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would be readily discernable in the structure of the pebbles, but I can find nothing of the kind. The sand grains are as round as those upon the sea shore.

THE TUBES IN THE LARGER NECTOCALYX OF ABYLA
PENTAGONA. BY J. WALTER FEWKES.

The course of the chymiferous tubes in the larger swimming bell of *Abyla pentagona* has never been satisfactorily described. Leuckart gives the best description of the very peculiar form of these tubes in the smaller bell, but simply says of them in the larger that "he could with certainty follow them to the circular vessel."¹ In the drawing of this nectocalyx, which he gives in his *Zoologische Untersuchungen*, Taf. III, fig. 1, he represents four of these vessels as passing directly from a common origin to the circular tube just as is the case in a simple hydroid Medusa.

Neither figures nor descriptions by other writers give a correct idea of the course of these tubes. In most cases, as in the figures of *Abyla* in the *Oceanic Hydrozoa* of Huxley,² they are wholly omitted both in the upper and lower nectocalyces. In one figure Kölliker³ gives a correct idea of their origin, but the drawing was only made to illustrate the structure of the smaller bell, so that the peculiar modifications in the course of these tubes in the lower part of the larger bell were not given. Of Vogt's⁴ description, Leuckart⁵ says, "Die Gefässe der hintern Schwimmglocke, die von Herrn Vogt nicht erwähnt werden, könnte ich u. s. w."

Gegenbaur gives a good description of the branched vessel which I have lettered e¹ and c¹.

As is well known the under side of the lower nectocalyx of *Abyla*, as it naturally floats in the water, forms a groove protected on either side by a ridge. From the side of the smaller of these ridges is formed a plate under which the stem of the *Abyla* is withdrawn. Kölliker⁶ gives a schematic drawing of the relation of this plate to the side of the bell. The existence of this plate causes certain

¹ Zur nähern Kenntniss der Siphonophoren von Nizza, p. 14, 1854.

² *Oceanic Hydrozoa*, pl. II, fig. 1, 1^a, 2, 2^a,

³ *Schwimmpolypen oder Siphonophoren von Messina*, Tab. x, fig. 2.

⁴ *Sur les Siphonophores de la Mer de Nice*.

⁵ *Siphonophoren von Nizza*, p. 14.

⁶ *Neue Beiträge zur näheren Kenntniss der Siphonophoren*, p. 355.

deviations in the normal course of the chymiferous tubes in the bell. Although their course is not so abnormal as that of the tubes in the smaller bell, it is still quite curious. Four chymiferous tubes arise from the single central tube which communicates with the stem cavity of the animal. Of these, three pass directly to the circular tube which they join, forming at the point of junction an enlargement. One of these continues along on the under side of the bell, following almost exactly the ridge, which forms, by being continued, the most prominent circumvelar projection of the bell. From its junction with the circular vessel, where a conspicuous enlargement is formed, a secondary tube arises which extends along the bell almost parallel with the normal tubes, and when under the junction of the protecting plate and ridge of the bell enlarges and sends out three short digitate branches. I do not know what the homology of this secondary tube is. At times it arises not from the enlargement but from the vessel itself. The fourth of the four chymiferous tubes, which arises from the common junction, passes a short distance down along the bell, and then divides, one part extending at right angles across the bell for about a quarter of the distance around the nectocalyx, and then turning again at right angles goes on parallel to its former course to join the circular tube. An indistinct drawing of a part of this tube can be seen in one of Kölliker's plates, but is not mentioned in the text. The former of the two branches into which the tube is divided extends directly on to the vicinity of the digitate-like structure already mentioned, but is then not probably joined to it. Gegenbaur leaves nothing new to be said of this abnormal vessel.

Such is the course of the tubes, not in a single specimen alone, but in hundreds of *Abylae*, as studied when alive or when acted upon by reagents. The tendency of the chymiferous tubes of the *Acalephae* to vary in their course is well known. The constancy of form in this case seems to indicate that it is an anatomical peculiarity of the bell. The plate which covers the stem when it is drawn to the side of the bell, into the longitudinal canal, is not a "deckstück" nor homologous to these structures. The existence, however, of this plate or so-called canal, is no doubt the cause of the peculiar variation of the tubes from the usual arrangement.

If we look for the homological solution of this plate we may conclude that it is the recurved extended edges of the ridge rising on the side of the groove, which shelters the contracted stem. Similar

ridges, less developed to be sure, are found in all the Diphyidae. Perhaps no where is this development carried so far as in the two irregularly circular lappets under the opening of the bell in Epibulia (Galeolaria), which structures play such an important part in directing the animal as it darts back and forth through the water.

The two-paged paper of McDonald¹ on the nervous system in Diphyes, Leuckart in his "Bericht," rightly criticizes as follows: "Was McDonald bei Diphyes als Nerven-system beschreibt, reducirt sich auf die an die Schwimmglocken tretenden und darauf sich vertheilenden Gefässe." He does not add upon what ground he bases such a conclusion. In Abyla the resemblance of these so-called tubes to a nervous system is great, but we know so little of their nature, and indeed of their course, even in the distal swimming bell of such a common Calycophore as *Diphyes Sieboldii*, that at present any generalization is premature. It seems to me that these structures are homologous to the chymiferous tubes on account of their position, and origin. I cannot understand, however, how what McDonald gives "affords presumptive evidence of the existence of a similar system in other forms of Oceanic Hydrozoa," as the title to his paper reads. In Physophora, Halistemma, Agalma and Stephanomia (Forskalia), we know that similarly placed structures in the nectocalyces are chymiferous vessels similar to those found in the hydroid Medusa. In Epibulia (Galeolaria), the Calycophore where these structures in the distal nectocalyx have often been described² and figured, they are without doubt true tubes as in the Physophoridae already mentioned. Such facts render it probable that these are also chymiferous tubes in Abyla.

Leuckart says,³ "Die Firste, die den Längskanal bildet, ist ohne gefäss." The "längskanal," if I am not wrong, is the same as the cavity or canal on the under side of the larger nectocalyx, as it generally swims, one side of which is formed by what I have called a plate. Into this cavity the stem can be drawn. My specimens, which are from the Mediterranean, show the rudimentary tube, which I figure.

¹ Ann. and Mag. Nat. Hist., 114-116.

² Gegenbaur. Beiträge zur näheren Kenntniss der Schwimmpolypen, 1854, p. 35, Taf. XVI, fig. 8. Leuckart. Siphonophoren von Nizza, p. 33-34, Tab. XI, fig. 14.

See also Zool. Untersuch. Vogt, Sur les Siphonophores de la Mer de Nice. Delle Chiaje. Descriz., etc., v, p. 135.

³ Zoologische Untersuchungen, p. 57.

This rudimentary tube runs directly under the ridge which seems to me the same as that which has the letter (c) in Leuckart's figure, Pl. III, fig. 6, Zool. Untersuch. The secondary tube, which originates from an enlargement where the right hand tube, looking at the lower surface of the bell as it swims in the water, joins the circular vessel, and which ends in the digitate portion described, may also be related to this rudimentary tube.

As the nectocalyces of all Physophoridae, exclusive of course of Athorybia, Physalia and Rhizophysa, where they do not exist, have bilateral symmetry as referred to a plane, passing through ventral and dorsal line as defined by Claus and Haeckel,¹ and as the same occurs also in Gleba (Hippopodius), and the second nectocalyx of Epibulia (Galeolaria), we have an anterior and posterior or superior and inferior spheromere as well as a right and left. These spheromeres resemble each other, and in most Siphonophores have the chymiferous tubes passing directly to the circular vessel, while the lateral spheromeres have tubes which do not pass so directly, but make a curious turn. *Abyla pentagona* does not present in its larger nectocalyx a bilateral symmetry of this kind in its chymiferous tubes. One side of the larger bell, however, is different from the other, in that it has the longitudinal canal (Längskanal), covered by a plate into which the stem is withdrawn on one side which is wanting on the other. I propose to call that the inferior side of the large nectocalyx. If the float is made out to indicate the anterior end of a Siphonophore in the Physophoridae, as to my knowledge it never has been, and if (as I believe), Leuckart² is right in considering that the somatocyst ("Saftbehälter," "Athemhöhle,"") of a Calyphore is homologous to one of those little blind tubes ("Mantelgefäß,"") on the median tube of the nectocalyx of an Agalma, these two sides of the larger nectocalyx of *Abyla* may be called anterior and posterior. Whether we use the terms anterior or superior all depends upon whether the float indicates the anterior extremity of the stem from which it buds or the superior end of the same, together with a true homology of the regions of the nectocalyx of a Calyphore. The

¹ Leuckart led the way to the institution of the term ventral line when he showed that the appendages all arise from one side of or in a direct line on the stem. Leuckart. Zool. Untersuch, p. 14. Archiv für Naturg., 1854.—Claus., Zeitschr. für wiss. Zool. XII, 7, 27.—Haeckel. Zur Entwick. der Siphon., p. 12.—Claus, Halistemma tegestinum, p. 5.

² Leuckart. Zoologische Untersuchungen, p. 10.

inferior side of the second swimming bell can be distinguished in *Diphyes Sieboldii* where two bounding ridges are continued on into two projections. The section thus marked out is not a spheromere, for it has no tube in it. It is easily to be recognized in *Epibulia* (*Galeolaria*), where it has homologous circular plates which can almost close over the entrance to the bell. In the two larger nectocalyces of *Praya* the difference lies rather in the enlargement of the superior spheromere than in any ridges with similar appendages. In the larger nectocalyx of *Abyla* I think there is nothing to represent the pair of appendages to the medial canal (*Mantelgefässe*) which one finds in *Agalma Sarsii*, and one of which is represented by the gastric cavity in the upper, smaller bell. In *Praya diphyes*,¹ both of the large bells have these appendages present; in *Praya maxima*, however, it is only in the smaller nectocalyx that this *Mantelgefäss* exists; a condition, as far as this is concerned, not unlike that in *Abyla*. Among *Physophoridae* the difference between superior and inferior spheromeres even in *Apolemia* is very slight. In *Agalma*, *Agalmopsis* (*Stephanomia*) *Halistemma*, *Stephanomia* (*Förskalia*), and *Physophora* it is very small. I would limit this inferior side of the bell in the genus *Abyla* by the tubes which pass to the circular tube. The smaller ridge which lies midway between the two larger, under which the tubes have such a modification, would then lie medially in this side. About a plane passing through this line, or indeed any longitudinal line in the larger swimming bell of *Abyla*, no bilateral symmetry can be said to exist as is the case in the tubes of the nectocalyx of many other *Siphonophores*.

I do not know what to consider the homology of this secondary tube in *Abyla*. It does not seem to be homologous to a side branch of a radial tube as in *Willia*, or if it is, that does not explain the other secondary branch already described, as also its existence in only one segment. A fifth chymiferous tube is a thing unknown in the nectocalyces of *Siphonophorae*. The secondary tube has some likeness to that connecting branch marked with a little star in Leuckart's figure, passing over the superior part of the anterior bell of *Epibulia* (*Galeolaria*).

¹ In my studies at Villa Franca I took *P. maxima*, *P. diphyes*, and a third species which I do not know. I have followed Gegenbaur in his distinction between these two species. Gegenbaur. Beiträge zur näheren Kenntniss der Schwimmpolypen. p. 19.—Leuckart, Zur nähern Kenntniss der Siphonophoren von Nizza. p. 40. For synonymy see Keferstein und Ehlers. Zoologische Beiträge pp. 20-26.

I give a figure of an *Epibulia* in my collection which illustrates this point. An objection to a comparison of this kind would be that we have in one a superior part of the first nectocalyx, and in the other, the inferior of the second. The two nectocalyces of *Diphyes*, *Abyla*, *Epibulia* and *Praya*, are probably homologous. The smaller, or anterior as they swim, may be called the superior, and the larger the inferior nectocalyx. It seems to me that the terms superior and inferior as applied to the nectocalyces and to the sides of the same would be preferable to proximal and distal, for then, since we have a right and left side to the bell, there would be more uniformity in the names of different sections. A somatocyst is, with one exception, confined to the superior bell. It is, however, almost impossible to homologize the different spheromeres of the inferior nectocalyx of *Abyla*, *Diphyes* and *Epibula*. Along the medial line of the inferior side of *Epibula* passes a chymiferous tube. Where is this tube in *Abyla* and *Diphyes*? I have found nothing in either of these genera to represent a tube along the medial line, and lying in a plane, in reference to which such a bilateral symmetry exists as we find in *Epibulia*.

Closely connected with the discussion of the homology of the chymiferous vessels in *Abyla*, the importance of which in an appreciation of bilateral symmetry among Siphonophores cannot be overlooked, comes the question of the relationship of certain appendages to the lateral tubes in *Apolemia*. These vessels I have figured and lettered *j* in figs. 2 and 5. Leuckart (*Zeitsch. wiss. Zool.*, p. 10), finds in them the representatives of the Mantelgefäße of *Agalma*, *Praya*, and *Gleba*. He says: "Bei *Apolemia* werden diese Kanäle (Mantelgefäße) von mehreren kurzen fast zottenförmigen Gefäßausstülpungen vertreten, die unter rechten Winkel aus dem obern Bogen der Seitengefäße hervorkommen und in die Substanz der Schwimglocken hineinragen."

I figure, I think for the first time, a single such vessel, fig. 6 *j*, appended to the lateral tubes of *Epibulia*.

In my figure of the nectocalyx of the *Apolemia* I have represented in addition to these structures a true Mantelgefäß not unlike the same structure in *Gleba*. It seems to me more natural to compare the tubular appendages in figs. 2, 5 and 6 with the connecting branch *k* fig. 5, than with the so-called mantle vessel which is the

same thing as the somatocyst. I have not found a like comparison made by others.

EXPLANATION OF PLATE 3.

Fig. 1. *Abyla pentagona*.

Fig. 2. Nectocalyx of *Apolesia uvaria*.

Fig. 3. Superior nectocalyx of *Epibulia aurantiaca*.

This drawing represents the course of the tubes in the superior side.

Fig. 4. Superior nectocalyx of *Epibulia aurantiaca*.

This figure is a view from the right side.

Fig. 5. Inferior nectocalyx of *Epibulia aurantiaca*.

A representation from the left side.

Fig. 6. Inferior nectocalyx of *Epibulia aurantiaca*.

Seen from the inferior side.

Figs. 3, 5, 6, in order to avoid a complicated figure, show only the tubes on the side towards the observer.

For the same purpose also the tract, polyp, tentacle, etc., are not shown on the stem of *Abyla* near where it leaves the longitudinal canal.

Fig. 2 is double the natural size of the specimen drawn.

Figs. 1, 3, 4, 5, 6, are four times the natural size.

a. Lateral chymiferous tubes.

b. Superior tubes.

c. Lateral chymiferous vessel.

c'. Branched tube peculiar to *Abyla*.

d. Origin of the same.

e. Inferior tubes.

e'. Secondary portion after division.

f. Connection of radial vessels with stem cavity.

g. Enlargement at junction of radial and circular tubes.

g'. Secondary vessel from the enlargement *g*.

h. Somatocyst.

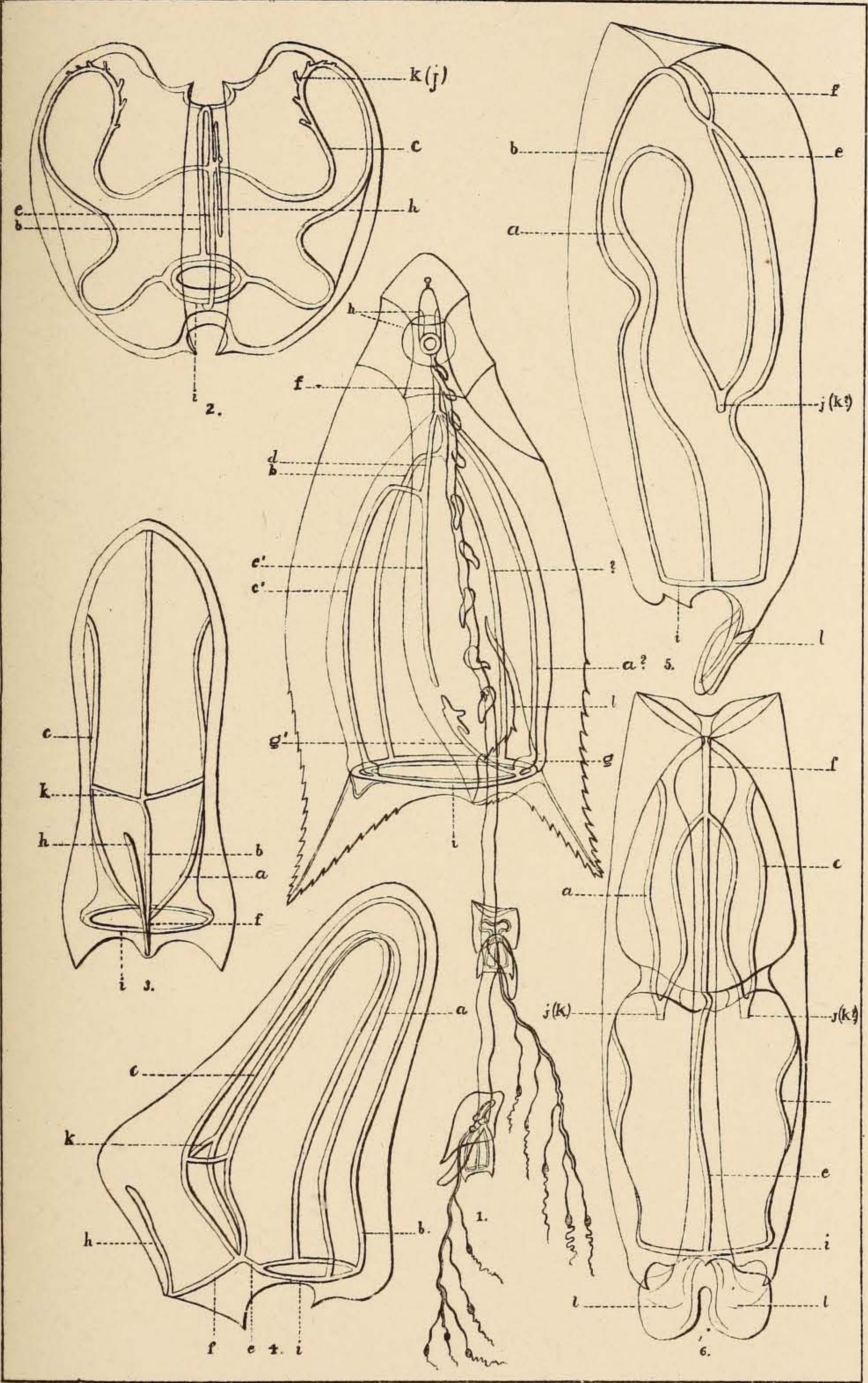
i. Circular vessel.

j. Appendages to the lateral tubes which are in

k. Connecting branches.

l. Protecting plate.

m. Circular lappets, used to direct the animal in swimming.



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