BULLETIN

OF THE

MUSEUM OF COMPARATIVE ZOÖLOGY

AT

HARVARD COLLEGE, IN CAMBRIDGE.

VOL. VI.

PART I.—NOS. 1—11.

CAMBRIDGE, MASS., U. S. A.
1879–1880.

No. 7. — *Contributions to a Knowledge of the Tubular Jelly-fishes.*

By J. Walter Fewkes.

I. The Development of the Tentacular Knob of Physophora hydrostatica.

The anatomy of those animals known to the zoölogist as the Siphonophoræ, or tubular Jelly-fishes, has been carefully studied, and minutely described. I present certain points in which my observations or conclusions differ from those of other naturalists. I have also discussed at length the limits and synonymy of the genus *Halistemma*, since I think it embraces animals with generic differences, and I conclude with a brief mention of North American Siphonophoræ and Velellidæ, adding three genera to those already described for our coasts. The development of the structures which have received the name of tentacular knobs has a certain interest, particularly the different stages in growth of that perhaps most complicated of all, the knob of *Physophora*. The development of these structures long since attracted attention, and Claus * twenty years ago (1860) published a description, with figures, of the younger stages of the knob in *Physophora hydrostatica*. Keferstein and Ehlers, to whom science owes so many discoveries in regard to these Jelly-fishes, followed this work with certain corrections and additions of the most important character. Their investigations were made upon a species of *Physophora* called *P. Philippi*, identical with or only distinguished from *P. hydrostatica* by the possession of lateral appendages to the external walls of the knob. The account which they give in most particulars applies also to *P. hydrostatica*, which has furnished me the material for my studies of the developmental history of the tentacular knob in this genus.

The growth of the knob of *Physophora*, although quite simple, is more complicated than that of any other Siphonophore. I have only, however, considered it necessary to figure a few stages assumed in this growth, illustrating the peculiar asymmetrical form of the involucrum, and the embryonic appendages to the sacculus, which are provisional in

* Ueber Physophora hydrostatica nebst Bemerkungen über andere Siphonophoren.

their nature, and give the early condition of the knob a likeness to that of certain other genera of Physophoridæ.

The knob of *Physophora hydrostatica* originates, like that of other tubular Jelly-fishes, as a simple bud, hardly distinguishable from the earlier condition of all structures in the Siphonophores. In its place of origin it resembles the genus *Agalma*, for it forms on the ciliated base of the feeding polyp, and is in fact a proliferation of the walls of that part. Whether all Physophore knobs originate from the same relative position is an open question. In *Rhizophysa filiformis* we have several of the polypites nearest the float with naked tentacles, from which the knobs bud, never arising from the base of the polypites. Of course these undeveloped appendages in the singular *Rhizophysa* may be looked upon as tasters,* a supposition hardly probable; or it is also possible that they correspond with somewhat similar structures between the nectocalyces of *Apolemia uvaria*. In the well-known genus last mentioned the polyp-like parts between the swimming-bells appear to have no filaments like those found on the tasters of other Siphonophores. The taster-like bodies near the float of *Rhizophysa* are undeveloped feeding polyps.

In the very earliest stages the Physophora knob is composed of layers which are apparently two in number. The differentiation of other layers takes place later in the course of the development. At first we find only ectoderm and entoderm in the walls of the knob. This simple bud elongates into a flask-shaped body, at the base of which the cavity becomes enlarged, imparting to this region a more or less spherical shape. (Pl. I. fig. 2.) From the ectodermic wall of the enlargement thus formed arises the involucrum. An examination of this region, even at an early period (Pl. I. fig. 3), shows that a differentiation has begun, and that the ectoderm has divided into two layers, one of which appears as a collar

* The word *taster*, to designate peculiar structures among the Siphonophores, is perfectly applicable in the case of *Physophora*. In other genera the designation "Saftbehälter" may seem better; but here in *Physophora* their function seems different from that of the same part in most of these animals. The filamentary appendage to the taster in Physophora, although very easy to see, has been overlooked by several naturalists. (See Kölliker, *Schwimmpolypen von Messina*. Vogt, *Siphonophores de Nice*. Leuckart, *Siphonophoren von Nizza*, p. 106.) According to Keferstein and Ehlers (*l. c.*, p. 31), these appendages to the taster were discovered by Philippi, but were omitted in the descriptions by naturalists who followed him until the investigations of Sars. In his *Anatomy of Physophora*, Claus (1860) speaks of them (p. 17), but has no representation of the filament in his figure of the genus. (Claus, *Ueber Physophora hydrostatica nebst Bemerkungen über andere Siphonophoren*, Zeitsch. f. Wiss. Zool., Bd. X. p. 1, fig. 1. Philippi, in Müller's *Arch. f. Anat. u. Physiol.*, p. 61, Taf. 5, fig. 4. Sars, in Middelhavet's *Littoral Fauna*, p. 4.)

around the base of the knob. If we watch the growth of this collar, which is the outer differentiated layer of the ectoderm, it will be found to gradually grow down around the sacculus until it has almost completely enclosed it, leaving, however, an opening at the distal pole of the knob, through which the end of the sacculus, or certain appendages to the extremity of this organ, project. (Pl. I. figs. 4, 5.)

Meanwhile, the sacculus has passed through certain changes, the most important of which is a coiling up of itself within the envelope of the involucrum, and the formation at its extremity, where it projects through the opening of the involucrum, of certain appendages of a provisional nature. The earliest condition of the sacculus is simply the terminal transparent part of the flask-shaped body already mentioned. It is now a complicated organ armed with lasso cells, and with its walls highly colored. The provisional structures at the distal end of the sacculus (Pl. I. figs. 4, 5, 6, 8) are mentioned and figured by most of those who have studied the young knob of *Physophora*. They have been seen in both species, but do not appear to exist in the fully developed form of the knob, either in *P. hydrostatica* or *P. Philippi*. The accompanying growth of another part of the young knob is destined to change materially the appearance of the whole, as well as the relative development of the parts. This change takes place contemporaneously with the enclosure of the sacculus by the involucrum, and the appearance of those provisional terminal filaments which I have already mentioned. The alterations of form to which I refer are as follows. The proximal or basal part of the spherical-shaped expansion of the young knob enlarges on one side, and in such a manner that the knob as a whole assumes an asymmetrical shape. (Pl. I. fig. 4.) This want of symmetry is brought about by an unequal growth in the two sides of the basal part of the knob itself. In a still more developed stage of the same structure the inequality in growth has gone still further, and the enlargement lengthens and extends along the side of the sacculus, now coiled on itself, carrying with it the former place of attachment of the sacculus, which is to be found at the opposite pole from its former junction. (Pl. I. figs. 5, 6.)

Meanwhile the knob is approaching its fully-grown form, and the terminal filaments become absorbed; the opening at the distal pole of the involucrum closes or is very much reduced in size, and the enlargement in the spherical cavity, which earlier gave the asymmetrical form to the whole knob, appears as a simple tube following down along the side of the knob from the pedicel to the place of attachment of the sacculus, at

the opposite end from its original junction. In the structure formed by these changes we have the fully-grown condition of the complicated knob of this Jelly-fish. (Pl. I. fig. 7.)

The resemblance of certain of the earlier stages in the growth of this organ, or individual if one so designates it, to the adult in a different genus is very great. *Athorybia* has a tentacular knob with many points of resemblance to the undeveloped forms which have just been described. The figures of the knob of this genus, as given by Gegenbaur, Kölliker, and Huxley, show a close likeness to the younger stages of the knob in *Physophora.*

While emphasizing this asymmetrical growth of the knob of the young *Physophora*, and suggesting a likeness to the same structure in the genus *Athorybia*, I recall the figures of the knob in the younger stages of an *Agalma*, called by Leuckart *Agalma clavatum.* As Claus suggests, this species is probably the young of *Agalma Sarsii.* Leuckart's figures of *A. clavatum* show a knob which assumes a similar asymmetrical shape to that which exists in the knob of *Athorybia.* This naturalist* has already made the comparison of a tentacular knob of *A. clavatum* with the same structure in *Athorybia.* The comparison seems to me a good one, and does not prevent a comparison of both to the undeveloped tentacular knob of *Physophora hydrostatica.* A likeness is further indicated by the existence in each genus of terminal filaments on the sacculus, provisional to be sure in *Physophora*, but none the less definitely pointing out the relation of the structures under consideration.†

II. The Mantle-Tubes of Apolemia uvaria and Gleba hippopus.

A wish to find out the homology of the somatocyst of the Calycophores led me to a study of the chymiferous tubes of the swimming-bells throughout the tubular Jelly-fishes. Especially in *Apolemia* and *Gleba*, from their aberrant forms, I hoped to find some facts bearing on the solution of this question; and when I came to see the former of these genera for the first time, my thoughts were turned to the question of its mantle-tubes. This genus, in many respects allied to the Calycophoridæ, is a true Physophorid; yet, in the published description of its nectocalyces, I find no mention of any structure which, I think, can be truly known as the

* Siphonophoren von Nizza, Pl. XIII. Fig. 5, p. 91.

† I find these structures in *hydrostatica* more leaf-like than they are represented in Keferstein and Ehlers's plate of *Physophora Philippi.*

mantle vessel. The four radial tubes of the bell, and the appendages to the lateral pair, have been well figured and described. Leuckart seems to liken rudimentary offshoots of the lateral vessels to mantle-tubes. I do not think these offshoots more than very distantly comparable with that special pair of vessels, which arises from a tube medially placed in the bell, connecting the junction of the radial system with the stem cavity of the animal. Such mantle-tubes, for instance, as are to be found in *Agalma*, *Gleba*, or other genera, do not seem to have been observed in the nectocalyx of *Apolemia*. I think, however, that I have found in the bell of *Apolemia* a structure homologous to the mantle-tubes in the Physophoridæ, and represented in the Calycophore by the somatocyst.

The mantle-tubes in *Apolemia* are difficult to make out, but seem to differ only in their size from those in *Gleba*. Radial tubes in these two genera, however, differ very greatly; for while in the one they reach a development hardly equalled among Siphonophores, in *Gleba*, where the cavity of the bell is very shallow, and the nectocalyx itself is more of a bract than a swimming-bell, the chymiferous tubes have a minimum development. So rigid is the nectocalyx of *Gleba* that the walls admit of little motion, and most of the propulsion is done similarly to that of *Circe* and other Trachynemidæ, by a movement of the velum, a crescentic-formed vail surrounding the opening into the shallow bell cavity. As a consequence, the radial system is quite diminutive in size. Nowhere among Siphonophores better than in the genus *Gleba* do we find a nectocalyx (Pl. III. Figs. 4, 5), when fully grown, so closely resembling a bract, and it seems to me that a better proof of the homology of the central tube of the bract or covering scale with the mantle vessel of a nectocalyx could hardly be desired.

Apolemia has a float and a true Physophorous nectocalyx,* while *Gleba* has no float, and is radically different from the Calycophoridæ, although its multiplicity of nectocalyces is a true characteristic of the Physophoridæ. Therefore I think that the Hippopodidæ should make one of the three great groups into which the Siphonophoræ may be divided, and be considered an equal division with the Physophoridæ and Calycophoridæ.

* I figure (Pl. I. Fig. 1) a fragment of an *Apolemia*, without nectocalyx or float. I have already published a representation of the nectocalyx of *Apolemia*. Proc. Bost. Soc. Nat. Hist., Vol. XX.

III. The Tubes in the larger Nectocalyx of Abyla pentagona.

The best description which I have found of the course of the chymiferous tubes of *Abyla pentagona* is by Gegenbaur.* At the regular meeting of the Boston Society of Natural History, on November 5, 1879, I pointed out the existence in *Abyla* of a supplementary tube, which takes an origin from the junction of one of the radial vessels with the circumvelar tube, and extends diagonally across one quadrant of the bell, ending in an enlargement of a peculiar kind. I also indicated the difficulties which present themselves to a determination of an homology between the chymiferous tubes in *Abyla* and other nectocalyx-bearing Siphonophores, on account of these supplementary tubes. The bilateral symmetry shown quite well in the swimming-bells of other Calycophoridæ, as *Epibulia*, *Diphyes*, and *Praya*, in the Hippopodidæ, and in *Agalma*, *Agalmopsis*, *Halistemma*, *Apolemia*, and *Physophora* of the Physophoridæ, does not appear in the different spheromeres of *Abyla*. In all cases except *Abyla*, bilateral symmetry, as referred to a plane passing through two opposite chymiferous tubes of the bell, and the ventral line of the stem, is very easy to make out. The want of symmetry in *Abyla* is the result of a covering in of the "Längskanal" by a growth from one of the bounding ridges of the bell. A like covering of the canal is to be seen in *Monophyes*, where the nectocalyx is hemispherical, with none of those marked elevations and projecting points continued beyond the opening of the bell which are so prominent in *Abyla*, and to which it owes both of the specific names *pentagona* and *trigona*. I have noticed no variation from a normal arrangement of the chymiferous tubes in *Monophyes*. (Pl. III. fig. 6.)

IV. On Halistemma, Agalma, and Agalmopsis.

The adoption of the generic name *Halistemma* has now become almost universal, and seems necessary for a proper understanding of the genera of Siphonophores, about which there has existed considerable confusion. The following animals have, I think, been erroneously placed in this genus; viz. *Halistemma tergestinum*, Claus, and *Halistemma carum*, Haeckel. Huxley, in "Oceanic Hydrozoa," proposed the name for certain forms of tubular Jelly-fishes, with elongated axes, biserial rows of swimming-bells, and naked tentacular knobs with a single terminal filament. The genus *Agalma*, by his classification, was to include those the

* Neue Beiträge zur Näheren Kenntniss der Siphonophoren. Nova Acta Carol., Vol. XXVII., 1860, pp. 349–356.

tentacular knobs of which had two lateral terminal filaments, while *Stephanomia* had but a single filament of this kind, although the last two genera have a biserial row of nectocalyces and an involucrum.

There are certain other characteristics of this genus which are not so well marked as those already given by Huxley. I refer to the character of the tentacles, and more especially to the position of the sexual organs. Tentacles such as we find in *Agalma* do not seem to exist in the genus *Halistemma*, but the tentacular knobs have very long pedicels, longer than in other Physophoridæ, which allow the knob to project so far beyond the covering scale as to resemble tentacles very closely. According to some observers true tentacles do exist in the genus Halistemma. For instance, Leuckart says that Kölliker missed the true tentacle, and mistook the pedicel of the knob for a tentacle itself.* Kölliker's figure of *Agalmopsis punctata*, which is the same thing as *Halistemma rubrum*, shows the absence of the tentacles very plainly. My observations on the tentacle agree with Kölliker's, yet his figure of the animal is not complete, in that he failed to represent the sexual system. The female sexual organs I shall later describe. (Pl. I. figs. 3 – 5.) Leuckart* figures a true tentacle in *Halistemma*. What Claus describes as *Halistemma tergestinum*† does not seem to belong to *Halistemma* in the signification given to the generic name by its founder, Huxley. It belongs rather to Huxley's genus *Stephanomia* in all its structure, but especially in the character of its tentacular knobs, a feature of greatest importance in the classification of the Physophoridæ.

Haeckel (*Entwickelungsgeschichte der Siphonophoren*) proposes a division of the Agalmidæ which has some advantages, although to use the trifid character alone of the tentacular knob as a basis of his subfamily Crystallodacea separates those with an involucrum, and places *Agalmopsis* (*Stephanomia*, Huxley) with *Forskalia* and *Halistemma*. These last have no involucrum in the tentacular knob, and the former has sexual organs arising at the base of a polyp, while the latter has these same structures midway between two tasters. There does not

* Leuckart, Zur Nähern Kenntniss der Siphonophoren von Nizza, Taf. XII. fig. 15. When I studied Halistemma, I did not know of this difference of observation by Kölliker and Leuckart.

† 1. Metschnikoff, Proc. So. Fr. Nat. Moscow, Vol. VIII.; Studien der Medusen und Siphonophoren, Zeitsch. f. Wiss. Zool., Bd. XXIV.

2. Claus, C., Ueber Halistemma Tergestinum, &c., Wien, 1878. Mittheilungen über Siphonophoren und Medusen Fauna Triests, Zool. bot. Gesell. Wien, Tom. XXVI.

3. Eschscholtz characterized the genus Agalma, "Tentacula ramulis clavatis : clava apice bicuspidata."

seem to be sufficient ground for such a subdivision. I think it would be better if all were placed with *Athorybia*, as separate genera, in the Agalmidæ, and no subdivision of the group of any other kind at present attempted.

In the *Neue Beiträge*, Gegenbaur substitutes the name *Stephanomia* for that of *Forskalia* to designate a well-known form. He says, however, nothing about the genera *Halistemma* and *Agalmopsis*, and neither appears in his scheme of classification at the end of that work. Possibly he considers both as simply species of Agalma.

That which Claus in the last year (1879) has described and figured under the name of *Agalmopsis utricularia*, ought to be a new genus rather than a species of *Agalma* or *Agalmopsis.**

There seems no reason why the name Stephanomia, which Lesson applied to both *Stephanomia contorta* and *Apolemia uvaria* of later authors, should designate the form with a biserial row of nectocalyces that it now does. Apolemia (Pl. I. fig. 1) is a well-marked genus. Leuckart adopts the name Forskalia of Kölliker in his *Siphonophoren von Nizza*, and in his *Zoologische Untersuchungen* applies the name Stephanomia to the same genus. He rightly says of the so-called *Forskalia* that it was first described by Milne-Edwards under the name of *Stephanomia contorta* (*Siphonophoren von Nizza*, p. 93).

St. delle Chiaje's use of the generic name, in a description of *Stephanomia ophiura*, although hardly accurate enough to be quoted in this discussion, should be mentioned. His designation of a species as *ophiura* is still retained in the nomenclature, and the form is easily to be known from *contorta*, from which even the fishermen of Messina distinguish it, although they affix to both a characteristic name, "Pinie di Mare."

Kölliker (*Siphonophoren von Messina*, p. 18) says that Lesson is wholly in error, "Wenn er die *Stephanomia contorta* und *prolifera* von Milne-Edwards zu derselben (*Apolemia uvaria*) zieht." In the *Nachtrag* to the same work he says: "Immer hin bleibe ich bei dem Genus Forskalia das nach einem vollständigen Thiere gebildet ist und kann der Name Stephanomia für das nur unvollständig bekannte Thier bleiben für das er von Peron zuerst aufgestellt wurde." The "unvollständig bekannte Thier" was that same form whose anatomy Huxley later published under the name which Peron gave it, although he says that Peron's sketch has "no scientific value." What animal Peron had will

* Claus, Agalmopsis utricularia eine neue Siphonophore des Mittelmeeres, Arbeiten aus dem Zoologischen Instituts der U. Wien und der Zoologischen Station in Triest, Bd. II. 2 Heft.

always remain problematical, and there is no good reason to identify the form studied by Huxley with it.

In the *Grundzüge der Zoologie*, 3 Auf., p. 237, Claus includes in the family of Agalmidæ *Forskalia* (*Stephanomia*, M. E.), *Halistemma*, and *Agalmopsis*. He, like Haeckel, mentions *Nanomia cara* as a species of *Halistemma*, and says that *Stephanomia* (Peron) is included in the same genus. Packard follows Claus in this reference of *Nanomia* to *Halistemma*.

In *Nanomia cara*, the first formed structure in the larva, according to Mr. Alex. Agassiz, is the float, as in *Agalmopsis* (*Stephanomia*, Metsch.). In Halistemma, according to Metschnikoff, the swimming-bell and float develop together from the very first. Although it is possible that the float is simply a modified Medusa bell or nectocalyx, no one would mistake the young of *Halistemma* for that of a *Nanomia* larva. As Metschnikoff has already pointed out, *Nanomia* in its younger stages resembles the genus *Agalmopsis* * (*Stephanomia*, Metsch.). Huxley's classification of the Siphonophoræ, with a verbal change, is the best which has been proposed as far as the Agalmidæ are concerned. We can retain the three generic names *Agalma*, *Agalmopsis*, and *Halistemma*. That would keep Eschscholtz's genus to designate a Physophorid with a trifid tentacular knob, the *Agalmopsis* of Sars with a single terminal filament on the same structure, and *Halistemma*, a form the tentacular knobs of which do not have involucra, and the tentacle is replaced by the pedicels of the tentacular knobs. In addition to the genera *Agalma*, *Agalmopsis*, and *Halistemma*, I would include *Athorybia* among the Agalmidæ, on account of its embryonic likeness to *Agalma*. It may possibly be simply the young of this genus. The only other Physophorid, except *Stephanomia* (*Forskalia*), where we have a multiserial necto-stem, is *Physophora tetra-*

* Notwithstanding Sars figures three radically different kinds of knobs in his genus *Agalmopsis*, a condition only observed, with this exception, in *Rhizophysa* and the larval forms of certain Agalmidæ, his figures 5, 6, on Plate V. are among the earliest, if not the first, representations of a tentacular knob with an involucrum and a single terminal filament. I retain, therefore, the name which he has given for the Jelly-fish with this characteristic, particularly on account of the exact use of *Stephanomia* by Milne-Edwards (Ann. d. Sci. Nat. 1841, Tom. XVI. p. 217). See also Leuckart's note, Siphonophoren von Nizza, p. 93 ; and Huxley, Oceanic Hydrozoa ; Sars, Fauna Littoralis Norvegiæ, 1846. In Middelhavet's Littoral Fauna, where all descriptions of Siphonophores are simply numbered, and with no subdivision, *Agalma rubrum* (*A. punctatum*, Köll.) is followed directly by *Agalma Sarsii*, a species with a trifid tentacular knob. In that work Sars makes no mention of the genus with a covered (by an involucrum) tentacular knob and a single terminal filament.

stica of Philippi (Müller's Arch., 1843). Leuckart thought (*Siphonophoren von Nizza*, p. 106, note 2) that this species ought to be made a new genus. I have not found the form redescribed by any naturalist since Philippi, and, although I have frequently taken *Physophora hydrostatica* and *Philippi* in my excursions on the Mediterranean, I have never seen *tetrastica*. Gegenbaur's view, to which Keferstein and Ehlers also incline (*Zoologische Beiträge*, p. 30, note 7) seems a good explanation of the apparently multiserial arrangement of nectocalyces spoken of by Philippi. Gegenbaur suggests that this multiserial character of the necto-stem in *tetrastica* is brought about by an accidental twisting of the necto-stem, a thing which often happens in *Physophora*, *Agalma*, and *Halistemma*. An *Agalma* which answers to Leuckart's description of *A. clavatum* was found in such numbers as to give me almost a perfect series between it and *Agalma Sarsii*. It was not possible, however, for me to raise the latter from the former, but the evidence which have mentioned seems enough to prove the identity of the two. Claus * has already made a similar suggestion. I have frequently taken at Villefranche a Jelly-fish identical, I think, with that which has been described by Claus as *Halistemma tergestinum*, and by Metschnikoff as *Stephanomia pictum*. A description of this animal, which I had formerly thought new to science, I had prepared without any intimation of the previous work of these naturalists. *S. pictum* was taken by Metschnikoff from the same locality where my studies were made. I think from the character of the tentacular knobs that we have in this interesting Siphonophore a true *Agalmopsis* as I have limited the genus, or a Physophorid with an elongated stem, no part of which is enlarged into a sac as in *Physophora*, and which is furnished with only a biserial row of nectocalyces. In addition it has a tentacular knob possessing an involucrum and a single filament. Metschnikoff's change of the Jelly-fish described by him, which is probably the same, from the genus *Halistemma*, to which he at first referred it, to the genus commonly known as *Stephanomia*, was well made.

The feature which distinguishes *Agalmopsis* (*Stephanomia*, Metsch.) *picta* from *Halistemma*, together with those already mentioned, is the position of the sexual organs (Pl. I. figs. 1, 3, 6), and, less definitely, the small size of the covering scales as compared with the nectocalyces. The crimson and orange sexual organs in *H. tergestinum*, as Claus figures them, and as I have also observed, are clustered, both male and female, at the base of a taster (Pl. I. fig. 6), the male mounted on an

* Zeitsch. f. Wiss. Zool., Bd. XII. p. 559.

especial stalk, and not separated from the taster, as in *H. rubrum*. The bracts are small, and so transparent that at first sight one is inclined to doubt their existence in *Agalmopsis picta*, while in *Halistemma* they are large and conspicuous. This feature effects very considerably the relative forms of the two Jelly-fishes.

All along the necto-stem and polyp-stem of *Agalmopsis picta*, more especially, however, upon the former, there are to be found in the ectoderm, as Claus has already mentioned, bright crimson pigment spots more clearly marked than is generally the case with similar spots on the stem of other Siphonophores. Two of these pigment spots, together with a finger-like process near them, also exist on the young nectocalyces. In very young swimming-bells there are three of these pigment spots. They occupy a position similar to that of the pigment spots of other hydroid Medusæ, at the junction of the lateral and superior * tubes with the circumvelar vessel. There are very interesting highly refractile red spots of a problematical function covering the bracts in *Agalma Sarsii* and *Agalma clavatum*. (Pl. I. fig. 2.) These bracts, from the place of attachment and the twisting of the stem, form a well-marked spiral around the polyp stem of the animal. The spots on each side of a central line are arranged on every scale in irregular rows, extending longitudinally across the bract, each pigment spot being enclosed in a cell. These peculiar pigment spots of the covering scales, represented remotely also in some genera, as in *Apolemia* (Pl. I. fig. 1), by elevations composed of clusters of cells on the surface of the bract, are the most apparent structures in the transparent bract of *A. Sarsii*, since with that exception there is hardly any coloration in the covering scale. In *A. clavatum*, the sexually mature young of *A. Sarsii*, only four rows of these pigment spots occur, as Leuckart has shown. When the bracts which bear these paralleled rows of spots are detached from the axis, their color changes to a yellow, and a fluid of the same color exudes into the surrounding water. I have not been able to find any mention of this rupture of the cell wall and discharge of a yellow fluid when the bract is detached, in the descriptions by other naturalists. I think these scale cells belong to the ectodermic layer.

* A nomenclature of the different spheromeres of the nectocalyx of a Siphonophore would simplify a description of the bell. As paired chymiferous tubes opposite each other have resemblances in their course from their relation to a plane passing through the dorsal and ventral line of the stem, they may be called lateral tubes, and the respective sections of the bell in which they lie, lateral spheromeres. The remaining spheromeres, according to their position in relation to a float, where such exists, may be called the superior, or the inferior, corresponding with a proximal and a distal.

The pigment spots mentioned in the nectocalyx of *Agalmopsis picta* have no resemblance to these peculiar bodies on the bracts, nor do they change their color when the swimming-bell is detached. The presence of such spots on the younger bell of *Agalmopsis picta*, and so little developed on the adult, rank them among patterns of embryonic coloration, examples of which are not unknown on other structures of these animals. *Stephanomia* * (*Forskalia*) has a similar large yellow spot, which persists in the adult nectocalyx, at the junction of radial and circular tubes.

The different stages in development of the female sexual organs of *Halistemma* have never been described or figured. Kölliker,† in his plate illustrating this genus, does not even represent these parts, and Leuckart‡ figures the female organs as a botryoidal structure, at the apex of a single polyp-like stalk. In several specimens, in addition to a structure of this kind, we have, as I have figured (Plate II. Fig. 3), others with the stalk on which the botryoidal mass is borne bifid at its extremity. This is probably simply another stage in development of these organs. As Leuckart well says, the sexual organs in *Halistemma* have no direct connection with the tasters; still, the female structures, at times, arise very near them.§

* The single yellow pigment spot at the junction of radial and circular tubes in *Stephanomia* (*Forskalia*) has on each side a finger-like process, and also, separated from these only by a short distance, an additional pair of the same rudimentary tentacles, as they may be called. The pigment spot is mentioned by Kölliker, who also calls attention to one pair of these tentacles or processes. He says: "Der Pigmentfleck ist insofern interessant als bei *keinerandern* Siphonophore Pigmentirungen de Schwimmglocken beobactet wurden." (Schwimmpolypen von Messina, p. 4.)

† Kölliker, Schwimmpolypen von Messina, Tab. IV.

‡ Leuckart, Zoologische Untersuchungen, Tab. II. fig. 14; Siphonophoren von Nizza, Tab. XII. fig. 15.

§ Claus says (*H. Tergestinum*, &c., p. 45): "Wo man bei verwandten Agalmiden die Sprossung der Geschlechts-träubchen am Stamme beschreiben findet representirt entweder der Stiel des Träubchens einen Taster dessen Endabschnitt kurz und verkümmert bleibt oder aber der Tasterschlauch hat sich von Stiele gelöst und ist abgefallen." The resemblance to a taster of the stalk upon which the botryoidal female organs of *Halistemma* are borne, is very small. However, in *Agalmopsis* and *Stephanomia* (*Forskalia*) we find the sexual system at the base of the true taster, which seems to support Claus's suggestion. Huxley, who had not seen the genus *Halistemma* when "Oceanic Hydrozoa" was written, says of reproductive organs that they are like those of *Stephanomia*, and are attached directly to the cœnosarc. The sexual organs have no similarity in point of attachment, as can be seen from my figures of these two genera (Pl. II. figs. 1, 3); for while in the case of *Halistemma* they arise directly from the stem, in *Agalmopsis* (*Stephanomia*) they are united to the base of the taster.

V. Notice of a few Siphonophoræ and Velellidæ from the Eastern Coast of the United States.

Up to the present time few forms of either of these groups of Jelly-fishes have been described from the waters of our bays and sounds. They seem to be only occasional visitors, blown into the neighborhood of our shores from mid-ocean, or brought there from the tropics by the Gulf Stream. The wealth of tubular Medusæ which one finds in the Mediterranean is unknown on New England coasts or in Charleston Harbor, localities in which these animals have been best studied. Upon many single excursions on the quiet bays near Nice, in Southern France, I have taken eight different genera of Siphonophoræ; but their rarity is so great at Newport that seldom have more than one or two genera been taken by me in the same day; and a whole summer, in which I was almost daily upon the water, has passed without the observation of a single genus. A similar case of absence of all pelagic animals happened at Villefranche, last November. In that month, although I was on the water daily, I observed not only no Siphonophores, but also none of those Heteropods and Pteropods which later appeared in such numbers. Certain of the Siphonophoræ, however, are more abundant with us than in Villefranche, Naples, or Messina. *Physalia caravella* is now rarely taken in numbers by naturalists at either of these stations; but many examples of *Physalia arethusa* may be found almost any summer in Vineyard Sound or the entrances to Narragansett Bay.

The well-known *Physalia arethusa* is the most common of New England Siphonophores. It was long ago described by one of the pioneers in the study of Jelly-fishes, and later beautifully figured by Prof. Agassiz in the Contributions to the Natural History of the United States. Prof. McCrady* describes a form, *Physalia aurigera*, which is considered by Mr. Alex. Agassiz† as the same species. In the Catalogue of the North American Acalephæ, the list of places from which specimens of *Physalia arethusa* had been taken includes localities all the way from Cape Cod to Florida, and beyond in the West Indies.

The two floating Hydroids, *Velella* and *Porpita*, so closely allied to the Tubularians and known as the Velellidæ, are also found in our waters. The problematical genus *Rataria*,‡ by some supposed to be the young of *Velella*, in swarms of which it is generally found, and by others an immature *Porpita*, I think has not been described from our coast. I

* Gymnopthalmata of Charleston Harbor, 1857.

† North American Acalephæ, 1865.

‡ Pagenstecher, Zeitsch. f. Wiss. Zool., Bd. XII., 1863.

find no mention of it from New England waters. According to Agassiz, our *Velella* is *Velella mutica* of Bosc. Of that identification there seems no doubt, considering where the animal which Bosc described was found; but, as Pagenstecher* and Delle Chiaje suggest, it is difficult to see exactly what Bosc meant by his other species, *tentaculata*. The former of these authors says Bosc called the *Velella* of Linné and Lamarck *mutica*, while the species *spirans* of Forskal received the name *tentaculata*. Mr. Alex. Agassiz mentions a *V. septentrionalis* from our Pacific coast. Some of the material for the earliest descriptions of the Siphonophoræ and Velellidæ was collected in the Pacific Ocean, and near our western shores, and we should naturally expect these species taken by early voyagers from those localities.

Porpita I have never seen alive in our waters, but have a dried specimen preserved on paper after the manner of a plant, taken by a sailor not far from Nantucket. Prof. McCrady describes a species of *Porpita* from Charleston Harbor, not very different from Guilding's *Porpita* (*Polybrachionia Linneana*), which he calls *Porpita Linneana*. He is inclined to think it a new species.

The only known member of the long-stemmed Siphonophoræ, provided at one end with a float or air-bladder, which has been described from New England waters, is *Agalmopsis cara* (*Nanomia cara*, A. Ag.; *Stephanomia cara*, Metsch.; *Halistemma carum*, Haeckel, Claus, Packard, and others). This animal was first described by Mr. Alex. Agassiz, to whom we owe so much of our knowledge of the Jelly-fishes of our waters. The drawings and descriptions of the development which he gives are not only the earliest of this particular genus, but, with those of Claus, Leuckart, Kölliker, and Gegenbaur, of the embryology of the Siphonophoræ as a whole.

As I have already said, Haeckel considers *Nanomia cara* a species of *Halistemma*, and places it under this genus in his table of the Agalmidæ. He seems to have been followed by Claus, who adopts the name *H. carum* in his *Grundzüge der Zoologie*. When Mr. Agassiz described the form he said it was closely related to *Agalmopsis* as well as *Halistemma*, but that the mode of arrangement of the swimming-bells and the nature of the tentacles of the feeding polyps show undoubtedly that it cannot be placed in the same genus as *Agalmopsis*, having in mind Sars's genus. *Nanomia cara*, according to Metschnikoff, as already shown, should be regarded as a species in the genus *Stephanomia*. The reason for his conclusion, he says, is on account of the resemblance between the larvæ as figured

* Pagenstecher, Zeitsch. f. Wiss. Zool., Bd. XII., 1863.

by Mr. Alex. Agassiz and Kowalevsky. He says: "Die Aelteste von Kowalevsky gezogene Larve mit Luft apparat Magen und Fang faden gleicht so sehr dem jungsten von Alex. Agassiz gefangenen Jugendzustande der Nanomia, dass es mir sehr wahrscheinlich ist, dass auch diese Physophoride in die Gattung Stephanomia eingezogen werden muss zumal zwischen beiden eine grosse anatomische Analogie besteht." The absence of the cap-shaped provisional bell in the very young *Nanomia* shows that it does not belong to the genus *Agalma*, and the fact that a float and not a nectocalyx is first developed, separates it from *Halistemma*. Metschnikoff's conclusion seems to me the most natural one. I therefore would refer it to the genus *Agalmopsis*, of which I regard *Stephanomia*, as ordinarily used, a synonym.

There are certain points in which, following the description by Mr. Alex. Agassiz (North American Acalephæ, pp. 200 – 213), *Nanomia* differs from the other related Siphonophoræ which I have studied. He says that the float in this genus contained a globule of oil. I have never seen the genus fully grown in our waters, and can only judge from my studies of most of the other genera of the justness of Metschnikoff's criticism (Studien der Medusen und Siphonophoren, p. 36) of Alex. Agassiz on this point. If the float does contain oil, I think it an exceptional case among Siphonophores.

The second kind of feeding polyps, as described in *Nanomia*, are, I believe, simply immature forms of the first, and the tightly-coiled corkscrew parts are only undeveloped tentacular knobs. I have often found the young knobs of *Agalma Sarsii* and *A. elegans* clustered in the same manner at the base of a feeding polyp before a true tentacle had been formed.

The resemblance of the tentacular knob of *Nanomia*, with its "cnidofils," as shown in Mr. Agassiz's drawing (Fig. 339), to the provisional structures bearing the same name in *Agalmopsis picta* and the "Athorybia stage" of *Agalma*, is very great. This likeness is a very interesting fact, indicating either an embryonic condition of the adult of *Nanomia*, or that it is the larval form, sexually mature, of another Siphonophore.

The origin and earlier development of *Nanomia cara*, according to Mr. Agassiz, as a bud from the stem, is, I think, exceptional. In those other Siphonophores whose development is more or less completely known through the studies of Claus, Haeckel, Kowalevsky, and Metschnikoff, we find only an egg development of the new colony.

Dana describes (Mem. Amer. Acad., Vol. II. Part I.) a Physophorid from the Pacific Ocean. He calls it *Crystallomia polygonata*. The

figures which he gives of the tentacular knob seem to show that it is the genus *Agalma* of Eschscholtz. Haeckel refers it to his genus *Crystallodes*. The whole embryological history of *Agalma* and *Crystallodes*, with the exception of the appearance of a yolk-sac in the latter, according to Haeckel, as Metschnikoff says, is very much the same. Dana published his description in 1857, two or three years after the great works by the German naturalists on the Siphonophores of the Mediterranean.

I know of two genera of Leuckart's Calycophoridæ, a group of Siphonophores, which appears to me well defined, which have been described from our eastern coasts. In his "Gymnopthalmata of Charleston Harbor," Prof. McCrady describes and figures a new diphyozoid, which he names *Eudoxia alata*, and a new *Diphyes*, *D. pusilla*. His *Eudoxia alata* seems to be the same as *E. Lessonii* of Huxley. This animal, according to this prominent English naturalist, is the diphyozoid of *D. appendiculata*, a synonym of Leuckart's *D. acuminata*. The mention which Prof. McCrady makes of *Diphyes pusilla* is too short to be of service in distinguishing it from Mediterranean Diphyidæ. A figure of a *Diphyes acuminata* from Villefranche may have some interest, especially as its diphyozoid, *Eudoxia Lessonii*, has been found by me at Newport. Leuckart mentions in his *Siphonophoren von Nizza* an *Epibulia* (*Galeolaria*), given him by Philippi, and taken from the coast of Greenland.

To the Siphonophorous fauna of eastern coasts of North America* I can add a new member of the Agalmidæ, probably the same as Sars's *Agalmopsis elegans*, and the two diphyozoids, *Eudoxia Lessonii* and *Diplophysa inermis*. There is a great diversity of opinion among naturalists what Diplophysa is. All seem to be united in the opinion that it is a diphyozoid, but there is an unanswered question of what Calycophore it is the fragment. I mention a few of the opinions. Gegenbaur,† who first described the form, seems to think its resemblance not very distinct from *Ersœa truncata* of Will. On page 366 of his *Neue Beiträge* he says that "Sie (Diplophysæ) entsprechen in der Sculptur der Diplophysen-gattung Praya." *Praya* is probably the same as *Ersœa*. Huxley (Oceanic Hydrozoa, p. 66) says that *Diplophysa inermis* has some resemblance to the diphyozoid *Cucubalus* described by Quoy and Gaimard, but says he was unable to arrive at any definite opinion as to what animals were included by the French voyagers in their genera *Cymba* and *Cucubalus*.

* My observations on American Siphonophores were made in the laboratory of Mr. Agassiz, at Newport, R. I.

† Beiträge zur näheren Kenntniss der Schwimmpolypen (Siphonophoren).

The title of one of Claus's valuable papers on the Siphonophoræ is *Die Gattung Monophyes und ihr Abkömmling Diplophysa*, in which he supports the idea that Diplophysa is a diphyozoid of *Monophyes gracilis*, Cls. He makes Huxley's genus *Spheronectes* a synonym of *Monophyes*. He repeats in his *Grundzüge der Zoologie*, 3 Auf., 1876, that *Diplophysa inermis* is a diphyozoid of *Monophyes gracilis*, as stated above.

Metschnikoff (Studien über die Medusen und Siphonophoren, p. 46) says, concerning the relationship of these animals, that fragments of the form *Praya inermis* were described by Gegenbaur as *Diplophysa inermis*. He bases his idea of the relationship of these two genera on the identity of the larva of *Praya*, which he describes, with the remarkable genus of Gegenbaur, and more especially on the resemblance in the form of their nectocalyces. He adds also, that both genera are of small size, which cannot, if taken alone, be a very strong argument for their relationship.

TABULAR LIST OF VELELLIDÆ AND SIPHONOPHORÆ,

FROM THE EASTERN COAST OF THE UNITED STATES.

VELELLIDÆ.

Velella mutica, Bosc.
Agassiz, L., Cont. Nat. Hist. U. S., Vol. IV. p. 366, 1862.
Agassiz, A., North American Acalephæ, p. 216, 1865.
Velella spirans.
V. tentaculata (?), Bosc.
Porpita Linnæana, Less.
McCrady, Gymnopthalmata of Charleston Harbor, 1857.
Agassiz, A., North American Acalephæ, 1865.
Porpita gigantea.
Fewkes, Nantucket.

SIPHONOPHORÆ.

I. Physophoridæ.

1. Agalmidæ.

Agalma elegans, Fewkes, Newport.
Agalmopsis elegans, Sars, Fauna Littoralis Norvegiæ, 1846.
Agalmopsis (sp. ?).
Nanomia cara, Agassiz, A., North American Acalephæ, 1865.
Halistemma carum, Haeckel, Ent. d. Siphonophoren.
Stephanomia cara, Metschnikoff, Zeitsch. f. Wiss. Zool., Bd. XXIV., 1874.

2. Physalidæ.

Physalia arethusa, Til.
Agassiz, L., Cont. Nat. Hist. U. S., 1862.
Agassiz, A., North American Acalephæ, 1865.
Physalia aurigera, McCrady.
Mr. Agassiz suggests that this is the same as *Physalia arethusa* of Tilesius.

II. Calycophoridæ.

1. Diphyidæ.

Diphyes acuminata, Leuck. The diphyozoid of this Siphonophore is *Eudoxia campanulata.*

Eudoxia campanulata, FEWKES, Newport.
Eudoxia Lessonii, HUXLEY, Oceanic Hydrozoa.
Eudoxia alata, MCCRADY, Gymn. of Charleston Harbor.

Diphyes pusilla, MCCRADY, Gymn. of Charleston Harbor.

2. PRAYIDÆ.

Praya inermis has, according to METSCHNIKOFF, the diphyozoid *Diplophysa inermis* (GEG.).
Diplophysa inermis, FEWKES, Newport.

In this incomplete list of tubular Jelly-fishes, we miss many of those beautiful forms which are so familiar to the naturalist on the Mediterranean. Extended observations in our Southern bays will probably bring to light the well-known Siphonophores common to all oceans, *Apolemia*, *Abyla*, *Physophora*, and *Gleba*. Some of these have already been taken in the Gulf of Mexico and Caribbean Sea. *Rhizophysa*, found in the same localities, may also be expected, brought by ocean currents to our coasts.

CAMBRIDGE, April 1, 1880.

EXPLANATION OF THE PLATES.

a, float; *b*, nectocalyx; *c*, necto-stem; *d*, polyp-stem; *e*, feeding polyp; *f*, taster; *g*, ovaries; *h*, testes; *i*, tentacle; *j*, tentacular knob; *α*, involucrum; *β*, sacculus; *γ*, pedicel; *δ*, terminal filaments; *k*, tentacle of the taster; *l*, somatocyst; *n*, radial tubes; *o*, circular vessel; *p*, covering scale; *q*, longitudinal canal; *ec*, ectoderm; *en*, entoderm; *r*, joint in polyp-stem; *s*, nectocalyx of diphyozoid; *t*, crescentic-formed velum in Gleba.

The mantle-tubes, somatocyst, and central tube of the bract or covering scale are designated by the letter *l*. They seem to be the same structures.

PLATE I.

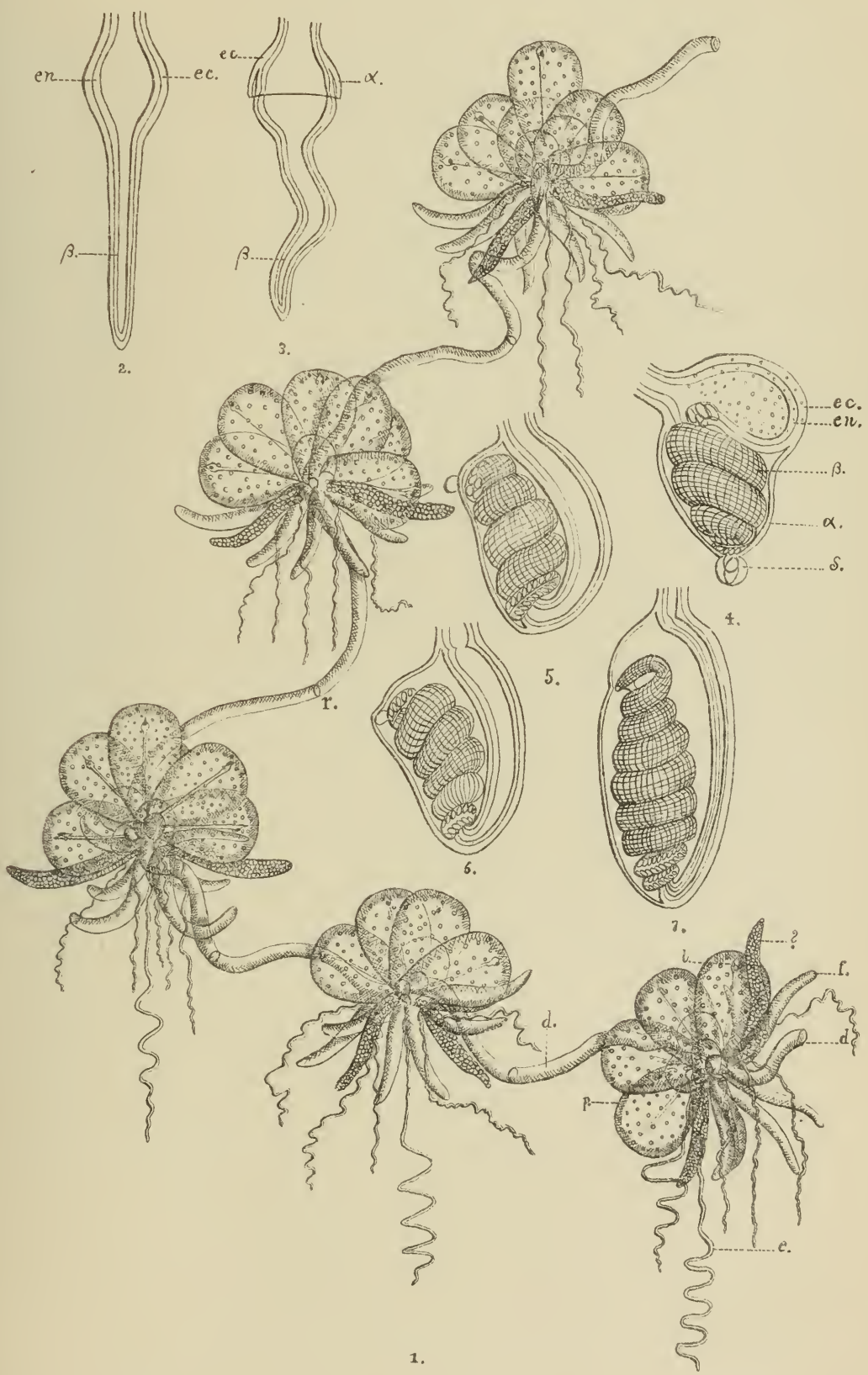
Fig. 1, *Apolemia uvaria*, a part of the polyp-stem, magnified four diameters. The longest stem observed by me was eight feet in length. Figs. 2, 3, 4, 5, 6, 7, different stages of development of the tentacular knob of *Physophora hydrostatica*. Fig. 3 shows the origin of the involucrum. Fig. 4, 5, 6, represents the provisional form of the knob, and the embryonic terminal filaments. Fig. 7, a knob in the most developed condition.

PLATE II.

Fig. 1, view of *Agalmopsis picta* from one side, magnified two diameters. The tentacles are drawn to the vicinity of the polyp-stem by which the tentacular knobs appear on the upper side of that appendage (an unusual condition.) Fig. 2, covering scale of *Agalma Sarsii*. Fig. 3, portion of the polyp-stem of *Halistemma rubrum*, magnified four diameters. Fig. 4, tentacular knob of *Halistemma rubrum*. The lower extremity of this figure joins figure 3 at the point *γ*. Fig. 6, taster of *Agalmopsis picta*. This figure shows the position of the male and female organs in reference to the taster.

PLATE III.

Fig. 1, *Praya diphyes*. Fig. 2, *Praya*, sp. (?) This unknown species of Praya differs from *Praya cymbiformis* in the equality in size of the nectocalyces, their triangular outline when seen in profile, and the direct course from junction to circular vessel of the radial tubes. The difference between it and *Praya diphyes* is plainly brought out by the accompanying Fig. 1. It has the somatocyst in but one nectocalyx, and the diphyozoids are crowded together along the polyp-stem, somewhat similar to the conditions among the Agalmidæ. I incline to regard Fig. 2 as the young of *Praya cymbiformis*. Fig. 3, *Diphyes acuminata*. Fig. 4, lateral view of the nectocalyx of *Gleba hippopus*. Fig. 5, inferior view of a similar nectocalyx. Fig. 6, *Spheronectes* (*Monophyes*) *inermis*. All these drawings are from Jelly-fishes taken in the Mediterranean.



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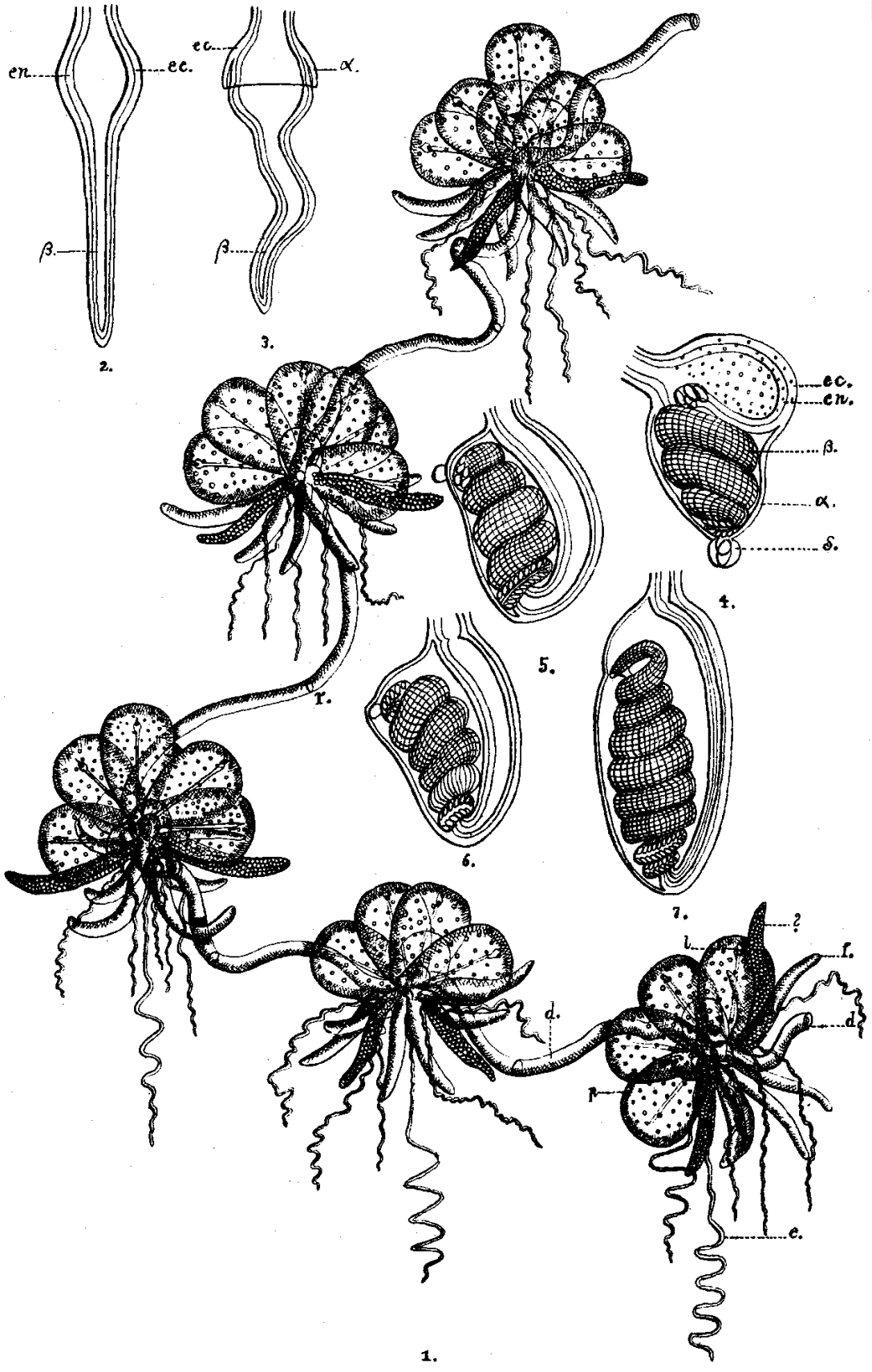

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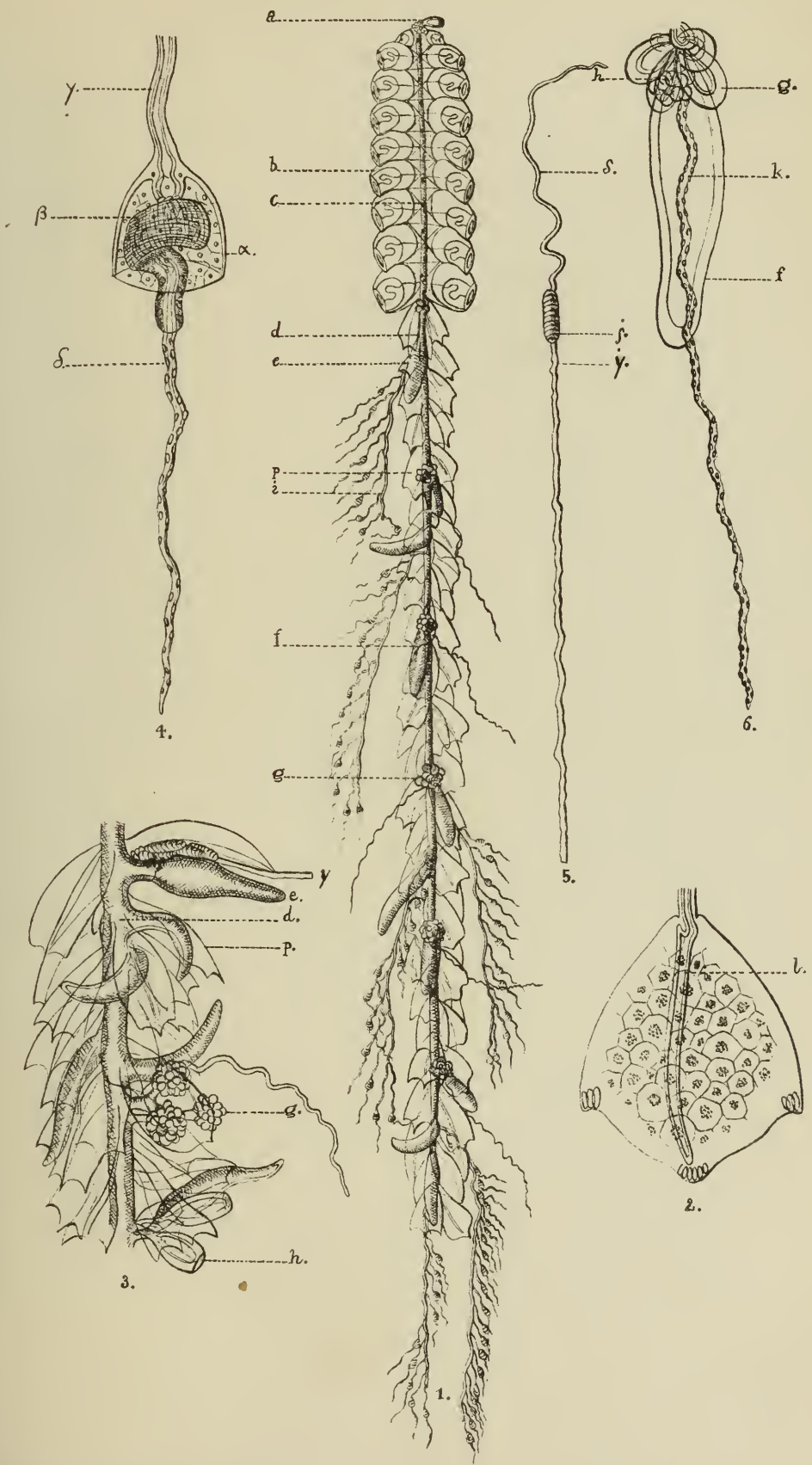

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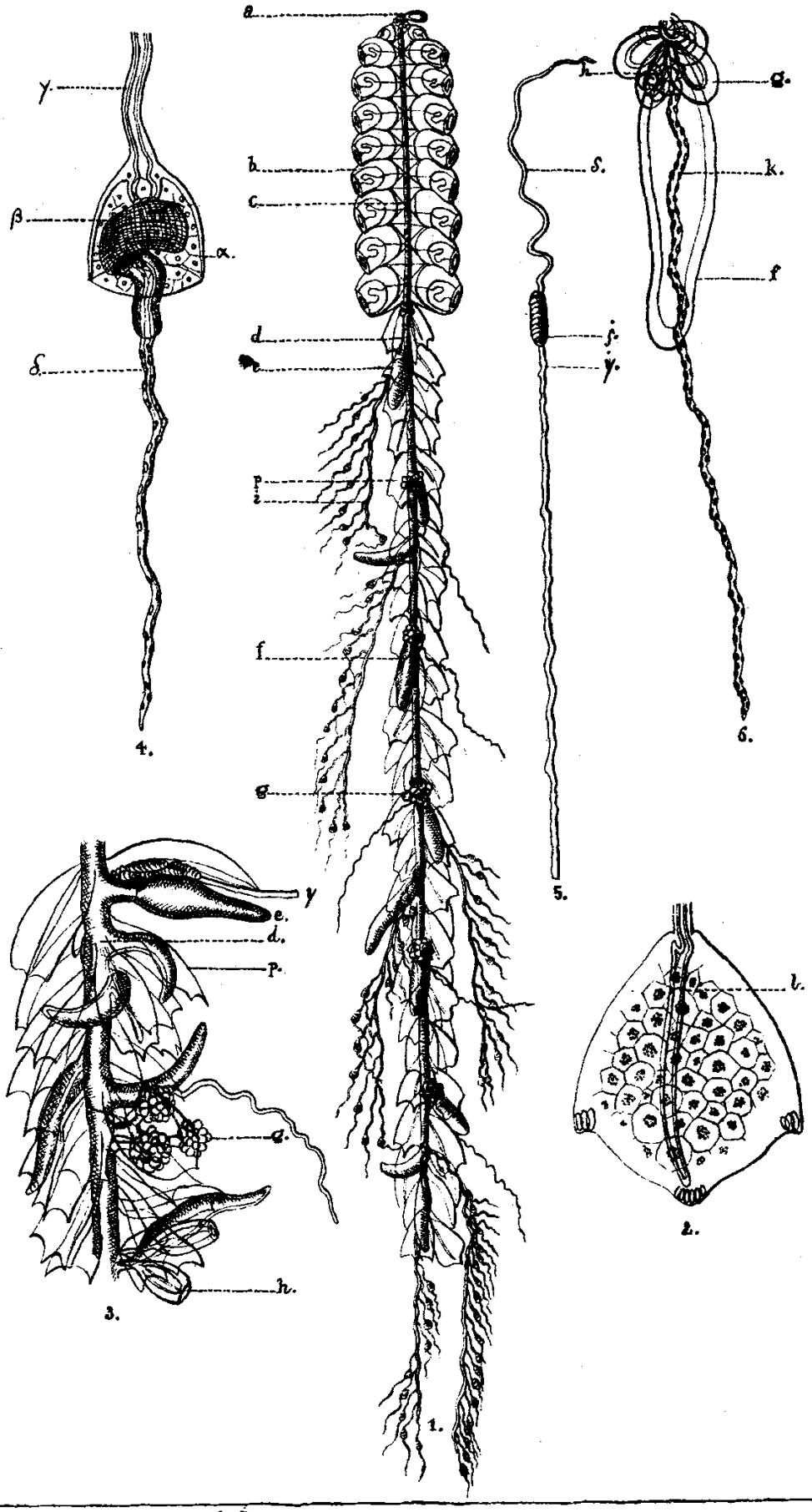

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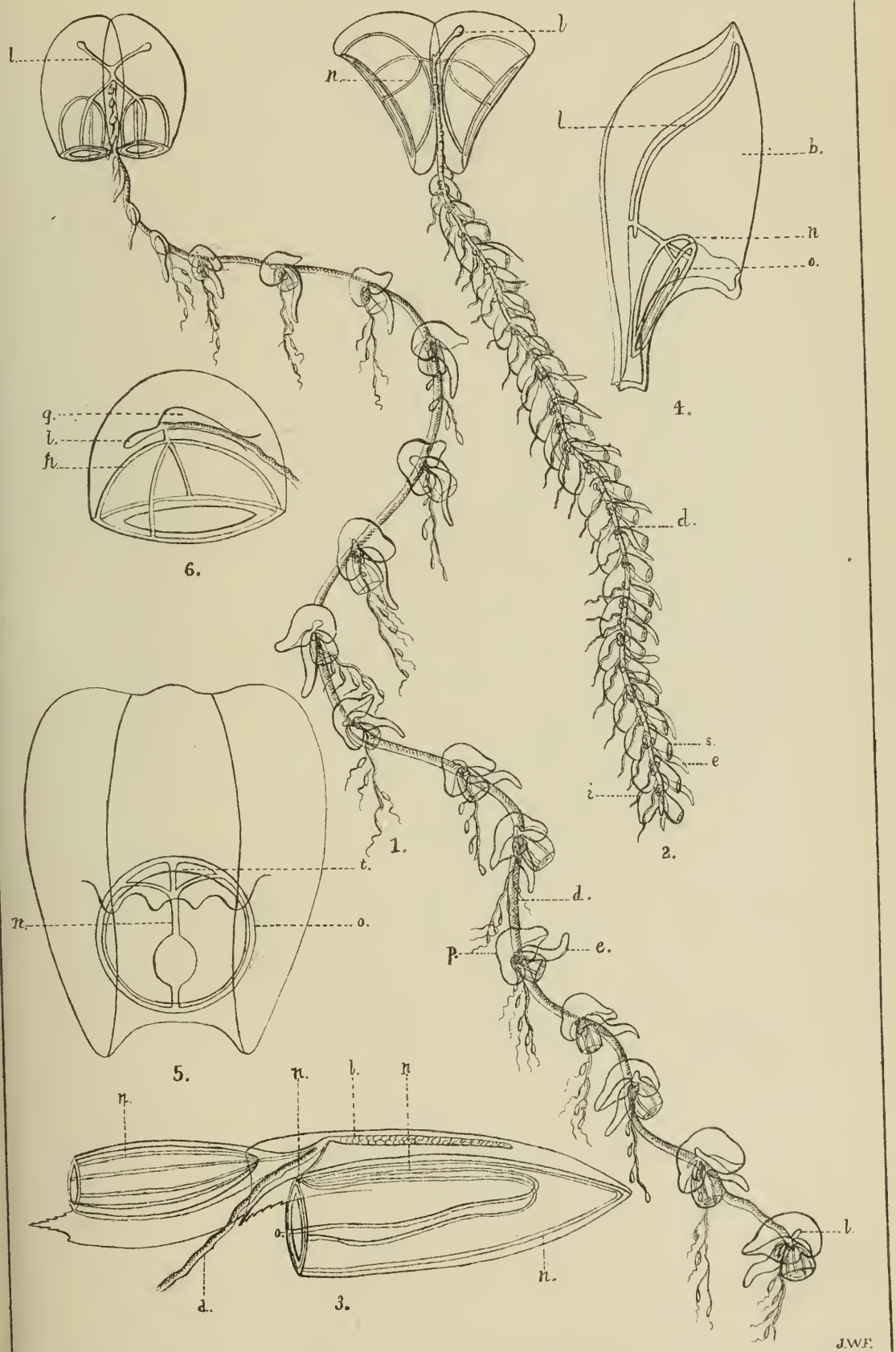

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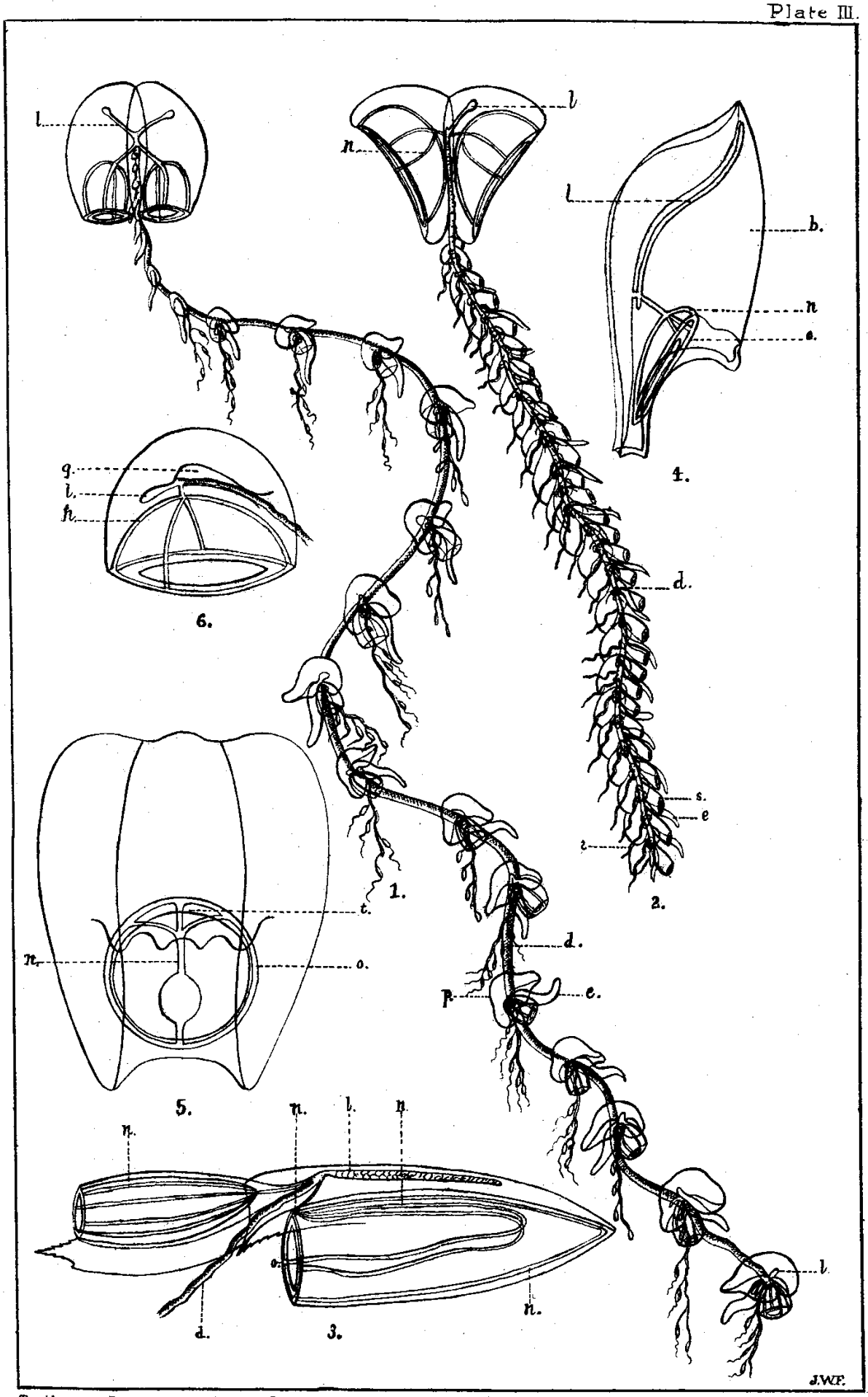

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