present known, reproduce new colonies by ovulation alone. The following observations have a bearing on the origin of the larva of Nanomia, although they leave the important question in doubt.

A minute comparison of the float of the parent colony with the "oil globule" of one of the tasters was made, in order to detect differences and resemblances, if any, between them. While it was found that there are marked differences in these two structures, I could not say that the differences would prevent the one being a development of the other. Still, I have not been able to persuade myself that such is the case. I have repeatedly found the tasters with their oil globules detached from the parent axis, but all attempts to raise these into older stages similar to those figured by A. Agassiz have failed. There is one point in which there is a great difference in the tasters which I have studied and the youngest larva he figures. They differ from the stages which he figures in the presence of the tentacle which always characterizes the taster. A failure to raise one of these tasters separated from the colony into a new colony, it might be said, does not prove that under other conditions better results may have been reached. As a question of opinion, it is regarded as highly doubtful that the colony of Nanomia reproduces by budding, and that the new colony is ever formed from a taster. Nanomia, however, as shown by Agassiz, has an egg development, and passes directly from a planula-like young into stages similar to the youngest which he figures. It is therefore thought that the embryo, without exception, is derived from an egg. The segmentation of the egg was observed, and, as nothing has ever been published on the egg of Nanomia, a few stages in the segmentation are here represented.

The egg of Nanomia, like that of Agalma and other genera, is transparent, colorless, almost invisible in the water. The interior is penetrated by and almost wholly made up of a spongy mass of protoplasm, forming a network filling the contents of the egg. A thin covering of protoplasm surrounds the egg. Metschnikoff * describes in the egg of Epibulia a similar network, and the author † has devoted some space to a consideration of the same in Agalma.

The first change (Plate II. Figs. 1, 2) in the external contour of the Nanomia egg is the formation of a primary cleavage-furrow. This furrow was formed by the bending in of the outer wall of the egg at one pole. This infolding of the primary furrow leads to well-marked folds on the outer wall of the egg, which recall the phenomenon of "Faltenkranz" in some other animals. In about an hour's time after the first appearance of the infolding to form the primary furrow, a 2-celled cleavage stage was formed, and the first cleavage plane (1 *cl*) is well developed. About another hour elapses before the second cleavage plane is formed and a well marked 4-cell stage (Figs. 4, 5) is developed.

In his paper on the development of Agalma the author points out the peculiar warping of the first cleavage plane by the formation of the second. It was there shown, that by the growth of the second cleavage furrow at right angles to the first, it was brought about that the plane of the first cleavage was broken near the equator of the egg. In the same way and by an analogous process in the development of the Nanomia egg the second cleavage plane is so formed that the continuity of the first plane is likewise broken. Figure 4 of Plate II. illustrates this broken condition of the plane in Nanomia. Whether this modification is of any morphological importance, or has any influence in subsequent development of the cells, cannot be at present determined. The 8-cell stage is produced by the formation of two new furrows (Fig. 6) bending in on one side of those cells already formed in a way analogous to that already described in Agalma.

* Studien über die Entwickelung der Medusen und Siphonophoren. Zeit. f. Wiss. Zoöl., Bd. XXIV.

† On the Development of Agalma, Bull. Mus. Comp. Zoöl., Vol. XI. No. 11.

The egg of Nanomia in the eight-cell stage is the oldest which has been studied. There seems to be nothing peculiar in the method of segmentation as compared with that of Agalma. Among other medusæ it has some likenesses with that of the Ctenophora and certain Trachymedusæ.

Between the eight-cell stage and the youngest as figured by A. Agassiz there is a considerable gap, which I am not able to fill by new observations. This interval is, however, in part bridged by observations on an allied genus found in the Mediterranean, already published by Metschnikoff. This observer * has studied a Siphonophore, which is closely allied to Nanomia, and seems to resemble in mode of growth, as far as known, that which has been already described and figured by A. Agassiz.

Older larvæ, which he supposes to belong to the same genus, Metschnikoff has raised from planulæ which are a little younger than the youngest Nanomia figured by A. Agassiz. He has shown that in these larvæ no "primitive hydrophyllium" † is formed, and that the first structure to develop is the float. He regards his genus as the same as Nanomia.

A few years ago I was inclined to regard the genus referred to by Metschnikoff as the same as Nanomia. The adult tentacular knobs described for the first time in this paper confirm me in that opinion, but there is one thing which leads me to doubt their identity. The existence of the large oil globules in the bases of the tasters is very exceptional among Physophores. I have studied the animal, *Stephanomia pictum*, referred to by Metschnikoff, and was one of the first to describe it,‡ but I do not remember seeing structures similar to the "oil globules" of the tasters of Nanomia. In the published descriptions of this animal there are no similar structures. The question then arises whether the presence of this structure is sufficient to sep-

* *Op. cit.*

† The term "primitive hydrophyllium" was suggested in my paper on the development of Agalma to designate the cap-shaped covering scale which forms such an important organ in determining the form of the larva. The designation "primitive larva," used to distinguish the stage in which this organ is most developed, was suggested in the same paper. The primitive larva is supposed to be an ancestral form of Calycophores and Physophores, and to be closely allied to the ancestral form of other Hydromedusæ.

‡ Contributions to a Knowledge of the Tubular Jelly-fishes, Bull. Mus. Comp. Zoöl., Vol. VI. No. 7, pp. 136, 137, Plate II. Neither in Metschnikoff's figure of Stephanomia, nor in Claus's figure of *Halistemma tergestinum*, which all seem to regard the same, the relative size of the hydrophyllia seems to be smaller than in Nanomia. The same is true of my Agalmopsis from Florida. Claus's figure of the taster of his Halistemma, Plate II. Fig. 4, shows what may be a small "oil globule" near the base of this organ, and the structure in the same figure lettered *m g*, "male sexual bell," has some resemblance to the "oil globule" of Nanomia. Still from his description it does not seem that the "oil globule" has the predominance in size which it has in Nanomia. It must also be said that if *m g* (Plate II. Fig. 4) is a male sexual bell, it is very different from the same bodies in Nanomia.

arate Nanomia from the allied Stephanomia, auct., Halistemma, Claus, and Agalmopsis, Fewkes. We have on the Florida coast an Agalmopsis, *A. fragile*, Fewkes, which has the same knot as Nanomia, and in other particulars is very near it. They are not the same species, although generically they seem to be very close. For the present I adopt Agassiz's name, Nanomia, not because it differs from other Siphonophores in the way some have thought, but on new grounds, or because of the marked character of the "oil globule" in the taster of Nanomia. In all other respects Nanomia is like Agalmopsis, Fewkes, from the Mediterranean and Floridan Seas.

It is predicted that the egg of Nanomia will be found to develop at first a float, and then an embryonic tentacle with embryonic knobs; that there is never developed a primitive hydrophyllium; and that an Athorybia-like covering scale does not form. The type of development, as compared with that of Agalma, is more abbreviated, and consequently more direct in Agalmopsis than in Nanomia.

The facts which lead to this conclusion may be seen from what is said below. The state of our present knowledge of the development or growth of the larval stages of Nanomia may be shown in the following historical summary: —

1. The larva in which the float is fully formed is traced from older larvæ into the genus Nanomia. This series of observations was made by A. Agassiz, the discoverer of Nanomia, who considers that the youngest stage (with float only) develops from a bud, and also from the egg. The earliest stage which he figures he regards as identical, whether formed by either method of development.

2. Metschnikoff obtained younger stages, or those before the float is developed, of an allied Physophore. The youngest stage which he figures is a planula.

3. The author here describes the segmentation of the egg of Nanomia into the eight-cell stage.

The only break now in a consecutive series of observations is between two and three, or the eight-cell stage and the planula. Judging from what we know of other Siphonophores, no embryonic structures appear in this gap, and we are justified in supposing that no primitive hydrophyllium, or covering scale, appears before the float in Nanomia.

The fact that in Nanomia no primitive hydrophyllium, such as is found in Agalma, exists, does not prevent our recognizing in the youngest larva with a float, and a tentacle with embryonic knobs, all the parts of the stage called the primitive larva. Metschnikoff has shown that a Siphonophore float is homologous to a bell,* and I have no hesitation in accepting the theory that the float of Physophores is homologous with one of the nectocalyces of the

* The primitive larva, or, as I have elsewhere called it, the primitive medusa, from which all the Siphonophores have phylogenetically arisen, would seem to be somewhat like older stages on Plate III. of my "Development of Agalma," Bull. Mus. Comp. Zöol., Vol. XI. No. 11.

Calycophores. In 1883 the float was compared with the anterior nectocalyx of Diphyes. I regard the first nectocalyx of Monophyes as the same as the primitive hydrophyllium of Agalma.*

In the phylogeny of the Siphonophores, both Physophores and Calycophores have a stage called the primitive larva in common, and it is possible their ancestor was not unlike the so-called primitive larva stage of Agalma, with a single cap-shaped hydrophyllium, one polypite, and a knob similar to that which I have called the embryonic knob (Plate II. Fig. 8). The Calycophores retain certain organs which characterize this form, as the primitive hydrophyllium and the embryonic tentacular knob. In the Physophores, however, a specialized float, a modified bell, is developed, the embryonic knob gives place to other kinds of knobs, characteristic of the different genera of Physophores.

The primitive larva preserves the Medusa form, and may be supposed to approach more closely the ancestral form of the Siphonophores among other Hydromedusæ than any other medusiform larva. The name primitive larva appears to me to be a good one, and can well be accepted as a help in studies of the phylogeny of the Siphonophores.

I have already elsewhere devoted some space to showing that the primitive larva finds its nearest homologue among Hydromedusæ, in certain Tubularian medusiform gonophores. I chose Lizzia for my comparisons. It was perhaps premature for me to take any one genus for such a comparison, and it might have been better to have chosen the Trachymedusæ instead of the Tubularians for such an homology. From the character of the egg cleavage, and the fact that the development, as far as known, is similar in the Siphonophores and genera of Trachymedusæ, it is possible that the young stage of the former, which I have named the primitive larva, is more closely related to certain medusiform larvæ among the Trachymedusæ than to genera like Lizzia. The close homology between a medusiform gonophore and a simple hydroid, however, is such that I think we are justified in regarding the young of Nanomia with a float and no primitive hydrophyllium as homologous with the primitive larva of Agalma. I believe the ancestral form of all Hydromedusæ, as well as of all the Siphonophora, will be found to be similar to the primitive larva of Agalma in its younger stages. It had the form of a ciliated planula, with an enlargement at one end and a mouth at the opposite. The enlargement at one end was formed of three layers, is bell-shaped or gelatinous, and forms the bell of the Medusa, the float of Nanomia, and the primitive hydrophyllium of Agalma. In the fixed hydroid it becomes a base of attachment, in Rhizophysa or Nanomia a float, and in Agalma a covering scale. It is well to have some name to designate this prototype, and no one has suggested any better one than the "primitive medusa." †

* Embryological Monographs, No. III. Plate VII., Mem. Mus. Comp. Zöol., Vol. IX. No. 3.

† It would be interesting to trace the resemblance of this primitive larva or

HYDROIDA.

Sarsia mirabilis, Ag.

Many specimens of Sarsia were seen at Grand Manan on a single excursion. Later they disappeared, and were not again collected. The hydroid Coryne * was also found.

Hydrichthys mirus, gen. et sp. nov.

Plates IV., V.

During the month of August of the past summer (1887), in the surface fishing carried on at the Newport Marine Laboratory, I captured a most interesting genus of parasitic hydroid. This genus and its peculiar life are undescribed as far as known. The mode of parasitic life is most extraordinary, and the modification of its structure of an anomalous character.

A small fish of the genus Seriola (*S. zonata*, Cuv.) was taken in the dip-net at a time when the sea was quiet.† Upon the side of the body (Plate IV.

primitive medusa, the ancestral form of the medusæ, with the prototype ("Pilidium-like larva") of the six groups of marine larvæ described by Balfour. It is thought that such a resemblance not only exists, but also has an important phylogenetic meaning. It is not in place to discuss this question in this paper.

It may be asked whether the primitive larva of Agalma, with its huge primitive covering scale, or the primitive larva of Nanomia, where that scale is replaced by a float, is nearest the primary or ancestral larva of Hydromedusæ. The youngest forms of the primitive covering scale and the float closely resemble each other, and the departure from that form seems greater in Agalma than in Nanomia. A nectocalyx seems more highly organized than a pneumatophore; still, between a primitive hydrophyllium, such as exists in Agalma, and a float like that of Nanomia, it is hard to tell which is more highly specialized. It cannot be said that the adult Nanomia is less highly specialized than the adult Agalma. Although the float of Nanomia is first formed, it follows the primitive hydrophyllium in Agalma. While this fact might seem to indicate want of homology of the float in the adults of the two genera, it does not seem to prevent our considering the primitive larva to be represented by the young Nanomia with a float and no covering scale.

* Although it was not my intention to speak of the hydroids collected in the Bay of Fundy, I must mention beautiful specimens of Corymorpha dredged in shallow water not far from Eastport. The medusæ were just ready to drop from the hydroids, and as they were almost mature in July probably in later months they are found in abundance free swimming in the sea. I was of course on the look-out for the so-called free hydroid Acaulis, Stimpson, and other similar hydroids, but was unable to collect any of these animals. The broken heads of the hydroid Pennaria, which somewhat resemble Acaulis, were found.

† The Seriola was in company with two others. Neither of its companions, however, were afflicted with the parasites mentioned below.

Fig. 1) and near the anal opening of this fish a patch of reddish-colored bodies was noticed. This patch was at first supposed to be a fungoid growth from a wound or abrasion of the body. A more careful examination of the supposed fungus showed me my error, and revealed the fact that it was an attached animal with true hydroid affinities. The fish with the attached hydroid was kept alive in an aquarium for some time, and from the hydroid many medusæ (Plate V. Figs. 1–3) of interesting relationship developed. Thousands of these medusæ were raised, and the general characters of their structure and external anatomy studied. They seem to be hardy in their younger stages, but it is doubtful whether I have raised them into adults.* The form of the medusa is quite different from that of any known genus thus far found at Newport, but not unlike in general affinities certain well-known tubularian genera commonly found there in surface fishing.†

The exceptional, and it is believed unique, condition in Hydrichthys is the character of the hydroid, and the unusual feature its attachment to the sides of the body of the fish as a parasite or commensalist.‡ The polymorphic structure of the hydroid is quite different from that of any known hydrozoön.

The modifications in the anatomy of the hydroid are believed to have been in part due to its attachment to its host. This supposition, if it is well founded, and the additional fact that Hydrichthys has never been found in any other habitat or attached anywhere else than to the body of an osseous fish, may mean that we have in this genus a case of parasitism, or possibly commensalism, and that this condition has rendered functionally useless or modified the form of certain structures commonly present in other hydroids, while it has increased in relative size and possibly importance other organs, especially those concerned in reproduction and the dissemination of the young. Hydrichthys, looked at in this light, presents us with one of the most interesting conditions of hydroid life which has yet been recorded.

It was impossible to determine how much nourishment the hydroid Hydrichthys draws from the fish upon which it lives through the network of tubes from which the gonosomes and filiform bodies arise. The absence of tentacles, or organs the function of which is the capture of food, would seem to deprive Hydrichthys of those means of capturing and drawing food to the mouth which are almost universal among fixed hydroids. Possibly in its parasitic life the hydroid obtains its sustenance from the fish on the sides of which it lives.

The question whether the fish ultimately succumbs to the parasite is an interesting one, but one which cannot be definitely answered at present. The only specimen of Seriola captured which was infested by the hydroid appeared to be well and healthy, and lived for a considerable time without exhibiting

* The oldest medusa raised from the parasitic Hydrichthys has four tentacles.

† *Sarsia mirabilis* and *Ectopleura ochracea.*

‡ From my limited knowledge of Hydrichthys we are not justified in considering it a commensalist.

any inconvenience from the attached parasite. The muscles of the fish, however, under the "basal plate" of the hydroid were somewhat wasted; and after the fish was killed, the shrinkage in its body walls seemed to indicate that the fish had not wholly enjoyed his strange companion.

Hydroid. — The hydroid colony of Hydrichthys forms a cluster of reddish and orange-colored bodies attached to the sides and circumanal region of *Seriola zonata.*

The base of the whole colony is about three fourths of an inch in lateral extent. The base of attachment to the fish is a flat thin plate with ramifying tubes, by means of which the colony is fastened to the fish, and upon it separate clusters of sexual bodies (gonosomes) and filiform structures (hydranths?) are united together. The structure of the flat plate is not peculiar to Hydrichthys, but resembles that of many other hydroids attached to submarine objects, as Perigonimus and Hydractinia. The walls of the basal plate are leathery, or coreaceous, rather than calcareous. This basal plate is destitute of prominent projections such as exist in Hydractinia, but is smooth both above and below.*

In studying the character of the basal plate of Hydrichthys I was reminded of the anastomosing tubes on the under side of the float of Velella.

Each gonosome (Plate IV. Fig. 2) is botryoidal, consisting of an axis and lateral branches with medusæ in all stages of growth. The axis of the gonosome arises by a single trunk from the basal plate, and tapers uniformly from attachment to apex, opening † at the free end into the surrounding water. This axis resembles in its histological structure the stalk which bears the medusiform gonophores or Chrysomitræ in the genus Velella. It is sensitive, highly contractile when touched, transparent, or but slightly colored.

The side branches are similar in structure to the stem. They are generally simple, but sometimes subdivided or branched. The lateral branches near the base of attachment are longer than those near the free end of the stem. The side branches are of uniform diameter, and arise irregularly from the main stem. Like the main stalk, they have a cavity within, which communicates freely with that of the main stem.

In specimens preserved in alcohol the lateral branches are short and contracted, but in live specimens both the main stalk and its lateral branches are long and extended. There is no chitinous sheath about the axis or branches. Each lateral branch or supplementary division bears at its free extremity, which is closed, a cluster of medusa buds in all stages of growth from a simple spherical enlargement or expansion of the axis to a medusiform body with two

* The attachment of the basal plate to the wall of the fish is so firm that it is with difficulty broken away. I was obliged to cut it off, and with the hydroid thus dissected portions of the body of the host were also ruptured.

† There appears to be an opening at the free end of the gonosome. I could not determine to my satisfaction that the supposed opening really exists. I could not observe that it was functional.

stumpy tentacles at its free extremity. Small lateral branches without medusa buds are not rare, especially near the free extremity of the main stem. They are small, however, and project but little from the main stem.

The free extremity of the gonosome, or of the main stem of the same, is destitute of medusa buds, and, as has been said above, is without appendage. There are no tentacles about this terminal opening, and its rim is entire.

Whether the terminal opening of the main stem serves as a mouth or not it is impossible for me to say. No food was found in the cavity of the stem, and it is supposed that the whole structure is dependent upon the tubes of the basal plate for its nutrition. The main stalk is not supposed to take in food from the surrounding water through the terminal orifice.

The cluster of buds at the extremity of the lateral branches of the gonosome are the structures which give the color to the colony. They resemble the medusiform buds found in other Tubularian hydroids in their mode of attachment, their general structure, and their mode of growth.

In addition to the botryoidal clusters of gonosomes there also arise from the basal plate by which the colony is fastened to the fish long flask-shaped bodies, recalling in their external form the tasters of the Siphonophores. These bodies (Plate IV. Figs. 3, 5), like the gonosomes, arise from the upper walls of the basal plate of tubes attached to the body of the fish. Like the gonosomes they are numerous in the hydroid colony. The filiform bodies are elongated flask-shaped structures, of about uniform size throughout, arising from different points of attachment at the base from the gonosomes. They are, like the gonosomes, destitute of appendages, but they probably have an opening at the free extremity. The walls of the filiform bodies are composed of an outer thin and an inner thickened layer. There is a cavity within. The walls are dotted with pigment spots, which are especially numerous around the free extremity. In one of these filiform bodies there is a spherical mass, which resembles half-digested food. It is doubtful whether this mass is food. The free end of the filiform bodies is sometimes trumpet-shaped, but ordinarily rounded, the opening being concealed by the contraction of the lips. The bodies of the filiform structures move backwards and forwards on their attachments, and are sometimes spirally coiled in a single turn. They recall in general appearance the spiral zoöids of Hydractinia and the tasters ot Siphonophora, but, unlike either of these structures, have an orifice at their free end. They are thought to have close likenesses to the "central polyp" of Velella.

Medusa. — At the extremity of each lateral branch or its subordinate division there is found a small cluster of buds, which is composed of medusæ in all stages of growth. While attached to the branch, and before separation from it, these bodies take on all conditions of growth, from a simple hernia-like spherical bulb to a cylindrical body with two stumpy tentacles. No more than two tentacles are developed in the oldest attached medusa gonophore which was studied. The course of the growth of the medusa of Hydrichthys from a hernia-like bud to a small medusa is in no respect peculiar, but follows the laws of growth so often described in these structures in related genera.

The cluster of medusa buds is confined to the terminal end of the lateral branches. Near the base of attachment of each bud there is a patch of red pigment. As the medusa grows in size and the proboscis begins to be formed, the shape of the bud gets elongated, cylindrical, and at the same time two opposite tentacles push out on its free margin. The proboscis has a yellow and orange color. The reddish patches of pigment near the base of attachment of the immature bell persist even after the medusa has detached itself from its connection with the lateral branches.

The different layers of the body of the medusa bell (Plate IV. Fig. 4) can be readily seen through its transparent walls. Of these the epiblast, hypoblast, and intermediate layer can be easily recognized. The origin and growth of the radial tubes, and the subsequent formation of the circular or marginal canal, was traced. This growth does not differ from what has already been described in Syncoryne (Sarsia) and several other genera.

The fish (Seriola) was kept alive in an aquarium for several days, and from the attached hydroid many free medusiform gonophores were raised. On the morning following the day when the fish was captured, many medusæ were found in the aquaria, and every day after its capture many specimens ripened from the undeveloped buds, and one by one detached themselves from their union with the gonosome. There is no possibility of a doubt that the free medusa, as here described, has detached itself from the gonosome attached to the body of the fish.

The free medusa (Plate V. Fig. 1), when it breaks its connection with the gonosome, has two short tentacles situated opposite each other on the bell margin. The medusa bell long before detachment had begun the peculiar expansion and contraction which precede separation, and when once free moves gaily about in the surrounding water. Shortly after its detachment, the medusa with two tentacles resembles a young Stomatoca.* The structure of the Hydrichthys medusa just escaped from its attachment to the gonosome is as follows.

The bell is oval, without apical projection, and recalls in outline that of Sarsia. The outer surface is dotted with numerous nematocysts.† Bell walls colorless and transparent. There are four broad radial vessels and a marginal tube. The tentacular bulbs are reddish, without ocellus. Two tentacles arise from tentacular bulbs diametrically opposite on the bell margin. No otocysts on the bell margin. The proboscis is cylindrical, of an orange and yellow color. There are patches of red pigment near its attachment. The mouth is simple, with entire margin destitute of appendages.

* The fact that Stomatoca is a medusa of Perigonimus was pointed out by Haeckel, Allman, Hincks, and others.

† These nematocysts are most prominent in younger stages in the growth of the medusa. They are well marked even before the medusa form is attained.

The medusa with two opposite tentacles was raised into one with four (Plate V. Fig. 2), passing out of the stage resembling Stomatoca into one like Sarsia.

The form of the bell and the arrangement of tubes is unchanged in the passage from the medusa with two tentacles into one with four. The new tentacles form on the bell margin, half-way between those already formed. They arise near the junction of the radial and marginal canals. All the tentacles now grow to a great length, and the medusa, once very active, sinks to the bottom of the aquarium. Its motion is from now on more sluggish than before, either from exhaustion or habit. I was unable to raise them into medusæ with more than four tentacles.

The affinities of Hydrichthys would not be difficult to make out if we were to deal with the medusa alone. So close are the resemblances with such genera as Sarsia, Ectopleura, and other allied Tubularians, that there would have been no doubt in my mind, if I had the medusa alone to deal with, that Hydrichthys is a close ally of these genera. It is the form of the hydroid which complicates the problem in regard to the affinities of the parasite, for, so far as the hydroids of the Tubularians allied to Sarsia are concerned, there are none which have any resemblance to the hydroid of Hydrichthys.

If we approach the study of Hydrichthys from the hydroid side, remembering the undoubted affinities of the medusa, it seems to me that we must regard the modifications in its structure and its polymorphism as due to the attachment to the walls of its host, the fish. We know, of course, too little of the other possible habitats of this strange hydroid to declare that it is never found in any other place, but the general structure of its body would seem to point to a special modification of its structure brought about by its parasitic life.

The peculiarities of structure which separate Hydrichthys from other allied Tubularian hydroids are the total absence of tentacles, combined with a polymorphism in which there are two kinds of individuals already described, viz. botryoidal gonosomes and filiform hydranths (?).*

In all Tubularian hydroids there are tentacles of some kind or other near a mouth opening. In Tubularia, for instance, we have circles of tentacles arranged about a mouth, and from the intertentacular regions or intervals on the head hang down grape-like clusters of gonophores. Suppose, for purposes of comparison with Hydrichthys, that in Tubularia the chitinous sheath of the single hydroid is absent, the tentacles reduced to nothing or absent, and the

* It might be supposed that the second of these are simply the main stem of the gonosomes, stripped of lateral branches with medusa buds. The differences in the structure of the two show the error of such a supposition. It might be objected to my interpretation that there are two kinds of individuals in Hydrichthys, on the ground that the filiform bodies are undeveloped gonosomes. That objection is also believed to be poorly supported, for young gonosomes differ even as markedly as the adults from the filiform bodies. The designation of the filiform bodies as hydranths is simply conjectural.

whole head modified into the form of an elongated axis or stem. By these changes the clusters of grape-like organs would appear as lateral branches of a main stem ; and if we suppose the clusters of gonophores pushed out to their tips, we should have an exact resemblance to the condition of the gonosomes * of Hydrichthys, where they are simply botryoidal clusters of immature medusæ mounted on peduncles which arise from a common stalk. How is it with the filiform bodies of Hydrichthys ? In reply, it may be said these do not occur in Tubularia. Morphologically, they may be supposed to be the single simple hydroid, stripped of tentacles, gonophores, and enveloping sheath, so that the axis alone, with its terminal opening, is about all that remains. By this reduction we have one of the simplest forms of hydroids. Such an individual is certainly as low in organization as the Protohydra, Microhydra, and similar low genera which are destitute of tentacles.

This reduction in the form of the hydranth by the disappearance of the tentacles in Hydrichthys is believed to be a degeneration brought about by its life, and not, as in Protohydra, due to the low zoölogical position of the hydroid.† The character of the medusa of Hydrichthys and its resemblance to

* As this comparison is only in general external outlines, no account of the fact that the gonophores of Tubularia take the form of actinulæ, while those of Hydrichthys appear as medusæ, is considered. *En passant*, however, it might be said that morphologically the actinula and the medusa are thought to be homologous, as several naturalists have already shown. I regard both medusa and hydroid as a modification in different directions of an ancestral form which is most closely adhered to in a stage of the Siphonophores to which I have given the name "primitive larva," or "primitive medusa." Morphologically considered, a medusa and a simple hydroid are homologous, as shown by a study of Stephanoscyphus (Allman), Cunina, the young of Agalma as compared with the young Nanomia, and other genera. This identity, in a morphological way, of medusa and hydroid has long been recognized, and was pointed out many years ago by Claus and others.

The egg in its development may pass into one or the other of these homologous stages. It may become fixed to a submarine object, and become a fixed hydroid; it may pass into a free medusa or medusiform condition homologous to a hydroid, as in Glossocodon or in Agalma; or it may be developed into a parasitic Hydrichthys. It seems probable that, as I have already elsewhere shown, the attached form of the medusa or the hydroid is a secondary condition, and that the primary condition is a direct development from the egg to the adult medusa. I would regard the ancestral form of metagenesis to be the development of the "primitive medusa," from an organism with both hydroid and medusan affinities, directly from the egg without attachment. From that medusa, — which I would call and have elsewhere named the primitive medusa, — in some instances, free medusiform gonophores bud, as in Agalma; in other cases, the primitive medusa becomes attached, and is modified into a hydroid from which free gonophores separate ; while in still other cases, Nanomia, the primitive medusa is neither medusiform nor attached hydroid-like, but planula-like, with a float. The primitive medusa is homologous in all these changed forms.

† There is no reason to suppose that non-tentaculated genera allied to Hydra

Sarsia shows that the affinities of the genus are higher than its hydroid would seem to indicate. There is a pretty close likeness between most of the hydroids of the medusæ to which the Hydrichthys medusa is allied. This radical departure in Hydrichthys in the form of the hydroid itself may have a meaning, and the exceptional anatomy is thought to be due, at least in part, to its parasitic life, especially as the medusa is so closely allied to other tubularian medusiform gonophores. In the development of the egg of Hydrichthys, it is supposed that the planula, instead of fastening itself to some submarine object, becomes attached to the fish. The necessities for the development of tentacles would be reduced from the fact that the fish (Seriola) carries the hydroid about, and perhaps furnishes sustenance for the parasite from its own body. As a result, the hydroid suffers a degeneration, or remains in a degraded condition.

The needs of procreation, however, still remain, and the necessity for the locomotion of the sexual zoöid and the organs for the development of new individuals is in no way diminished by the parasitic life of the hydroid. Instead of being reduced in size, they are, if anything, enlarged in number ; and as the medusiform gonophore separated from the gonosome is placed under exactly the same conditions as that of any fixed hydroid, it retains characters of its near relatives.*

Hydrichthys has certain features in the anatomy which recall the floating hydroid, Velella. The gonosomes resemble in several particulars the sexual bodies of Velella, and the free medusa is not very different from Chrysomitra, the medusa of Velella. The flat basal disk also of Hydrichthys has points of resemblance to the basal plate and the ramifying tubes on the under side of the float in the well-known *V. spirans*. In the polymorphism of the two there is some likeness. In Velella we have a single non-tentaculated "central polyp," or polypite, surrounded by many sexual bodies, or gonosomes. We have in Velella, moreover, two kinds of individuals, which is perhaps the simplest kind of polymorphism anywhere known among Siphonophores, except in the kindred genus Porpita. In Hydrichthys we also have two

ever have a free medusiform gonophore. They probably have a development like Hydra, and are destitute of special locomotive zoöids.

It is, of course, an open question whether Hydra and Protohydra are nearer the ancestral type than other hydroids. It is not unlikely that they are degenerate forms, and not ancestral. The peculiarities of their habitat in fresh water might have led to their low zoölogical position. As a question of opinion, the author regards them as phylogenetically low, and nearer the ancestral form of hydroids than Syncoryne and others.

* Those who have studied the Hydromedusæ have for the most part based their classifications either on the form of the hydroid, or the form of the medusiform gonophore. Both are in error if they rely upon either hydroid or medusa alone as a basis of classification. Hydrichthys certainly shows that this is true ; for, if known from the hydroid alone, it might be placed in a zoölogical position very far from that which its medusa would indicate as its true one.

kinds of individuals: the gonosomes, which are similar to the sexual individual of Velella, and the "filiform bodies," which closely resemble the central polypite of Velella and Porpita. If this likeness between the parasitic Hydrichthys and the free-swimming Velella is a morphological one, it may throw new light on the relationship of the hydroids and Siphonophores. The parasitic nature of the life of Hydrichthys leads us to compare it with the strange Cœlentrate organism, *Polypodium hydriforme*, also parasitic, described by P. Owsjannikow,* and later by O. Grimm,† in the ova of Acipenser. The resemblances between the two are, however, of a most distant kind, and the affinities of the two are slight.

The only stage in the life history of Polypodium which can be homologized with Hydrichthys is the hydroid stage, the cylindrical hollow tube covered by buds. This is the spirally twisted tube with numerous lateral appendages, figured by Ussow ‡ in Figs. 1–5. If we suppose the hydroid of Hydrichthys to have the lateral branches reduced in size, the buds brought to the side of the main axis, and the main axis itself closed at either end, flexible, and motile, we should have something similar to what exists in the first stage of Polypodium, found in the egg of the sturgeon. I cannot, however, believe that the likeness is very close between them, although the form of both is undoubtedly due, in part at least, to their parasitic life on the animals with which they are associated.

When we come to compare the organism formed from Polypodium by the breaking up of or budding from the stem, and the relatively highly organized Sarsia-like organism (medusa) derived from Hydrichthys, we find little likeness between them, judging from the figures of Polypodium given by Ussow, and my own. I am therefore convinced that the affinities of Hydrichthys and Polypodium are very remote, and that parasitism has affected them in very different ways,§ so far as the modifications in their anatomy are concerned.

Turris episcopalis, Fewkes.

This beautiful medusa was found in great abundance at North Head, Grand Manan. The few specimens of this genus which have been found at New-

* Arbeiten der dritten russischen Naturforscherversammlung in Kiew. Reference: Zeit. Wiss. Zoöl., XXII. 292; Mélanges biologiques de l'Acad. des Sci. de St. Pétersbourg, 1871.

† Arbeiten der Naturforschergesellschaft zu Petersburg, 1873.

‡ Morphologisches Jahrbuch, XII. 137–153; Ann. Mag. Nat. Hist., XVIII. 110–124, Pl. IV. It is of course not impossible that Hydrichthys may be a transition form between true hydroids like Tubularia and Syncoryne on the one hand, and the extremely modified genus Polypodium on the other. The author does not deny this possibility, although the relation of the two is distant.

§ The amount of modification in the structure of Polypodium would naturally be very much greater than in Hydrichthys, on account of its peculiar habitat inside the fish.

port, R, I., from one of which the type was described, are evidently stragglers from cold water, where they are abundant, and not from the warm waters of the Gulf Stream, from which they have yet to be taken.

Melicertum campanula, Esch.

This large and beautiful medusa is one of the most common at Grand Manan.

Specimens of the young in all stages of growth were easily collected. These are found to have been well described by Agassiz, and nothing of value was added to his observations.

Nemopsis* bachei, Ag.

Staurophora laciniata, Ag.

This beautiful medusa is common at Grand Manan. It grows to a large size, and is one of the most conspicuous genera in sheltered bays near the north end of the island. I have also found several large specimens of Staurophora at Frye's Island, New Brunswick.†

Halopsis ocellata, A. Ag.

Plate III. Fig. 1.

The genus Halopsis was found quite abundantly near the wharfs at Grand Manan. The specimens which were taken differ somewhat from the figures and description of the type, but evidently belong to this species.

The bell, in several specimens, is from four to six inches in diameter. Its walls are thick, without apical prominence. The radial canals arise regularly,

* Sometimes erroneously written Mnemopsis. The derivation is νῆμα, tentacle, and ὄψις. The use of the wrong spelling is liable to lead to confusion with the Ctenophore, Mnemiopsis.

† In the surface fishing at Frye's Island, New Brunswick, several interesting larvæ were found with Staurophora. Among these were many specimens of the singular worm larva, Mitraria. These larvæ were taken in great abundance in July, and were generally captured with the Müller net in night fishing. In Narragansett Bay, Mitraria is not found. The problematical affinities of this singular worm larva, and its abundance in Passamaquoddy Bay, would seem to invite naturalists to observations upon its development.

Swarms of an Appendicularia different from that found at Newport were also observed at Grand Manan and Eastport. The body of the Grand Manan Appendicularia is larger than the Newport, and more dumb-bell-shaped, the tail arising from the middle of the body.

not in four groups,* from the stomach cavity. Sexual glands are situated ordinarily as described, but often have a bright pink color instead of white.

Otocysts large, compound, as already described in Halopsis by A. Agassiz. This medusa is very abundant at Eastport, Me., as well as at Grand Manan,† where it seems to occur during the whole summer. No subject would better repay investigation than that of the histology of the "compound eyes," or otocysts, of Halopsis.

Oceania languida (Ag.),‡ A. Ag.

An Oceania similar to *O. languida* was found in abundance near Eastport, Me. A few specimens occurred at North Head, Grand Manan.

Obelia, sp. ?

An unidentified Obelia is common at Grand Manan.

DISCOPHORA.

Cyanea arctica, Per. et Les.

Nowhere on the Atlantic coast, except at Eastport, Me., have I seen such magnificent specimens of this medusa as near the landing-place at North Head, Grand Manan.

Aurelia flavidula, Per. et Les.

The *Aurelia aurita* described by Stimpson from Grand Manan is evidently, as already pointed out by A. Agassiz, the *A. flavidula*, Per. et Les. Specimens were found at North Head in considerable numbers, and of great size.

Callinema, Verrill.

Plate VI.

Since its discovery at Eastport by Prof. A. E. Verrill, the interesting genus Callinema has not been studied, although Eastport has been repeatedly visited

* In this respect my specimens differ from the type.

† This is thought to be the first mention of Halopsis from localities north of Massachusetts Bay, on the New England or New Brunswick coasts.

‡ Name *languida* used by L. Agassiz in 1862 in "Contributions to the Natural History of the United States." A special description of *O. languida*, with figures, is to be found in "North American Acalephæ," by A. Agassiz. The specimens studied closely resemble the types.

by naturalists. No additions worth mentioning to our knowledge of this extraordinary genus has been made since Verrill's original paper. Prof. Verrill collected Callinema on two different occasions, and he records that he found three specimens in all. In the summer of 1885, I also found this jelly-fish among the Eastport wharves, and took a single specimen.

My specimen of Callinema was collected under most unfavorable circumstances. The water was very rough, and it was with great difficulty that I succeeded in capturing the medusa and bringing it on shore. When the genus was first seen it was mistaken for a Cyanea, and before its capture it was regarded as a new specimen of Zygodactyla. It was only later, when brought on shore, that it was possible for me to detect its true relationship, and to establish its identity with the rare Callinema.

This genus is one of the most extraordinary found on the New England coast. It is believed that an extended account of its anatomy is necessary, not only to show how distinct it is from a Pacific Ocean relative, *H. ambigua*, but also to afford a means of comparison and determination of the systematic position of a Mediterranean ally, called by Haeckel *Phacellophora sicula.*

The original description * of Callinema by Prof. Verrill is concise, and leaves no doubt as to the form of the more important organs of his genus. Unfortunately, his account is unaccompanied by figures, so that some details of structure need illustration to render his description clearer. Since my rediscovery of Callinema, Prof. Verrill has sent me woodcuts representing portions of the disk and tubes, and part of a tentacle, so that I can easily follow his written description as far as these organs are concerned. There is, however, still believed to be a call for the publication of figures of the medusa as a whole, to show the relationship of the parts. In the present description I have simply tried to emphasize certain details of structure, barely touched upon in the original accounts, and to figure the outlines of the medusa as a help to future investigators.

Callinema ornata, Verr.

Disk (Figs. 2, 3) flat, thick, with rounded apex, fourteen inches in diameter.† The margin of the bell hangs downwards when the medusa is in motion. The external surface of the bell (Figs. 1, 2) is covered with small

* Description of a Remarkable New Jelly-fish, and two Actinians, from the Coast of Maine. Am. Journ. Arts and Sci., Vol. XLVIII. pp. 116–118. See also Ann. Mag. Nat. Hist., Vol. IV. p. 161.

Haeckel (System der Medusen Acraspeden, p. 643) prints a condensed notice of Callinema, under the name Phacellophora, but does not mention Prof. Verrill's *original* description in the American Journal. Verrill's description in the "Annals and Magazine of Natural History," used by Haeckel, is, however, the same as the original account.

† One of Verrill's specimens was eighteen inches in diameter and another ten.

warts or papillæ. Walls of the bell transparent, with conspicuous radiating tubes.

The radial tubes (Fig. 3) are of two forms: those which lie in the radius of the sense bodies, which are more or less anastomosing and branching; while those in intermediate sphærosomes are unbranched, straight, and almost parallel with each other. Tubes broad, slightly brown color, extending from the stomach cavity to the marginal vessel. There are sixteen sets of anastomosing tubes and the same number of unbranched vessels. The former lie in the radii of the sense bodies of the bell margin. The marginal vessel is continuous, obscurely sinuous, broad, without lobes.

There are sixteen hooded (Fig. 5, *v*) sense bodies on the bell margin. Each marginal sense body (*o*) is pearl-white and conspicuous. The intimate structure is like that of *P. sicula*, described by the Hertwigs.* The rim of the bell between each pair of marginal sense bodies (Figs. 4, 5) is filled by a broad lobe (*a*, *b*), the margin of which is indented and incised or scalloped. The sixteen marginal lobes are separated by deep incisions, at the deepest part of which lie the marginal sense bodies. The marginal lobes are penetrated by blindly ending vessels or tubes (*cr*), which arise from the circular tube (*cl*) between and among the tentacles. These blind tubes of the marginal lappets are sometimes slightly bifurcated at the end, and sometimes send off small lateral serrations. They are never branched, nor anastomosing. The tube which arises from the marginal circular vessel in the radius of the otocyst divides into three divisions shortly after it leaves the point of origin. The median, or smallest of the three divisions, extends into the cavity of the style of the otocyst (*o*). The two lateral divisions (*ch*) are somewhat bow-shaped and follow along the side of the cleft in which the margin of the bell is incised for the otocyst. The cavity of the two bow-shaped divisions (*ch*) is entire on the inner border, and more or less serrated on the side turned toward the marginal cleft in which the otocyst lies.

The tentacles (*p*) are numerous, and arise, not from the edges of the marginal lappets, but from the neighborhood of the circular marginal vessel (*cl*). The tentacles vary very greatly in size, and are placed side by side (Figs. 3, 4) along the circular tube into which, alternating with the marginal vessels, they open. Each tentacle is long and somewhat flat, with a finely scalloped double edge of white color. There are from eight to ten tentacles between each pair of marginal sense bodies.

The mouth lobes (*ga*) resemble those of Cyanea, and consist of folded curtains of yellow and brown color. The walls of the actinostome are more or less extended outward (Fig. 1), and the lips are entire.

There are eight large sexual bodies (*sp*) hanging at the base of the mouth parts near their attachment. These structures are prominent and have a brownish color. The sexual filaments are large and conspicuous.

No other species of Callinema, or of the closely allied Phacellophora, has

* Nervensystem und Sinnesorganen der Medusen, pp. 113, 114.

been taken in the Atlantic or in the Mediterranean, with the exception of the problematical *P. sicula*, Haeck., from Messina.

In his original description Prof. Verrill suggests that Callinema is allied to *Heccædecomma ambiguum*, Brandt, of the North Pacific, but finds that the Eastport species differs from the Pacific in the shape and character of the tentacles, the marginal lobes, and ovaries, and that the figures of the Pacific form have much more complicated mouth-folds. I agree with Professor Verrill in his conclusions in regard to the differences between the two medusæ, and find his medusa specifically different, not only from the published figures of the Pacific Phacellophora, but also from specimens themselves, some of which were collected on my recent visit to the Pacific coast. It is also believed to be generically different from Heccædecomma.

Haeckel * suggests that Callinema is a new species of Phacellophora. There are close likenesses between Callinema and Phacellophora, and also differences which seem great enough to give the name Callinema a generic worth. Haeckel, however, regards these differences as specific only, and regards Callinema as a new species of Phacellophora. In the same genus he places three other species, *camtschatica*, Brandt, *ambigua*, Brandt, and *sicula*, Haeckel. I consider, as stated above, that there is a generic difference between Callinema and the first two species. Of the third species, from Messina, there are no special descriptions, and no figures of the medusa as a whole, and we are wholly in the dark in regard to the structure of the mouth parts. What is known from the notices by the Hertwigs † — the figures are of a quadrant of the bell and an enlarged sense body — would lead me to suppose that his medusa is very close to Callinema. It would seem to be a species of Callinema allied to *C. ornata*. Until we know more of its general anatomy, we must remain in doubt whether it is more closely allied to Phacellophora or Callinema. I can heartily agree with Haeckel that an exact study of the structure of the medusa considered by Hertwig is very desirable. The author believes that histological researches lose some of their value if not preceded by an accurate specific identification or specific description of the animal studied, if it is different from known species.

* Das System der Medusen. Acraspeden, p. 643.

† Nervensystem und Sinnesorganen der Medusen, pp. 113, 114, Taf. IX. Fig. 15, Taf. X. Fig. 16.

CAMBRIDGE, October, 1887.

EXPLANATION OF THE PLATES.

PLATE I.

View of *Nanomia cara* (life size).

f.	Float.	*nc.*	Nectocalyx.
g.	Sexual bell.	*ns.*	Nectostem.
h ph.	Hydrophyllium.	*og.*	Oil globule.
ht.	Hydrocyst.	*p.*	Polypite.
h ta.	Tentacle of the hydrocyst.	*ps.*	Polyp-stem.
k.	Retracted tentacular knob.	*ta.*	Tentacle.

PLATE II.

Nanomia cara, A. Ag.

c.f.	Stiff projections at the distal end of the embryonic tentacles.	*inv.*	Involucrum of adult knob.
1 cl., *2 cl.*	First and second cleavage planes.	*lc.*	Lateral nematocyst of the embryonic knob.
ft.	Terminal filament of the adult tentacular knob.	*og.*	Oil globule.
		ped.	Peduncle of the tentacular knob.
ht.	Hydrocyst.	*pl.*	Protoplasmic elevation.
h ta.	Tentacle of the hydrocyst.	*sac.*	Sacculus.

Fig. 1. Egg with the primitive furrow almost formed, showing superficial protoplasmic envelope and protoplasmic network.

Fig. 2. The same, a little younger.

Fig. 3. Two-cell stage.

Fig. 4. Four-cell stage.

Fig. 5. Four-cell stage turned in another plane.

Fig. 6. Beginnings of the furrows which form the eight-cell stage.

Fig. 7. Hydrocyst of Nanomia found detached from the parent stem.

Fig. 8. Embryonic tentacular knob.

Fig. 9. Adult tentacular knob.

PLATE III.

Fig. 1. Upper portion of a taster of Nanomia, showing the so-called oil globule forming a protuberance on one side. The tentacle is not represented.

Fig. 2. Four nectocalyces of Nanomia, showing their mode of fitting together. The stem is shown through the sides of the "horns," or gelatinous extensions of the nectocalyx. The sinuous tubes are the lateral chymiferous vessels. The radial tubes, which pass directly, without a sinuous course, from the tube which joins the system to the stem, are not shown.

Fig. 3. *Halopsis ocellata* (side view).

PLATE IV.

Fig. 1. A fish (*Seriola zonata*) with Hydrichthys attached to its side and anal region.

Fig. 2. Single cluster of gonophores separated from attachment to the basal plate by which the whole colony is united to the fish. The attachment is at the lower end. Medusa buds in various stages of development are shown at the ends of the lateral branches. Each attached colony has a large number of bodies like Fig. 2 scattered irregularly on the basal plate. The structure represented in Fig. 2 is described as the gonosome of Hydrichthys.

Fig. 3. Single filiform body of a Hydrichthys colony.

Fig. 4. Section (optical) of a medusa bud of Hydrichthys. The two projections on the left are the opposite tentacles, which have an internal cavity communicating with radial tubes, two of which are represented. The two spurs from this cavity which arise near the bases of the tentacles are the beginnings of the circular canal. The large cavity at the centre of the bell is the cavity of the proboscis. The slit-like cavity separated from the cavity of the proboscis by the thick layer and the thin layer which lines the former, is the future bell cavity.

Fig. 5. Enlarged end of the filiform body of Hydrichthys, showing the orifice open and a round mass (food ?) in its cavity.

PLATE V.

Fig. 1. Adult medusiform gonophore of Hydrichthys with four tentacles (side view). This medusa was raised from the hydroid, and is supposed to be not much younger than the adult.

Fig. 2. An immature medusa of Hydrichthys found in the aquarium on the morning after capture. Raised from the Hydrichthys in countless numbers. (Side view.)

Fig. 3. View of the last-mentioned from actinostomal region. This medusa is a very little younger than Fig. 2, since the two stumpy tentacles have not yet begun to appear.

PLATE VI.

Callinema ornata, Verr.

a. Portion of the marginal lobe adjoining the marginal cleft in which the otocyst lies. The separation of this lobe from the remainder of the marginal lappet is indicated by a slight depression in the margin or rim of the lappet.

b. Intermediate portion of the marginal lappet between two indentations which separate it from *a.*

Of the two regions of the margin of the umbrella, *a* may be called the ocular lappet and *b* the velar lappet.

ch. Vessel arising from the marginal tube and blindly ending in the ocular lappet.

cr. Vessels of the same character as the last in the velar lappets.

cl. Marginal or circular chymiferous tube.

ga. Oral folds.

o. Otocyst, or marginal sense body.

p. Tentacle.

sp. Sexual organs.

v. Hood over the marginal sense body.

Fig. 1. Side view of Callinema, bell contracted.

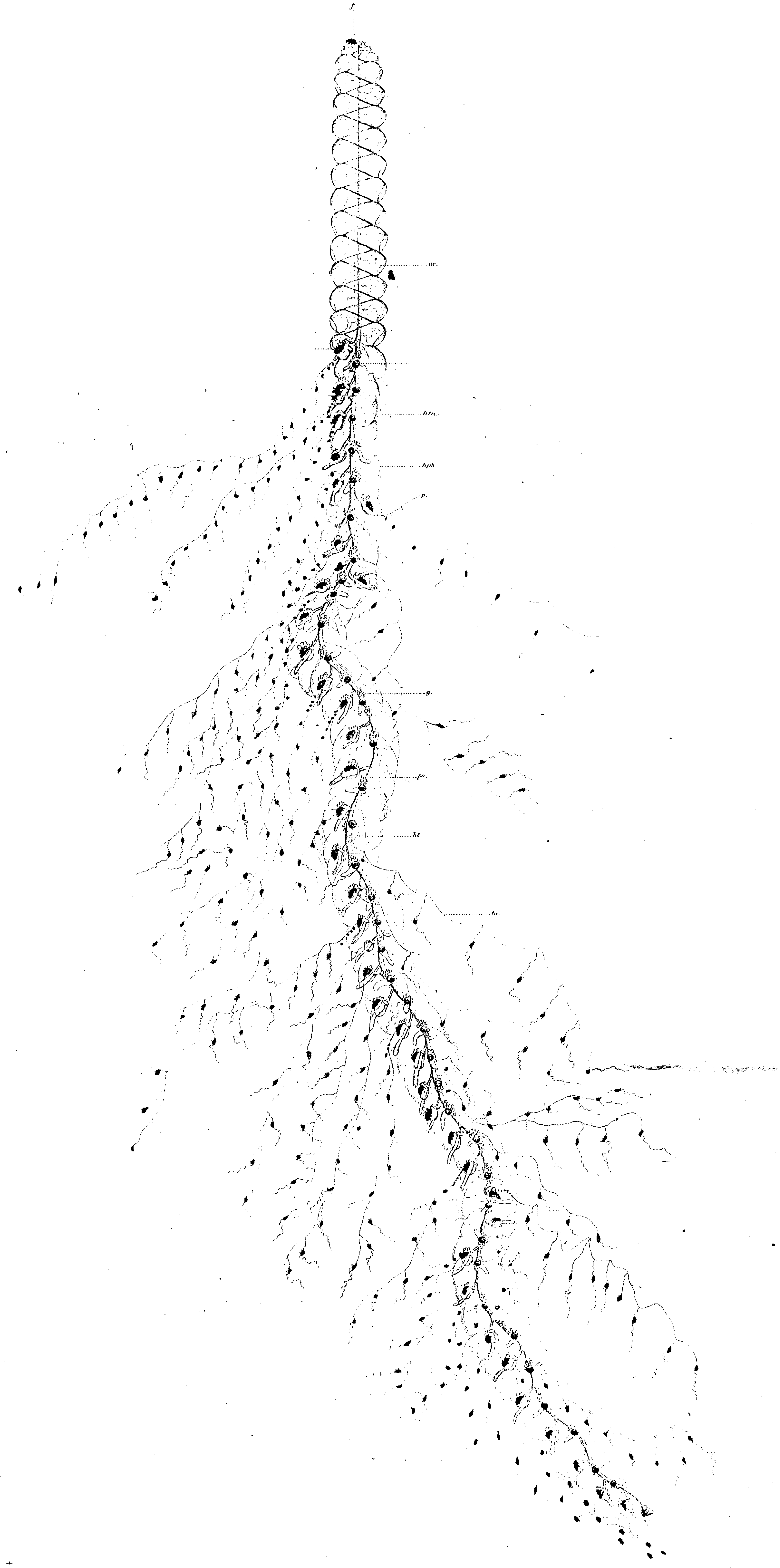
Fig. 2. Same, bell more expanded. (The tentacles are cut off in Fig. 2 and more or less retracted in Fig. 1. Half of the figure drawn in outline.)

Fig. 3. View of the anastomosing and unbranched radial tubes, seen from above. (Tubes drawn in a quadrant of the bell.)

Fig. 4. Section of the bell margin, including a velar (*b*) and an ocular lappet (*a*). This figure shows also the relative position of the otocyst, tentacle, and blind tubes of the marginal region.

Fig. 5. A section of the bell margin of the same specimen from which the last was drawn (shown from a different spheromere).

All figures except Fig. 1, Plate IV., were drawn from nature by the author. The pen and ink sketches of Plate III. Fig. 3, and of Plates IV. and V., were made by Mr. S. W. Denton. All the others are by the author.



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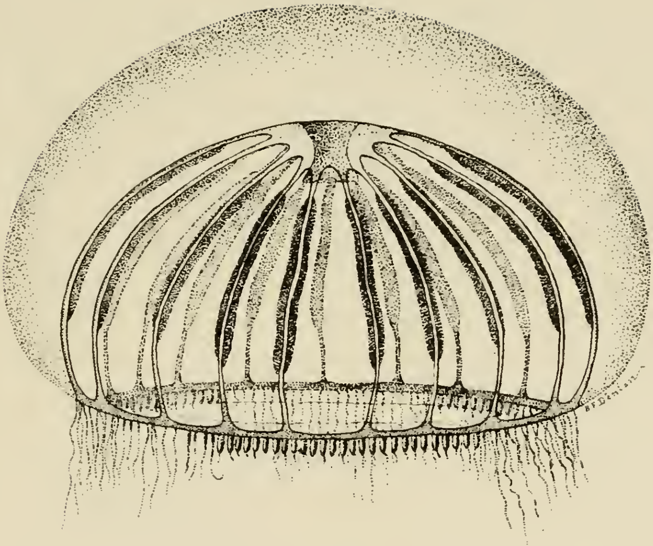

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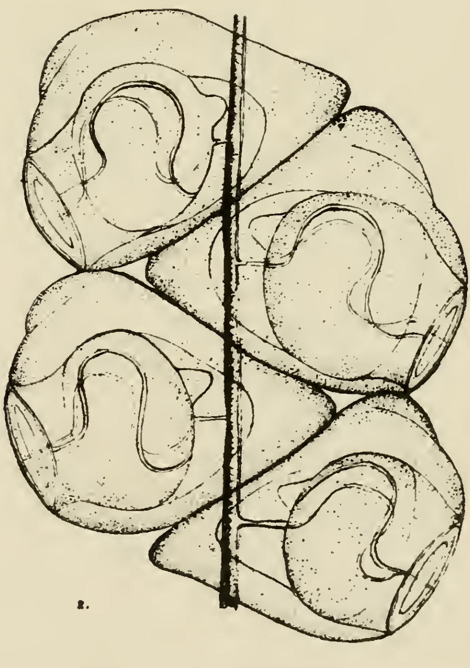

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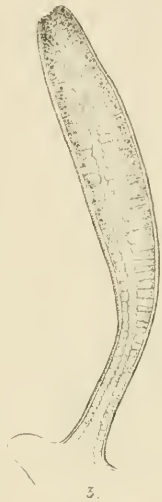

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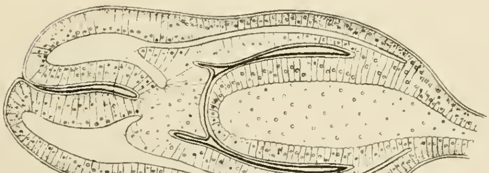

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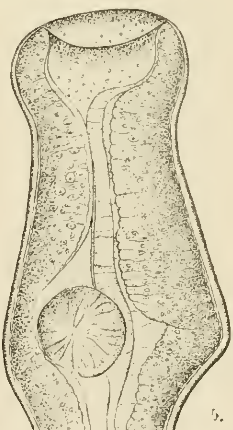

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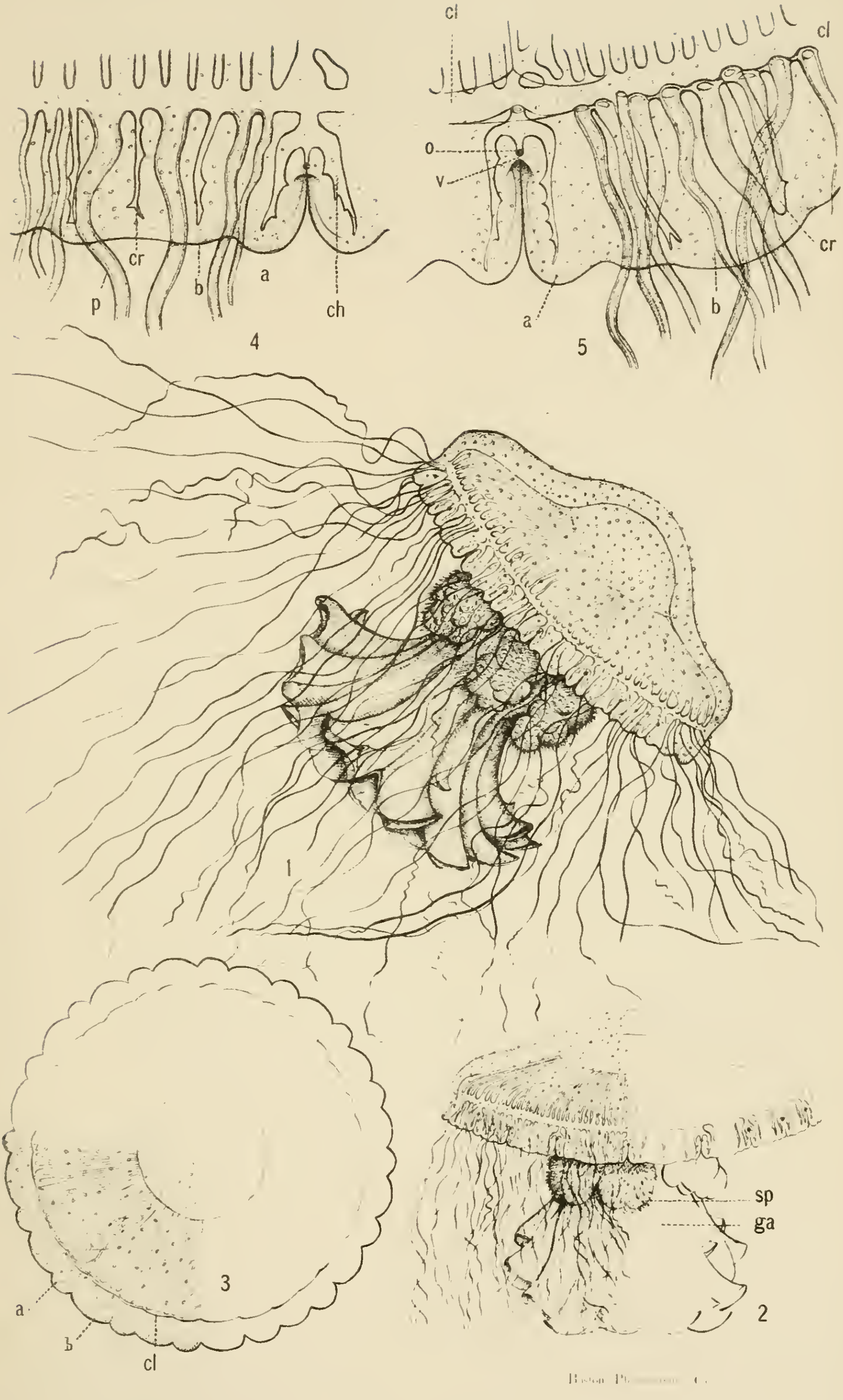

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