The Siphonophores (Continued)

J. Walter Fewkes

American Naturalist, Volume 17, Issue 8 (Aug., 1883), 833-845.

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noticing the presence of a covered basket of carrion placed among them, decided him forever against the ideas I have endeavored to prove in this paper.

I find in the introduction to "A Manual of the Ornithology of the United States and Canada," by Thomas Nuttall, a short paragraph referring to this self-same experiment, and, as it echoes the sentiments of his friend Audubon, whose follower he was, with other naturalists of that day, I will finish by its quotation:

"Comparing animals with each other we soon perceive that smell in general is much more acute among the quadrupeds than among the birds. Even the pretended scent of the vulture is imaginary as he does not perceive the tainted carrion on which he feeds through a wicker basket, though its odor is as potent as in the open air."

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THE SIPHONOPHORES.

BY J. WALTER FEWKES.

(Continued from February number, 1882.)

V.—The Diphyæ.

THERE remain of tubular Medusæ yet to be mentioned a few genera closely related to Diphyes[1] which form a characteristic group called the Diphyæ.[2] While all of these jellyfishes like Agalma and the majority of its relatives are furnished with a long tube like axis, none of them have at one end of this stem an air bladder for flotation in the water or upon its surface. Most of the animals which we are now to consider have swimming-bells as means of self propulsion by which they move through the water with a velocity which is very great when compared with many of their float-bearing relatives. As a rule, however, the members of the division are smaller than the Physophoræ, and the gelatinous substance of their swimming-bells is generally of a firmer consistency. The group may be said to include some of the most specialized forms of the Siphonophores.

The Diphyæ with the exception of at least one genus called

[1] For a popular account of the anatomy of Diphyes the reader is referred to the American Naturalist for February, 1882.

[2] The terms Physophoridæ and Diphyidæ are family names and should give place to Physophoræ and Diphyæ, which may be applied to groups containing several families.

Monophyes[1] have, like Diphyes, two swimming-bells or nectocalyces. The most apparent difference in external shape between the genera which compose the group lies in the modification in size and shape of one or the other of these structures.

The genus of Diphyæ which resembles Diphyes most closely is known as Galeolaria (Epibulia). By many writers on these animals, instead of being regarded another genus it is simply called a species of Diphyes. It is larger, however, than the latter, and capable of very rapid motion, darting hither and thither through the water, principally by the contractions of the posterior of its two swimming-bells.

Galeolaria is widely distributed in the different seas, being very common in the Mediterranean. In American waters it has been taken off the Florida Keys in the Gulf Stream near Nantucket and is likewise recorded as far north as the latitudes of Greenland.

The variation in the shape of their swimming-bells is one of the most prominent differences between it and Diphyes. While in both genera these structures are two in number in *Galeolaria aurantiaca* Vogt, both are much larger than in our common Diphyes, *D. formosa* F. The anterior swimming-bell of the former genus is less conical in shape than that of the latter and as far as external appearance goes seems less perfectly adapted to rapid progress through the water. The part of the anterior bell which is in advance as it moves through the water is rounded and blunt as compared with the pointed conical end of the bell in Diphyes. Upon this end there is the most resistance in onward motion through the water, for it is the anterior portion of the animal as it forces its way along in the direction in which it swims. While, however, it is the anterior end of the bell as it moves forward, it is not homologous to the apex of other medusa bells, but is morphologically one side of such a bell, or one wall which has become very much thickened and modified in such a manner that in its sidelong motion it may encounter the least resistance from the surrounding water.

There are deep-seated internal differences between the anterior of the two nectocalyces in the genera Diphyes and Galeolaria,

[1] The same is true, according to Chun, in Muggiæa. Specimens of a Diphyes with but one nectocalyx are very common in Bermuda and Tortugas. I had formerly supposed with the majority of authors that they were mutilated specimens of Diphyes. They resemble closely the genus Muggiæa as limited by Chun.

although their outward resemblances are so close. A somatocyst and bell cavities exist in both. The radial chymiferous tubes have the same inequality in length and a like tortuous course brought about by the unequal development of the bell walls. One peculiarity of the radial tubes in the bell of Galeolaria is that two of the four radial vessels are connected by a smaller vessel or lateral branch which extends through the bell walls parallel with its rim. The posterior swimming-bell of Galeolaria likewise differs in shape from that of Diphyes. One of the most interesting of the differences in general form is the existence in Galeolaria of two circular gelatinous plates which extend backward from the lower side of the posterior bell rim, one on each side of the median line. These small disks have an important function to perform in the movements of the medusa, for they serve as rudders by which the direction which the water takes on leaving the bell cavity is determined. The steering of the animal while it is in motion is thought by some to be brought about in the following manner: When the lower bell by a simultaneous contraction of its walls on all sides drives the water violently from its cavity through the bell opening, the liquid thus expelled strikes the surrounding medium and meets with a resistance. The result is that the animal itself is driven forward. The direction which the water takes as it leaves the bell depends upon the angle at which these disks are set on the bell margin, and by altering this angle the direction in which the animal moves is determined. Both anterior and posterior bells in Galeolaria contribute to the onward motion, although propulsion is brought about in the main by the posterior.

In the genus next to be noticed, allied in many respects to those already studied, the disproportion in size of the two swimming-bells is very apparent on account of the anterior bell being so very much reduced in size. As it is much smaller than the posterior it performs only a very small amount of work in the onward motion of the medusa. A genus which possesses these characters is called Abyla.[1]

Abyla is smaller than Galeolaria and somewhat larger than Diphyes. It is more sluggish in its movements than either, and consequently more easily captured.

[1] Abyla is very common in the Mediterranean, but has not yet been taken on our coasts.

The anterior bell (*a*) is distinguished by some of the most important characters of the genus. It is very small and has a rhomboidal shape. The anterior end is not conical as in Diphyes nor rounded as in Galeolaria. The bell walls are stiff and the bell cavity and bell opening relatively very small. Most of the interior of the bell is taken up by a large somatocyst of globular shape. The anterior and posterior bells fit closely together by faces, of which that of the anterior is slightly concave.

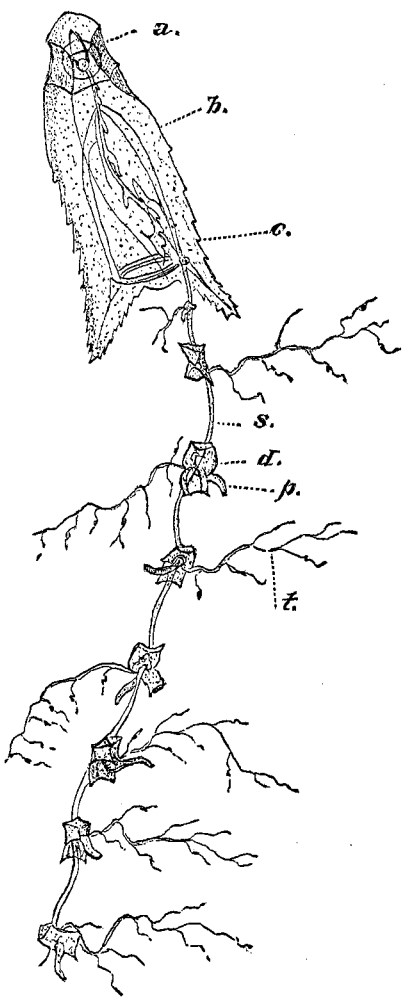

FIG. 1.—*Abyla pentagona* (side view). *a*, anterior bell; *b*, posterior bell; *c*, longitudinal canal with cover; *d*, diphyizoöid; *s*, stem; *t*, tentacle.

The posterior swimming-bell (*b*) differs widely in shape from that of either Diphyes or Galeolaria. Unlike the latter there are no circular plates or rudders on the bell margin. From the point of union of anterior and posterior bells there passes from one end of the nectocalyx to the other a number of serrated ridges, five of which are continued into triangular projections below the bell opening. Upon one side of the bell between two of the more prominent of these parallel ridges there is a groove (*c*) for the lodgment of the axis when retracted. This groove lies on the same side of the posterior swimming-bell as the opening into the anterior bell cavity. Throughout a part of its length from the anterior bell, for two-thirds of the distance to the termination, this groove is covered by a thin transparent plate formed by a reflexion of one of the neighboring longitudinal ridges. The

function of this groove and its cover, the thin plate which has been mentioned, is to form a receptacle into which the retracted stem and its attached members can be wholly or partially withdrawn. The modification in the form of the bell, resulting from the formation of the groove and its cover, gives rise to a complication in the course of the radial canals in the bell walls. While three of these tubes have a normal course extending directly from a common origin to the bell margin; a fourth which lies on the same side as the groove or external canal and its cover, is somewhat modified. It starts from a common union with the others, but instead of passing directly to the bell margin divides midway in its course into two branches. One of these branches ends blindly in the bell walls a short distance from the bifurcation, while the other after a tortuous course eventually ends in the immediate vicinity of the bell margin.[1]

The diphyizoöid of Abyla (Figs. 2, 3, 4) closely resemble those of Diphyes in many particulars. The covering scale (*cs*) is, however, polygonal in shape instead of hemispherical, and almost its whole interior is taken up by a large somatocyst (*s*). The swimming-bell, clusters of male and female sexual bells, tentacle and polypite are similar to those of Eudoxia.

The diphyizoöid of Abyla, like that of Diphyes, was formerly described as a genus widely different from that to which it is now known to belong. Historically it is interesting from the fact that from a study of its anatomy and growth the true nature of the diphyizoöid in general was recognized.

The reduction in size in the bell of Abyla has gone so far in a genus called Monophyes that the anterior bell is missing and we find a single swimming-bell which has resemblances to both the anterior and the posterior nectocalyces of the genera which have already been described.

The single swimming-bell of Monophyes has a hemispherical shape and is without ridges on its external surface. On one side of the bell walls there is an enclosed canal out of the opening into which hangs the axis. The axis or stem can be withdrawn into the canal where, when retracted, it is securely packed in the same way that a like organ of Abyla is placed in the groove

[1] A blindly ending tube also arises from the point of union of a radial and circular tube and extends to the neighborhood of the plate which has been described above.

covered by the gelatinous plate. The swimming-bell of Monophyes resembles the posterior bell of Abyla in its possession of

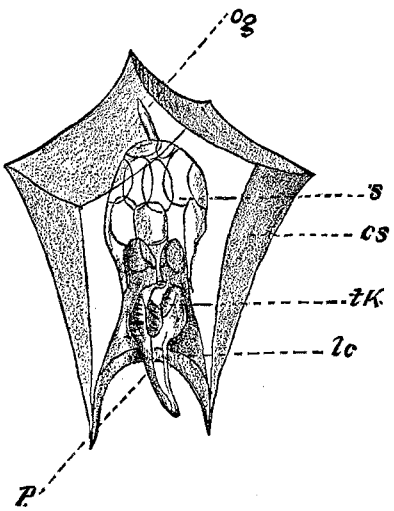

Fig. 2.

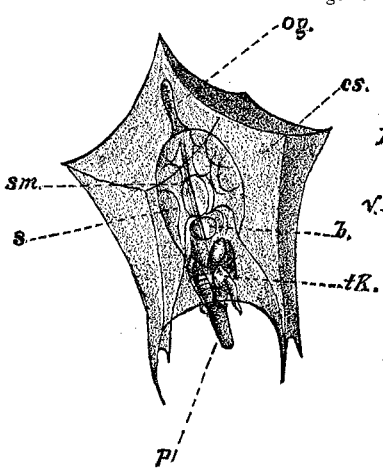

Fig. 3.

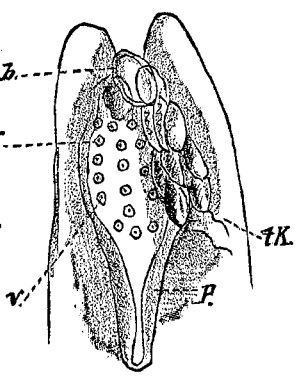

Fig. 4.

FIG. 2.—Diphyizoöid of Abyla (?) (Aglaisma). FIG. 3.—The same from upper side. FIG. 4.—Polypite of Aglaisma. *b*, budding sexual bells; *cs*, covering scale; *lc*, longitudinal canal on the under side of the covering scale; *og*, oil globule, part of the somatocyst; *p*, polypite; *s*, somatocyst; *sm*, tube in covering scale; *tk*, tentacular knobs; *v*, villi on inner side of polypite.

this cavity. There is also in the walls of the bell of Monophyes a blindly ending tube communicating with the cavity of the axis which corresponds with the somatocyst of the

anterior bell. The strict homology of the single nectocalyx of Monophyes is therefore difficult to determine. In connection

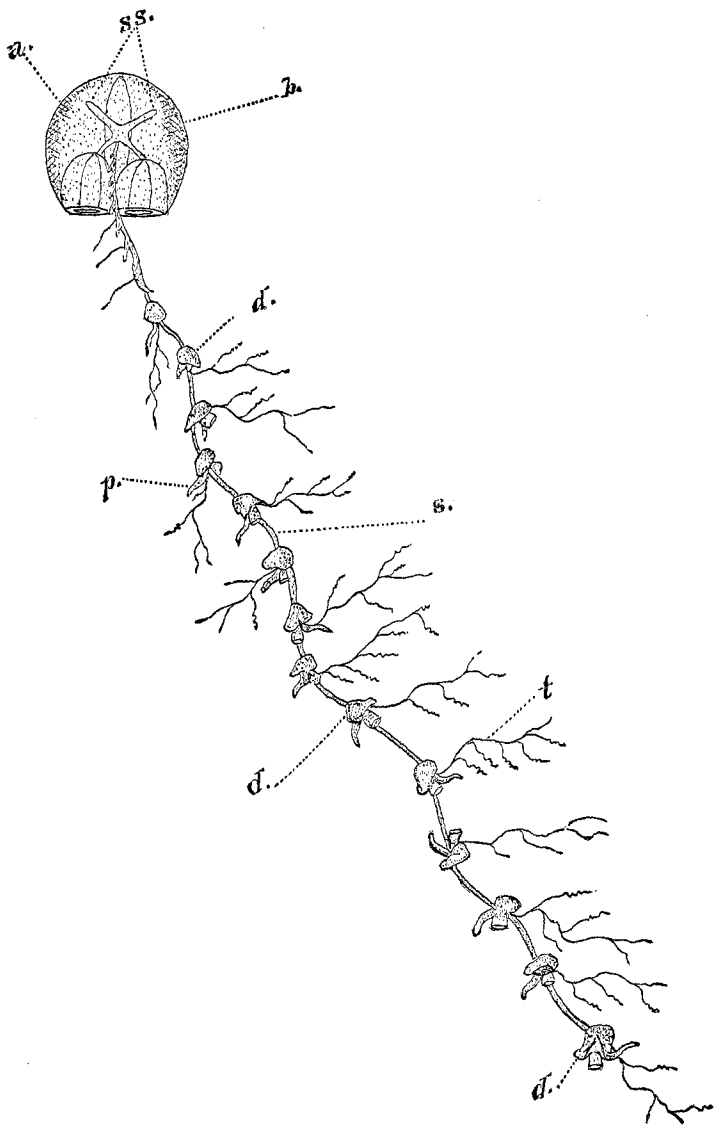

FIG. 5.—*Praya diphyes* Köll. *a*, anterior bell; *b*, posterior bell (nectocalyx); *d*, covering scale; *p*, polypite; *s*, stem; *ss*, somatocyst; *t*, tentacle.

with Monophyes a very curious medusa from Newport, R. I., as well as from many other localities, ought to be mentioned. This

medusa is called *Diplophysa mermis*, and is regarded by many authors as the diphyizoöid of this genus.

There are several of the tubular medusæ belonging to the Diphyæ which depart very widely in general form from that assumed by Diphyes, although they are evidently more closely related to these than to the genus Agalma and its relatives. One of the most beautiful of these is a genus Praya,[1] of which several species have been described (Fig. 5). Praya has two nectocalyces at one extremity of a long, highly flexible axis or stem, which fit together side by side with the openings into their cavities facing outward and backward in the direction of the stem. Each bell is almost globular and has very flexible walls. In one species[2] one of the bells is much larger than the other, but in the others they are of about the same size. In many respects the swimming-bells of Praya are peculiar. One species (Fig. 5) has a somatocyst (*ss*) in both of the swimming-bells, while in others this structure is confined to one of the bells, as in other Diphyæ. The radial tubes in the species take a direct course from a common junction to the bell margin.

The axis (*s*) is not capable of being drawn up into the interval between the bells, but as the animal swims in the water trails far behind and is thrown into many graceful curves by the onward motion. This stem, when extended, is found to bear at intervals along its length little helmet-shaped transparent bodies (*d*) which in general shape resemble the primitive covering scale of the larval Agalma. The helmet and accompanying structures presently to be described, form the diphyizoöids which in the subsequent growth of the Praya fall off one by one. After they have thus separated themselves from their attachments, they develop into medusæ of very different outward shape from that of the attached young (Fig. 6).

Although the helmet-shaped body (*p*) gives these diphyizoöids their form, they are by no means the only structures in the clusters. They cover other organs of a most important character. Below each helmet-shaped body we find a small botryoidal cluster of bells bearing ova and probably spermatozoa, and a flask-shaped stomach (polypite) (*e*) which resembles a similar body in

[1] Named from Porto Praya in the Cape Verde islands.

[2] The species of the Praya found in the Gulf of Mexico is probably new. Bull. Mus. Comp. Zoöl., Vol. IX, 7.

Eudoxia. From the base of this polypite there hangs a tentacle (*i*) which has many side branches, each of which bears a simple pendant knob. The whole tentacle with lateral branches is easily retracted under the helmet-shaped covering scale, as is shown in Fig. 6. As the Eudoxia separates from the Diphyes and leads an independent existence, so the helmet-shaped members of the Praya colony separate from it, and after subsequent growth assume a very different shape from that which they have when attached. Although it is not yet known what the ultimate condition of the separated fragment is, there is probably no doubt that it later acquires a very different form as it grows older.

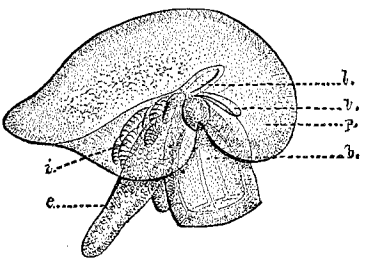

FIG. 6.—Diphyizoöid of *Praya cymbiformis* (d Ch.) Leuck. *b*, sexual bell; *e*, polypite; *i*, tentacle retracted, with tentacular knobs; *l*, somatocyst; *p*, helmet-shaped body.

There are two well-marked species of Praya found in the Mediterranean sea, which are known as *P. cymbiformis* Leuck., and *P. diphyes* Köll.; they differ from each other in the relative size and shape of the swimming-bells and in a character already pointed out of the absence or presence of somatocysts in the posterior bell. In still a third species from the Bay of Villa Franca in Provence, we find the different attached diphyizoöids so closely crowded together that they touch each other side by side along the length of the stem. This species, *Praya gracilis* F., is smaller than the others, has swimming-bells of a different shape and the openings into the bell cavity are larger and open more on the sides than in the above species.

One of the most interesting genera of floatless Siphonophores is a genus called Gleba or Hippopodius, which is very common in the Mediterranean. This genus is placed by many writers on these medusæ among the Diphyæ, but its many differences from the other genera are so great that it should probably be made the type of a new group equal in rank to the Physophoræ and Diphyæ. The Siphonophoræ[1] will then be divided into three

[1] Exclusive of Velella (Rataria) and Porpita, aberrant genera which have few likenesses with the true Siphonophores and which are called Discoideæ. These medusæ are more closely related to floating hydroids than to medusæ with attached buds.

divisions, of which Agalma, Diphyes and Gleba are representative genera.

Gleba resembles the Physophoræ in possessing many swimming-bells, and the Diphyæ in being destitute of a float. Diphyizoöids, if such exists, are unknown, and an opposite law from that which exists in Agalma is followed in the order of development of the nectocalyces on the nectostem. The group of Hippopodiæ contains the two genera Gleba and Vogtia. The American representative is the genus Gleba, which is found in the Gulf Stream.[1] Vogtia is probably the young of Gleba. The swimming-bells of Gleba are hoof-shaped structures and are arranged in two rows or series, the opposite members of which fit closely together. The resemblance in shape of each bell to a horse's hoof is very striking. The upper portion of the hoof points downward and outward, and upon its face is found an opening, the bell orifice, into a shallow bell cavity. The lower surface is concave, and as the animal swims is uppermost in the water. The bell substance although gelatinous and transparent, is less flexible than that of most other Siphonophores. The bell walls have little or no power of contraction and expansion, and the bell approaches closely in structure the covering scales of several other Siphonophora.

The velum of the swimming-bell has a crescentic shape, and by its strokes upon the water, rather than by the contractions of the bell walls, the medusa is driven from place to place. The shallowness of the bell cavity and the irregular shape of the bell itself brings about a variation in the regular course of the tubes of the bell. One of the radial tubes of the bell is much larger than the others, although all pass directly from a common origin to the circular marginal tube. This long tube is swollen midway in its course into a flat disk-shaped cavity or enlargement of unknown function and homology. The somatocyst lies just below the floor of the concave face of the bell, opposite the bell opening, and has a tubular form. It closely resembles the central tube of the covering scales of Agalma. As it is probably homologous with the somatocyst of other Diphyæ, it gives us a hint of the homology of the central tube of the covering scale. The somatocysts, wherever found, are the same as the "mantle tubes" in Agalma. There are no true covering scales without

[1] Bull. Mus. Comp. Zoöl., IX, 8.

bell cavities as in Agalma and some other Physophoræ. The size of the swimming-bells of Gleba follow an opposite law of decrease in size from that which exists in Agalma. In Agalma the bells near the float are very small, simple buds, while their size increases as we recede from that point. Those, however, which make up the most distant portion of the series are of about equal size. An opposite law exists in Gleba, for the swimming-bells near the end of the stem opposite that from which the polypites hang are the largest and those at the other extremity of diminutive size. By the arrangement of bells in Gleba those placed highest, as the animal naturally swims, are small, and those lowest are well developed, so that the axis is reversed as compared with that of Agalma. The polyp stem is inconspicuous or wholly wanting. The polypites and their appendages seem to hang from the upper end of the nectostem. The differences between Gleba and Vogtia are mainly in the form of the nectocalyces, and by many the latter genus is regarded the young of the former. Much obscurity, however, still hangs about the anatomy and development of both these most interesting genera.

The following more or less artificial classification is presented as an aid to beginners in a study of these Siphonophora. The genera known from our waters are designated by an asterisk (*):

SIPHONOPHORA.

Polymorphic medusæ generally with a tubular formed body. With or without a float. Young and adult free-swimming. With flask-shaped stomachs called polypites and long contractile tentacles. Many have swimming-bells, covering scales and tasters. Colonies moncecious or dicecious. Reproduction (always) generally by eggs.

A.—With a float.

Physophoræ.

I.—Without axis, covering scales or nectocalyces.

Physaliadæ.[1]

**Physalia arethusa* Til.

II.—With an axis.

a. Without covering scales or nectocalyces.

Rhizophysidæ.

**Rhizophysa filiformis* Forsk.

**Rhizophysa gracilis* F.

**Rhizophysa eysenhardtii* Geg.

[1] In a natural system of classification Physalia and Rhizophysa should be separated from the other Physophoræ, and form a new group of equal rank. For these Chun suggests the name Pneumatophoridæ (Pneumatophoræ).

b. With nectocalyces, without covering scales.
Physophoridæ.
c. Without nectocalyces, with covering scales.
Athorybiadæ.
**Athorybia formosa* F.
d. Nectocalyces in several series with covering scales.
Forskaliadæ.
**Stephanomia atlantica* F.
e. With nectocalyces in two rows, with covering scales.
Agalmidæ.
1. Tentacular knobs with involucrum and many terminal filaments.
Calliagalma F.
2. Tentacular knobs with involucrum and two terminal filaments.
**Agalma elegans* F.
**Crystallodes rigidum* Hæck.
3. Tentacular knobs with involucrum and one filament.
**Agalmopsis fragilis* F.
4. Tentacular knobs without involucrum, with one terminal filament.
Halistemma Huxley.
Polyp-like bodies on the nectostem between the nectocalyces.
Polyp stem with appendages in clusters.
Apolemiadæ.
**Apolemia* sp.
Doubtful genera and species from American waters:
**Nanomia*[1] *cara* A. Ag.
**Haliphyta*[2] *magnifica* F.

B.—Without a float. Flotation sometimes effected by an oil globule in one or both (?) nectocalyces.
I.—Several nectocalyces.
Hippopodiæ.
**Gleba hippopus* Forsk.
II.—One or two nectocalyces.
Diphyæ.
a. One nectocalyx.[3]
Monophyidæ.
b. Two nectocalyces.
1. Nectocalyces with flexible walls of about equal size, arranged side by side.

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[1] The peculiar development of Nanomia, described by A. Agassiz, is different from that of any other known Physophore. It resembles in many particulars Halistemma, but as its adult tentacular knobs are unknown, I am unable to refer it to this genus. The absence of a primitive scale in the young allies it to Agalmopsis as I have limited the name.

[2] The tentacular knobs of Haliphyta are unknown.

[3] Muggiæa, as limited by Chun, would also come under "B, *a*" if a posterior nectocalyx is never developed and not broken off as formerly supposed. One species of this genus is sometimes found in North American waters.

Prayidæ.

**Praya blaino.*

2. Anterior bell conical or rounded, posterior with marked longitudinal sides. Swimming-bells of about equal size.

Diphydæ.

**Diphyes acuminata* Lkt.

**Diphyes formosa* F.

3. Anterior bell small, polygonal in shape. Posterior bell with longitudinal canal covered with a plate.

Abylidæ.

There are a few genera of Mediterranean Siphonophores which are introduced in the above key since they represent families which probably occur in the Gulf Stream, although they have not yet been taken on our coast.

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EDITORS' TABLE.

EDITORS: A. S. PACKARD, JR., AND E. D. COPE.

The long persistence of the mediæval type of education which prevails in our schools and colleges has rarely been more happily and forcibly stated than by Charles Francis Adams, Jr., in his address before the late meeting of the Phi Beta Kappa Society. His adverse criticism is chiefly directed against the great waste of time involved in the study of Greek literature; and in the true scientific method he appeals to the facts best known to himself in proof of the position he assumes. The examples he cites are the lives of his ancestors, commencing with John Adams, President of the United States, who graduated at Harvard University in the class of 1755. We cannot do better than transfer to our pages some of his remarks:[1]

"And so for us the college course, instead of being a time of preparation for the hard work of life, was a pleasant sort of vacation, rather, which preceded it. We so regarded it. I should be very sorry for myself not to have enjoyed that vacation. I am glad that I took my degree. But as a training place for youth, to enable them to engage to advantage in the actual struggle of life, to fit them to hold their own in it, and to carry off the prize, I must in all honesty say that, looking back through the years and recalling the requirements and methods of the ancient institution, I am unable to speak of it with respect. Such training as I got, useful for the struggle, I got after instead of before graduation, and it came hard; while I never have been able—and now, no matter how long I may live, I never shall be able—to overcome some great disadvantages which the superstitions and wrong theories and worse practices of my alma mater inflicted upon me.

[1] The Boston *Herald*, June 29, 1883.