

## On some Ascidians from the Isle of Wight:

### A STUDY IN VARIATION AND NOMENCLATURE.

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With Plates VI and VII.

ALTHOUGH the Isle of Wight has been a favourite haunt of the geologist and the palæontologist, references to its present marine fauna are exceedingly rare in zoological literature. Early in May of the present year, however, I had an opportunity, at the suggestion and through the kind hospitality of my friend Mr. Poulton, of examining the littoral fauna of the eastern shores of the island, and of making a considerable collection of zoological specimens. A list of the species which I obtained will be published as soon as I have had time to complete the examination of them; but several of the Ascidians throw so much light upon the brief and obscure descriptions of certain species, that I believe it will be serviceable to give a full account of them without further delay, especially since the pressure of other work may prevent an early appearance of the complete list.

#### I.

##### ***Ascidia mollis*, Alder and Hancock.**

*ASCIDIA MOLLIS*, Hancock. Ann. Mag. Nat. Hist. (iv), vol. vi, 1870, pp. 358, 359.

I found eleven individuals of this species attached to rocks in the *Zostera* bed off Nodes Point, St. Helen's, at extreme low water, May 7th.

The short account of *A. mollis* given by Hancock is admirable as regards the description of the external features, but is insufficient in some points of internal structure. I am glad, therefore, to have an opportunity of re-describing this Ascidian. It appears to be a comparatively rare species, and I am not aware that it has been

hitherto recorded from any other locality than the coast of Connemara, in the West of Ireland.

The *body* is ovate in form, thick, lobate, attached generally by the posterior half, sometimes by a larger area of the left side. When living, it is invariably of a rosy-flesh colour; and this colour, upon close examination, is seen to be due to a number of crimson dots (the culs-de-sac of the test-vessels) profusely scattered in the substance of the test.

The dimensions of the largest individual (Pl. VI, fig. 1) are as follows:

Maximum length (antero-posterior)	.	.	$1\frac{1}{16}$ inch
„ breadth (dorso-ventral)	.	.	$\frac{3}{4}$ „
„ thickness (right to left)	.	.	$\frac{3}{8}$ „

The oral and cloacal *apertures* are on the right side of the body; the oral is sub-terminal, the cloacal half-way down and near the dorsal edge; both are small and inconspicuous. The position of the cloacal aperture varies very little in these specimens; in a few it is slightly posterior to the middle dorso-ventral line, but never so much so as to be two-thirds of the way down. No *ocelli* were observed around the apertures.

The *test* is, in Hancock's words, "firm, thick, semi-transparent, smooth and soft to the touch, rather shining, obtusely lobed, of a rosy flesh-colour, showing minute punctures and veinings of crimson." In its thick, smooth, firm, and shining character, the test of this species resembles that of *Phallusia mammillata*, a resemblance further borne out by the lobes of its surface, although these are much flatter and less protuberant in *Ascidia mollis*, than in the latter species. In its softness, however, the test of this species is very unlike that of *P. mammillata*.

Hancock states that the "terminal extremities" of the blood-vessels of the test are "more inflated and globular in this than in any other species." I have a distinct recollection of their pyriform character in the living animal, but their appearance in specimens after preservation in alcohol is very different; and they are seen to be elongated and finger-shaped, rather than inflated and globular (Pl. VI, fig. 2).

When the test has been removed from the rest of the body, the oral and cloacal *siphons* are seen to be short (Pl. VI, fig. 3). The *musculature* is, as usual, almost confined to the right side of the body; the fibres are long and delicate. Round each of the siphons a number of delicate fibres form a complete sphincter.

On the left side, the course of the intestine is visible through the body-wall. The *stomach* is rounded in form and is situated at some little distance (about one-fifth of the total body-length) from

the posterior end of the body. The *intestine* is narrow and uniform; its first bend is well in front of the cloacal siphon, its anterior wall being on a level with the ganglion; the second bend of the intestine is behind the cloacal siphon, its posterior wall being on a level with the opening of the œsophagus into the pharynx; the rectum is directed obliquely forwards towards the cloaca.

Upon opening the pharynx from end to end, along the line of the endostyle, the remaining structures can be examined.

The *coronal tentacles* are forty or more in number. In an individual possessing forty tentacles, they were of three sizes and regularly arranged—ten long and slender primaries, ten intermediate secondaries, and twenty short tertiaries.

The *præbranchial zone* is studded with microscopic papillæ.

The aperture of the *dorsal tubercle* is crescentic in the smaller specimens, horse-shoe shaped in the individual represented in fig. 1, the horns not being incurred.

An *epipharyngeal groove* extends along one-third of the distance between the dorsal tubercle and the ganglion, which is situated half-way between the mouth and the cloacal aperture. The ganglion is small, three times as long as broad, and extends over three of the meshes of the pharyngeal wall, beginning at the fourteenth horizontal bar. The epipharyngeal groove becomes elevated towards its posterior end, and behind it commences the *dorsal lamina*, which is very narrow, strongly ribbed transversely, and pectinated at its margin. The ribs and teeth of the lamina correspond in number with the horizontal bars of the pharyngeal wall. Occasionally there are minute projections from the edge of the lamina which alternate with the teeth in position. The concave side of the lamina shows a series of weak ridges running towards its edge very obliquely from before backwards.

*Branchial apparatus.*—A portion of the inner face of the pharyngeal wall is shown on Pl. VI, fig. 4. The horizontal vessels form three complete series and a rudimentary growth. The primary vessels (*h. v. 1*), which give off branches\* to the body-walls, are usually of greater diameter than those of the remaining series. Between each pair of primaries are situated one secondary vessel (*h. v. 2*), and two tertiary vessels (*h. v. 3*), at approximately equal distances.

Connecting ducts (*c. d.*) arise from all these vessels and support delicate internal longitudinal bars (*i. l. b.*) which are surmounted at the points of junction by moderately stout conical papillæ (*p.*) and at intermediate points by comparatively slender ones (*i. p.*). The

\* The origin of these branches—the dermato-branchial connectives—is marked in some specimens by white spots upon the primary horizontal bars.

connecting ducts themselves are sub-triangular in shape when seen in profile. The horizontal and internal longitudinal vessels delimit meshes, which are sometimes almost twice as long as broad, and contain four or five stigmata each. The stigmata are elongated, with rounded ends; they are frequently double, and then consist of an anterior and a posterior portion of elliptical shape. The pharyngeal wall is minutely plicated in a longitudinal direction. The meshes almost invariably show some trace of a division into two equal portions by the formation of an incomplete quaternary series of horizontal vessels; the extent to which this process is carried out varies in different individuals and in different parts of the same pharynx. The process is interesting, and may be completely traced in fig. 4. A small projection arises from the internal face of an interstigmatic bar, at its middle point (see fig. 4, upper row, third mesh from the left), and is joined by a similar projection from the opposite wall of the stigma (see the mesh below). The concrescence of the two projections forms a horizontal bridge across the middle of the stigma. The formation of several such bridges across adjacent stigmata thus gives rise to a small horizontal vessel (see the mesh below), which may be said to form part of a quaternary series; these quaternary vessels (*h. v. 4*) may even form connections with the internal longitudinal bars beneath the intermediate papillæ (*i. p.*) of those structures. My figure represents the condition of the branchial apparatus in the individual shown in fig. 3; but in a somewhat larger individual (fig. 1) the intermediate or quaternary vessels are much more highly developed, and there is less difference between them and the other horizontal vessels. There is no pharyngo-cloacal slit.\*

The *œsophagus* opens into the pharynx high up on its dorsal edge, halfway between the cloacal siphon and the posterior end of the body. In the largest specimen there are six primary horizontal bars between the *œsophageal* opening and the posterior end of the pharynx.

All my specimens are immature; in even the largest individual the development of the generative organs is still incomplete, and the ducts are very slender in form; while in smaller specimens the gonads are quite rudimentary.

In addition, however, to the specimens of which the above account has been given, I took another Ascidian which there is every reason to believe to be an adult individual of the same species, but which, from its exceptional shape, is at least an abnormal one, so that I have excluded it from the general description.

\* See p. 132.



It is represented of the natural size on Pl. VI, figs. 5*a* and 5*b*, and deprived of the test, by fig. 6. The *body* is not compressed from side to side (right to left morphologically) like an ordinary Ascidian and like normal individuals of the same species, but dorso-ventrally; and thus it comes about that, although attached in the usual manner by its left side, its right side does not present a flattened surface, but is elevated so as to form a thickened longitudinal ridge of considerable height.

The dimensions are as follows:

Length (antero-posterior)	. . . . .	2 inches.
Breadth (dorsal-ventral across the plane of attachment)	. . . . .	$\frac{5}{8}$ „
Thickness (morphological right to left)	. . . . .	$\frac{7}{8}$ „

The breadth becomes considerably reduced towards the summit of the ridge which represents the right side of the body.

The *test* is very thick and presents all the characters of normal individuals of *Ascidia mollis*, except that it is much corrugated on that face of the body which contains the cloacal aperture (see fig. 5*a*). The *oral aperture* is sub-terminal and on the same side as the cloacal aperture, which is slightly nearer the anterior than the posterior end of the body. The body is attached by almost the whole of the left side, which is deeply furrowed and irregularly pitted. The test is overgrown by extensive colonies of the Polyzoan *Cylindrocium dilatatum*.

Upon removal of the test, the extent of the dorso-ventral compression is at once noticed. The *ganglion* and *cloacal siphon*, instead of occupying their usual position upon the apparent left of the body, are in the median line of the upper side; and the whole of the *viscera* appear to have suffered a similar rotation through 90 degrees. Strictly speaking, however, the viscera present exactly the same morphological relations to the rest of the body as in the normal individuals described above.

The *generative organs* are well developed, and the oviduct and vas deferens are remarkably dilated. The former contains numerous ripe ova, of small size; and the latter is filled with a mass of spermatozoa.

The only difference of any importance in the pharynx is the presence of a *pharyngo-cloacal slit*,\*  $\frac{1}{8}$  inch in length, in the usual position opposite the cloacal aperture.

The *præbranchial zone* is closely studded with minute papillæ.

The growth of the aperture of the *dorsal tubercle* has progressed still further; both horns are now curved inwards.

*Epipharyngeal groove* and *dorsal lamina* as in younger specimens,

\* See p. 132.

but the lamina is a little deeper; the ribs are very strong and regular, the teeth rather short, very regular, without intermediate smaller ones; the concave side of the lamina as described above.

Behind the œsophageal aperture is a long smooth area (the "post-buccal raphé" of Roule), bounded on the left by a continuation of the dorsal lamina, and on the right by a series of terminal elevations of the horizontal membranes of that side, as in *A. mentula*.

*Branchial apparatus*.—This is much as in younger specimens, but the arrangement of horizontal bars into primaries and secondaries, &c., is less obvious, owing to the increase of the quaternary vessels which are in many parts of the pharynx completely formed. Rudimentary quaternaries are rare.

The papillæ at the junctions are bluntly conical; the intermediate papillæ are well developed and slenderly conical. The meshes are slightly longer than broad, except where new quaternaries are forming, when they are twice as long. There are from five to seven stigmata in a mesh.

Between this Ascidian and the immature specimens of *A. mollis* described above, the only points of difference, which are not obviously the consequences of further growth, are the different plane of compression and the presence of a pharyngo-cloacal slit.

As to the former, it is a pure abnormality. By Professor Lankester's kindness I have had an opportunity this year of examining in detail the collections of Tunicates in the Oxford Museum, and I found there a specimen of *Phallusia mammillata* which exemplified precisely the same kind of variation. The broadly ovate test was compressed dorso-ventrally, the apertures and ganglion being in the middle line of the upper side, and the viscera and visceral septum of the test being correspondingly rotated. Yet there were no structural differences at all to warrant a division of the species.

As to the pharyngo-cloacal slit, its presence in the adult and not in the young may seem surprising, especially when its supposed morphological importance is taken into account; but I have found exactly the same phenomena in the species *Ascidella aspersa*. The ordinary specimens of that species show no trace of this aperture, but I have seen a distinct pharyngo-cloacal slit in a particularly large individual, taken from a Falmouth trawler, which I examined this year at Plymouth; in it the slit\* occupied its usual position

\* The walls of the slit were definite, straight, and smooth, resembling in all respects those of the slit in *Ascidia mentula*. It must not be imagined that the slit, which I have mentioned, was an irregular abnormality of the kind described by Prof. Herdman in specimens of *Ascidella aspersa* from the west coast of Ireland (Proc. Liv. Biol. Soc., v, 1891, p. 210, pl. x), an abnormality which may also occur in *Ascidia mentula*, as I have myself observed in a specimen from Loch Long.

opposite the cloacal aperture. It may therefore be admitted that the presence of this slit is in some way a consequence of increased size, and that its absence in young individuals is not a matter of specific value. An attempt to explain the meaning of this remarkable aperture is made below (see p. 132).

## II.

### *Ascidia depressa*, Alder.

*ASCIDIA DEPRESSA*, Alder. Cat. Moll. North. Durham, Trans. Tyneside Nat. Field Club, 1848, p. 107.

- — *non Heller*. Untersuch. über die Tunicaten d. Adriat. Meeres, Denks. d. Kais. Akad. Wiss. Wien., xxxiv, ii, 1875, p. 15, Taf. v, figs. 10—12.
- — *nec Herdman*. Notes on British Tunicata, Journ. Linn. Soc., xv, 1881, pp. 286, 287, pl. xviii, figs. 4, 5.
- — *nec Roule*. Rech. s. les Ascidies Simples d. Cotes de Provence, Ann. Mus. d'Hist. Nat. Marseille, tom. ii, 1884.

Under this name I describe a species of Ascidian of which I took four specimens on May 11th. They were attached to the under surface of a stone near the *Zostera* bed off Nodes Point.

**SPECIFIC DIAGNOSIS.**—*Body* oblong ovate, much depressed, greenish when alive, attached by the whole of the left side. *Oral aperture* subterminal; *cloacal* two thirds of the way down, on the right side, near the dorsal edge. *Test* rather thin, cartilaginous, provided with numerous minute tubercles on its free surface. *Oral and cloacal siphons*, especially the cloacal, rather long. *Stomach* rounded, at the posterior end of the body; first bend of intestine considerably anterior to the cloacal siphon; rectum directed obliquely forwards, sometimes almost horizontal. *Tentacles* 25 to 30, long and slender. *Præbranchial zone* studded with minute papillæ. Aperture of *dorsal tubercle* horse-shoe shaped, horns not incurved, concavity anterior. *Ganglion* much elongated, slightly dilated at each end. *Epipharyngeal groove* low, moderately long. *Dorsal lamina* continued behind the œsophageal opening, fairly deep, strongly ribbed on the convex side and regularly pectinated, with stout papillæ profusely scattered on the concave side. *Pharyngeal wall* minutely plicated; horizontal bars usually broad and narrow alternately, their breadth never exceeding half the length of the meshes; internal longitudinal bars slender; papillæ above the connecting ducts erect, discoid, provided with a supporting ridge in front and behind; no intermediate papillæ; meshes square, each containing four or five stigmata. *Æsophageal aperture* on dorsal side of pharynx, near its posterior end.

The *body* in all the specimens is much depressed, oblong in form, with sloping and expanded edges, and attachment is affected by the whole of the left side. The position of the oral and cloacal apertures is indicated in fig. 7 (Pl. VII), which represents the largest individual of twice the natural size. The cloacal aperture varies

slightly in position, but it is always nearer the posterior than the anterior end of the body, between half and two thirds of the way down the dorsal edge. Both apertures are small and inconspicuous; no ocelli were observed in the living animal.

The dimensions of the largest specimen are as follows :

Maximum length . . . . .	$\frac{15}{16}$ inch
„ breadth . . . . .	$\frac{5}{8}$ „
„ thickness . . . . .	$\frac{1}{4}$ „

The *test* is firm and cartilaginous, though rather thin; it is not rough to the touch, but its surface is in reality studded with minute tubercles of bluntly conical form. They are so small that they cannot be readily observed when the test is immersed in alcohol, but when removed for a moment from the fluid, the presence of minute projections is detected by the broken reflection of light from its upper surface. A portion of the surface of the test is shown on Pl. VII, fig. 9, considerably magnified. A series of vertical sections through the test shows that the tubercles are quite solid, and that the culs-de-sac of the test-vessels have no connection with them. The greater part of the test is composed of huge "bladder-cells," the largest of which are as large as many of the tubercles on the surface; they are of spherical or polyhedral form. The superficial tubercles are entirely destitute of bladder-cells.

The body when deprived of the test is at least twice as long as broad in the majority of the specimens, but in one individual the proportion between the two dimensions is slightly less than this. The oral and cloacal siphons are both rather long and tubular, and the cloacal siphon is particularly so (Pl. VII, fig. 8).

From the œsophageal opening being situated near the posterior corner of the pharynx, the viscera extend to the posterior end of the body. The *stomach* is rounded in form and considerably wider than the intestine. The course of the intestine has been sufficiently indicated above.

The *ganglion* is remarkably elongated, being six times as long as broad; it extends from the level of the fifteenth to that of the twenty-first horizontal bar in the specimen shown in figs. .

The *epipharyngeal groove* in the same individual is a low furrow, not elevated behind, extending from the dorsal tubercle as far as the ninth horizontal bar, but at the sixth bar its left lip suddenly thins out and bends over the right lip, concealing it from view, and continuing posteriorly as the *dorsal lamina*. This structure has a very characteristic form in this species (Pl. VII, fig. 10). It is moderately deep, provided with a regular succession of transverse ribs on its convex side and of well-marked teeth on its edge, the latter corresponding to the number of ribs. There are no inter-



mediate pectinations of its edge ; but the concave side, instead of being smooth, as is usually the case in Ascidians, is profusely studded with stout papillæ, as shown in the figure. There is a certain tendency of the papillæ to be arranged in rows directed obliquely from the summit to the free edge of the lamina, from before backwards ; but this general tendency is frequently departed from. The dorsal lamina is continued for some distance behind the œsophageal aperture.

*Branchial apparatus.*—The horizontal vessels are often of two sizes,\* broad and narrow, and these vessels alternate with one another in position ; but the breadth of the larger vessels never exceeds half the antero-posterior diameter of the meshes—usually it is considerably less. The pharyngeal wall is minutely plicated. The internal longitudinal bars are slender in form. At their junctions with the connecting ducts are situated blunt papillæ of characteristic shape ; they are of an erect discoid form, with a semi-circular edge, compressed from before backwards, and provided with a supporting ridge or buttress upon their anterior and posterior faces (fig. 11 *b*). Usually the meshes are square, and intermediate papillæ quite absent ; but in some parts of the pharynx transverse rows of meshes may frequently be observed which are distinctly elongated in a longitudinal direction, and in such regions minute intermediate papillæ may be detected upon the internal longitudinal bars. The elongation of the meshes and appearance of intermediate papillæ is preparatory to the formation of a new series of horizontal vessels, in the manner which I have described above in *Ascidia mollis*. There are four or five stigmata in each mesh (fig. 11 *a*). There is no pharyngo-cloacal slit.

My largest specimen is mature, and minute white ova are present in the oviduct.

After much consideration I have arrived at the conclusion that the specimens whose structure I have just described represent the species *Ascidia depressa* of Alder, and that the Ascidians described under this name by Heller, Herdman, and Roule, are distinct from it.

A reference to Alder's original account will show how perfectly in every point my specimens agree with his description, with the exception that I can make no statement as to the presence of red ocelli around the apertures. I did not observe these spots in the living animals ; but on the other hand I paid no attention to the point, and probably overlooked their existence. In every other respect the correspondence is complete, and I may draw especial attention to the following details—the shape and colour ; the expanded edge ; the position and form of the apertures ; the granulations (minute tubercles) on the upper surface ; the absence of inter-

\* This distinction of size is much less apparent in mature than in young individuals.

mediate papillæ in the branchial sac (for it was Alder's habit to imply the absence of these structures when he made no direct reference to them); and the size.

If this be really so, it necessarily follows that Heller's specimen described under the same name is distinct. The structure of the test is alone sufficient to distinguish my specimens from his. The bladder-cells in the former are huge, of spherical or frequently polyhedral form, exactly as Heller has himself described and figured for his *Ascidia rudis* (l. c., p. 14, Taf. v, fig. 6); but for his *A. depressa* a very different condition was described by him (l. c., p. 15). Further, Heller's *A. depressa* was destitute of the superficial microscopic tubercles which are present in my specimens (and in Alder's), and which Heller himself also figured for another species (*A. rudis*, l. c.).

Secondly, the specimens which Prof. Herdman has referred to this species differ from Alder's in possessing intermediate papillæ on the internal longitudinal bars; Alder would certainly have noticed the existence of such papillæ as Herdman has figured (l. c., *supra*, pl. xviii, fig. 4), if they had existed in his specimens. Prof. Herdman's specimens cannot belong to the same species as these from the Isle of Wight, because in the latter the internal longitudinal bars rarely show a trace of intermediate papillæ, except when the meshes have grown to a size when they are almost twice as long as broad; in Prof. Herdman's species these papillæ are normally present, and the meshes are elongated transversely. Further, the structure of the dorsal lamina is very different in the two cases. Prof. Herdman in the same paper noticed the existence of tubercles on the dorsal lamina of *Ascidia plebeia*, so that there is no reason to suppose that he overlooked them in his *A. depressa*.

Lastly, M. Roule has described under the name *Ascidia depressa*, a species which, while probably identical with Heller's, is undoubtedly distinct from Alder's species. The mode of attachment, the shape of the body, and the structure of the branchial sac are very different in the two cases. The species described by Heller and by Roule presents a close affinity with *Ascidia mentula*, and still more, perhaps, with Alder's (not Heller's) *Ascidia rudis*; but there is nothing in Alder's description of *A. depressa* to indicate a similar relationship for that species, and my specimens are distinctly against it.

*Ascidia depressa*, as now re-described, is very closely related to Traustedt's *Ascidia* (*Phallusia*) *pusilla* (Mitt. Zool. Stat. Neap., iv, 1883, p. 465, Taf. xxxiv, figs. 16, 17; Taf. xxxv, fig. 26). The chief points of difference are found in the different proportions of the length to the breadth of the body, the length of the siphons, the breadth of the largest horizontal vessels of the pharynx, the

number of stigmata in the meshes, the shape of the stomach, and especially the structure of the dorsal lamina. Some of these differences are trivial, and it is impossible at present to say whether Traustedt's single specimen of *A. pusilla* is, or is not, merely an abnormal individual of our species; but the constancy in the structure of the dorsal lamina in my specimens is, when associated with the other peculiarities, a strong piece of evidence in favour of the specific distinctness of the two types.

*Ascidia depressa* is also allied to *Ascidia marioni*, Roule, on account of the close agreement between the two species in the following points—the mode of fixation, the position of the apertures, the minute tuberculation of the surface, the absence of intermediate papillæ, the strong pectination of the dorsal lamina, the elongation and approximation of the stigmata; but the two species are of course quite distinct owing to the important difference between them in the structure of the subneural gland and its accessory organs.

I have already pointed out the curious resemblance between *Ascidia depressa* and Heller's *Ascidia rudis* in the histological and superficial structure of the test. Since Heller's specimen agrees with Roule's *Ascidia marioni* both in the position of the cloacal aperture and in the minute tuberculation of the surface, it is not improbable that the two are specifically identical; but whether Heller's individual was rightly referred to Alder's species or not is very doubtful. Alder's *rudis* possessed "small, distant tubercles" on the test, and was "sometimes nearly smooth,"—a condition very different from that in Heller's specimen, as well as in Roule's *A. marioni*.

If, as I believe it will now be generally admitted, the forms described by Heller, Roule, and Herdman under the name *Ascidia depressa* can no longer lay claim to that title, it will be necessary to refer to them under new designations. I would propose for the Mediterranean species described by Roule the name *Ascidia Roulei*. To the variety *petricola* of this species, Heller's specimen almost certainly belongs. I believe that *Ascidia Roulei* is closely related to, if not identical with Alder's *Ascidia rudis*: but it is impossible to give a final decision upon this question until our British Ascidiæ have been collected and re-examined in greater detail.\*

The form described by Herdman as *Ascidia depressa*, in the paper to which reference has been made above, appears to be distinct from *Ascidia Roulei*, although it is impossible, from the want of correspondence between the descriptions, to speak decisively. But Prof. Herdman has himself thrown doubt upon their identity

\* It is needless to say that we look forward with interest towards Prof. Herdman's promised re-description of some of Alder and Hancock's types.

in his recently published\* Revised Classification of the Tunicata, so that a new name is, at least provisionally, desirable. I therefore propose for it the name *Ascidia Herdmani*.

The subjoined synonymic lists show briefly the conclusions to which I have been led by the study of this species from the Isle of Wight.

1. *ASCIDIA DEPRESSA*, Alder, 1848, loc. cit.

= *ASCIDIA DEPRESSA*, Garstang, 1891 (the present paper).

?? = *PHALLUSIA PUSILLA*, Traustedt, 1883, loc. cit.

non *ASCIDIA DEPRESSA*, Heller, 1875, loc. cit. (= *A. Roulei*, Garstang, 1891).

nec — — Herdman, 1881, loc. cit. (= *A. Herdmani*, Garstang, 1891).

nec — — Roule, 1884, loc. cit. (= *A. Roulei*, Garstang, 1891).

2. *ASCIDIA RUDIS*, Alder, 1863. Ann. Mag. Nat. Hist. (3), ii, p. 195.

? = *ASCIDIA ROULEI*, Garstang, 1891.

= *A. DEPRESSA*, Roule, 1884 (non Alder, 1863, nec Herdman, 1881).

= [var. *PETRICOLA*] *A. DEPRESSA*, Heller, 1875.

non — *RUDIS*, Heller, 1875.

? = *A. MARIONI*, Roule, 1884.

### III.

*Ascidia mentula*, O. F. Müller.

*ASCIDIA MENTULA*, Müller. Zoologia Danica, 1788, vol. i, pp. 6, 7, pl. viii, figs. 1—4.

— *RUBROINCTA*, Hancock. Ann. Mag. Nat. Hist., 1870.

— *RUBICUNDA*, Hancock. Ibid., 1870.

— *ROBUSTA*, Hancock. Ibid., 1870.

*PHALLUSIA MENTULA*, Kupffer. Jahreshb. d. Komm. z. Unters. d. deutsch. Meere in Kiel, Berlin, 1874, p. 209, pl. iv, fig. 1.

*ASCIDIA MENTULA*, Heller. Untersuchungen, 1875, loc. cit., pp. 2—13, pls. i—iv.

— *RUBESCENS*, Heller. Ibid.

— *LATA*, Herdman. Journ. Linn. Soc., xv, 1881.

*PHALLUSIA MENTULA*, Traustedt. Die einfachen Ascidien, 1883, loc. cit., pp. 457—459.

*ASCIDIA MENTULA*, Roule. Recherches, 1884, loc. cit.

Several large Ascidians, which I refer to this species, were found attached to the sides of a rock, situated far out in the Zostera bed off Nodes Point, on May 7th, at extreme low water,

\* Journ. Linn. Soc. Zool., vol. xxiii, 1891, p. 594.



spring-tides having then almost reached their height. The following descriptions refer to two individuals which I brought away with me for more detailed examination; they are given separately in order to indicate the degree of variation the more naturally.

A. *Body* oblong, elongated, attached by almost the whole of the left side. Dimensions—Length, 3 inches; breadth,  $1\frac{1}{2}$  inches; thickness,  $\frac{1}{2}$  inch. An idea of its external appearance may be gained from the figure which Heller gives (l. c. pl. v, fig. 5) to represent a supposed specimen of Alder's *Ascidia rudis*, but the position of the cloacal aperture is different.

*Test* thin, hard, cartilaginous, greatly wrinkled in a longitudinal direction on the right side, almost entirely overgrown by small algæ, and extensive colonies of the Polyzoon *Alcyonidium mytili* and some Didemnids. Here and there on the right surface a few minute tubercles may be detected. *Oral aperture* on the right side, sub-terminal, not prominent, bounded by nine lips; *cloacal aperture* on the right side near the dorsal edge, very slightly nearer the anterior than the posterior end of the body, bounded by six lips.

Upon removal of the test the rest of the body is seen to be of a yellowish colour, the musculature being of a rather deeper amber-colour. The *oral* and *cloacal siphons* are tubular but short. The oral siphon terminates in nine sub-triangular lips, which are rather prominent, with rounded apices and with a spoon-shaped concavity on their external surfaces. The edge of the siphon is bounded by a thin red line which is discontinuous towards the tips of most of the lips. A small red ocellus is found behind the red line between each pair of lobes, and the surface of the siphon is slightly sprinkled with red dots. The cloacal siphon terminates in six lobes, bounded similarly by a thin red line, but without ocelli. It is directed straight towards its external orifice.

*Musculature* coarse and strong, the fibres amber-coloured.

*Viscera* disposed as usual in the species, the posterior border of the stomach being nearly  $\frac{1}{2}$  inch from the posterior end of the body; the anterior wall of the intestine at its first bend is on a level with the ganglion; the posterior wall at its second bend is on a level with the opening of the œsophagus into the pharynx.

*Renal vesicles* large, forming a soft yellowish coating over the stomach and intestine; concretions showing as a small brown spot in each vesicle, when looked at with a lens, but resolving themselves in each case into a compact mass of several concretions, of different sizes and of a yellowish-brown colour, when examined under a low power of the microscope (cf. Roule).

*Tentacles* about thirty in number, short, of unequal sizes, irregularly arranged.

*Præbranchial zone* studded with microscopic papillæ arranged more or less regularly in longitudinal rows.

*Dorsal tubercle* longer than broad, presenting two apertures, one behind the other. The anterior is crescentic, with the horns produced and curved inwards; the posterior is crescentic, with the left horn slightly produced and curved towards the mid-dorsal line, and with the right horn also curved round and produced a little beyond the mid-dorsal line (Pl. VII, fig. 12).

*Epipharyngeal groove* present for a short distance and then ceasing abruptly (fig. 12). The *dorsal lamina* is quite absent anteriorly, and does not appear until halfway between the position of the ganglion and the level of the pharyngo-cloacal slit, when it gradually rises up in the form of a narrow membrane and is continued to the posterior end of the pharynx. Dorsal lamina strongly ribbed transversely and minutely pectinated at the margin, the teeth corresponding to the ribs; no intermediate pectinations; concave side smooth.

A *pharyngo-cloacal slit*\* present on the right side of the dorsal

\* I give this name to the curious aperture, so commonly found in the pharyngeal wall of *Ascidia mentula*, in which species it was first noticed by Kupffer (l. c.). It has been ingeniously suggested lately that it represents the persistent internal opening of the right primitive atrial canal, in spite of the fact that it is absent in the more primitive Ascidiæ, such as *Clavelina* and the *Distomidæ*. Now, as has been stated above (pp. 123 and 124), I have discovered this slit to be present in large individuals of two other species of Ascidiæ which are not closely allied to *Ascidia mentula* (*Asciidiella aspersa* and *Ascidia mollis*), although it does not exist in young specimens of those species. This fact is a sufficient disproof of the theory which gives to the slit the value of a phylogenetic remnant. My own theory is less attractive, but possibly more true. The slit is always situated opposite the cloacal orifice, and only occurs in large species (*Ascidia mentula* and its close allies, e.g. *Ascidia lata*, Herdman) and in large individuals of smaller species (e.g. of *A. mollis* and *Asciidiella aspersa*). May it not be a special adaptation for the prevention of the over-accumulation of fæces in the cloacas of large Ascidiæ, where the ordinary methods of ejection are insufficient? Ascidiæ, being sessile animals, are especially liable to danger from such over-accumulation, as Giard long ago stated in the case of the *Didemnidæ* and *Polyclinidæ* (Arch. Zool. Exp., i, p. 520); and special means are adopted in various sections of the group to ward off the danger. For instance, as Maurice has well suggested, the cloacal languettes of the *Polyclinidæ* serve the definite function of keeping open the cloacal canals in colonies of that family (Arch. de Biol., viii, 1888, p. 243); while in the *Botryllidæ* the end is achieved only by the united efforts of the zooids in a cœnobium: they simultaneously and suddenly contract their bodies, and so drive a strong current of water through their peribranchial cavities into the common cloaca, ejecting the fæces with such violence, as Gaertner observed, "ut ingenti saltu oppositum favæ marginem transiliant" (see Giard, loc. cit.).

In the large Ascidiæ under discussion, the presence of this big oval slit—it is frequently over a centimetre in length—directly opposite the cloacal cavity, will enable the animal, by a strong contraction of the muscular tunic, to drive a considerable body of water from the pharynx into the cloaca, and thus to effect the desired object more thoroughly than is possible when stigmata exist alone.

Kupffer has also recorded the existence of paired pharyngo-atrial slits, symmetrically

lamina, directly opposite the cloacal aperture; slit,  $\frac{1}{4}$  inch long and smooth-edged.

*Ganglion* hour-glass shaped, midway between the slit and the dorsal tubercle.

*Esophageal opening* high up in the pharynx, between the slit and the posterior third of the body. Behind it is a long smooth "post-buccal raphe" (see Heller's figure, l. c.).

*Branchial apparatus*.—Meshes elongated transversely; stout conical papillæ at the junctions, provided with supporting ridges in front and behind (fig. 13); intermediate papillæ equally long, but more slender than the primary papillæ; six or seven stigmata in a mesh; minute plications deep, the longitudinal furrows frequently bifurcating.

B.—The second individual differs from the one just described in the external form, and in the absence of any malformation of the dorsal tubercle and lamina; in other respects it is closely similar to the first specimen.

*Body* of a compressed pyriform shape, the narrow end anterior, attached by a circular area over the posterior half of the left side. Dimensions—Length,  $2\frac{1}{2}$  inches; Maximum breadth across middle,  $1\frac{3}{8}$  inches; Thickness,  $\frac{3}{4}$  inch.

*Test* very slightly furrowed, overgrown with algæ and Polyzoa.

*Oral aperture* terminal; *cloacal* on the dorsal edge, slightly nearer the posterior than the anterior end of the body.

*Oral siphon* with very short and obtuse lips; no red pigment upon either of the siphons.

*Tentacles* forty in number, considerably longer than in the preceding specimen, irregularly arranged.

*Dorsal tubercle* circular in shape; aperture horse shoe-shaped, the right horn curved inwards.

*Epipharyngeal groove* considerably longer, its lips gradually narrowing and becoming continuous with the dorsal lamina.

In all other respects this individual agrees with the former.

Both individuals are mature and have ova and spermatozoa in their generative ducts.

I believe that in point of size these specimens have undergone a placed in the posterior region of the pharynx, in *Ascidia conchilega* and *Ciona* [*canina*] *intestinalis*. The former species I have been unable to examine, but in *C. intestinalis* (preserved material) some individuals possess huge slits, through which the intestine conspicuously projects into the pharynx, while in other individuals no unusual apertures can be made out at all. (Cf. Traustedt, loc. cit., p. 455. Heller, loc. cit., ii, p. 118, seems merely to repeat Kupffer's statement. Roule, loc. cit., makes no reference to any exceptional openings.) I am inclined, therefore, to believe that in both these species Kupffer's apertures are accidental or artificial rather than natural.

considerable reduction since their capture. In the rough notes which I then made, I put down the length as "about 5 inches," while actual measurement now shows that the largest of the two brought away does not exceed 3 inches. Allowing for a possible degree of error in my original estimate of their size, there must still, I think, have taken place some contraction of their test and body in the four months during which they have been in alcohol. It is, I admit, unsafe to argue upon these grounds, for the larger ones may have been just those which I dissected at the time of capture and did not retain. I will, therefore, merely state that the size of some of the specimens which I found was fully 4 inches.

The colour of the individuals when alive was hardly different from that which these spirit specimens now exhibit. It is sufficient to say that there was an almost total absence of red pigment in their bodies, and what did exist was confined to the region of the siphons, particularly the oral siphon. The test-vessels, also, with their terminal dilatations, were destitute of red and of all conspicuous colouration.

The species *Ascidia mentula* has been described in greatest detail upon Mediterranean specimens, although it is widely distributed round all the coasts of Europe, and has been called the commonest of the British deep-water Ascidiæ. Off the south-western shores of England, however, it is certainly not common within the 40 fathom line; I have only taken it once or twice there, and its place seems to be occupied by two other large Ascidiæ, *Phallusia mammillata* and a coarse variety of *Ascidella aspersa*. Indeed, the fact that there is extant no anatomical description of British specimens referred to Müller's species, seems at first to be strange, if they are really so abundant.

A comparison of my specimens with Müller's original description revealed some distinctions which at the outset seemed to be of some importance. Both of Müller's specimens were brilliantly pigmented, the whole of the body within the test being of a bright crimson colour, except over the area occupied by the viscera on the left side, which was whitish, the intestine being of a livid green colour ("colorem luridum exhibens").

But in Traustedt's specimens from Naples the red pigment was found to be a very variable and unreliable characteristic; sometimes the stomach only was so coloured, sometimes this pigment was spread over the entire area of the branchial sac (as in Müller's specimens), whilst sometimes individuals were taken which were quite destitute of red colouration.

Roule, at Marseille, has observed that the test is almost always



rose or red in colour, and he gives some beautiful figures in illustration of this condition, but he also admits a considerable degree of colour-variation in the species, which he attributes to local influences.

Heller's specimens from the Adriatic seem to have been much more subdued in colour than those from the neighbourhood of Naples and Marseille. He describes the colour as "greenish or yellowish-white, seldom brownish, the oral siphon usually edged with red (*rothgesäumt*) ;" further on he adds that the blood-corpuscles are brownish. My specimens, therefore, approach Heller's very closely in this respect.

Now a perusal of Hancock's paper on *Several New Species of Simple Ascidiæ* (1870, l. c.) shows that he attached a considerable importance to distinctions of colour in his definitions of species, an importance which can no longer be admitted for *mentuloid* forms at any rate; and Roule has quite rightly, in my opinion, merged Hancock's *A. rubro-tincta* into the species *A. mentula*. *Ascidia rubicunda* of Hancock agrees perfectly with the typical *mentula* of Müller in its brilliant colouration, and I shall show below how unimportant is the only other character which distinguishes it from the general form of that species. *Ascidia robusta* of Hancock is distinguished from the specimens which I have described from the Isle of Wight by hardly any other point than the prolongation of the oral and cloacal siphons.

It may be observed that in all the *mentuloid* forms there is a distinct correlation between the position and extent of the area of attachment and the zone of the sea-bed from which individuals have been taken. The *Ascidia mentula* of authors is an inhabitant of the deeper waters, and is found attached usually to stones and shells by its base and a very little of the left side. Adhering in this way, it is obvious that it has an erect position upon the seabottom. Now the three species named above were distinguished by Hancock from *Ascidia mentula* partly on account of the mode of their attachment; *A. rubrotincta* adhered "by the middle portion of the side," *A. rubicunda* "by the whole side with imperfect marginal expansions," *A. robusta* "by the whole side, but [was] sometimes much distorted, and with adherent root-like prolongations."

These three "species" were all taken from between tide-marks, the first at Guernsey, the second at Tobermory (Isle of Mull), Portaferry (Strangford Lough), and Bertraghbuy Bay (Connemara), the third at Herm.

The Isle of Wight specimens also were attached by the whole or the greater part of the left side, and they also were taken from a rock at low water.

Now no one can have much attended to the conditions of existence in the littoral zone without having been impressed by the extent of the disturbing forces which littoral animals have to resist, if they are to survive in that locality. They are battered by the waves almost incessantly, and cannot exist without special means of defence. This defence in many groups is ensured by the development of strong adhesive or clinging organs, the prevalence of which among littoral animals shows, by a reversal of the argument, the extent of the disturbing forces that play around them.

Tunicates are essentially plastic creatures, for the structure and mode of development of their tests renders their external form easily modifiable. It would, therefore, be extremely improbable to find that the larvæ of *Ascidia mentula*, when carried by in-flowing tidal currents from deeper water into the littoral zone, would grow in quite the same way in one place as in the other. The incessant motion of the water would necessitate, and indeed frequently bring about, as growth proceeded, a larger area of attachment than would suffice to resist the comparatively feeble currents of deeper water.

The results of such a process would be (1) Hancock's *Ascidia rubicunda*, which is merely the red-coloured variety of *A. mentula* adapted to a littoral existence; (2) my specimens from the Isle of Wight, which are merely the pale variety of *A. mentula* adapted to a littoral existence upon a comparatively smooth surface of rock; (3) Hancock's *A. robusta*, which is a pale reddish variety modified in its mode of attachment by tidal influences, and in its general shape by the irregularity of the surrounding objects ('roots' of *Laminaria digitata*).

Even Müller a hundred years ago recognised the plasticity of form in his species, for, referring to the oral and cloacal apertures, he says:—"Pro figura massae, quae ab adjacentibus corporibus determinatur, vel utraque lateralis, vel altera plerumque terminalis."

If it should be objected that the Mediterranean zoologists can supply little or no evidence of variability in the extent and mode of attachment in their specimens, the fact is rather in favour of my contention than against it; for the causes to which the variation has been here attributed are absent in the Mediterranean, where the tidal oscillation, with its accompanying disturbance of the sea-bottom, is so small that it may practically be neglected.

With regard to internal structure, the differences between the Isle of Wight specimens and those described by the Mediterranean zoologists are very slight and unimportant.

For a comparison of the descriptions of Mediterranean forms shows that variability is not confined to points of colour and external form. Traustedt gives the number of tentacles as from

78 to 85 in Neapolitan specimens, while Heller, who also examined the species in great detail, ascribes from 30 to 35 to Adriatic examples. There are 30 in one of mine, 40 in the other. Herdman's *Ascidia lata* ( $3\frac{1}{2}$  inches long; one specimen) possessed from 16 to 20, and the species was defined upon the ground of this difference\* and of a peculiarity in the aperture of the dorsal tubercle.

Take again the dorsal lamina. Heller unfortunately gives no details upon this point, but Traustedt and Roule agree that the lamina is strongly pectinated. In Roule's specimens the right face of the lamina is also provided with a few smaller "languettes." On the other hand, Hancock's *A. rubicunda*, Herdman's *A. lata* (from Loch Long), and my specimens agree in being merely minutely denticulated along the edge of the lamina.

It is true, therefore, that we have at last arrived at a point wherein some of the north Atlantic forms agree to differ from their Mediterranean relatives; but he would be rash who would distinguish the species upon this ground alone, in view of the numerous cross-resemblances in other respects.

The præbranchial zone is minutely tuberculated in my specimens just as in Traustedt's.

Altogether, therefore, there appears to be no sound reason why the numerous *mentuloid* forms mentioned in this paper should not be grouped together into one species and entitled *Ascidia mentula*. Some other "species" might even be added to the list. Heller's *A. rubescens* has rightly been included by Roule as a young individual of the species, and it is just possible that Herdman's *A. fusiformis* ( $1\frac{3}{8}$  inches long; three specimens) is merely a young condition also.

It is difficult to form an opinion upon Hancock's *A. plana* and *A. alderi*; but they appear to belong to this species also.

I cannot hope to have altogether avoided error in the course of this paper, but I have certainly endeavoured to do so; and I trust that, as an attempt to throw a little light upon some of our British Tunicates, my essay will not be without useful results.

Moreover, it would seem to be serviceable if a word or two should be said upon the desirability of keeping in mind the facts of variation, and of adopting some method by which the broad phenomena of variability within the limits of a species can be properly and systematically recorded.

\* Since the above was put in type, I have been enabled to examine some specimens of *A. mentula*, which were dredged in Loch Long and are now under Mr. Hoyle's charge in the Manchester Museum. The number of tentacles is so variable as to be only 18 in an individual  $4\frac{1}{2}$  inches long, while it is nearly 40 in an individual 3 inches long.

It is now a truism that variation does not only consist in the manifestation of irregular abnormalities. The commonest Anemone of our sea-coasts, *Actinia equina*, Linn., sufficiently testifies to the existence of a fixity and a stability even in variation. Yet it would be a strange misconception of the species-idea that would lead anyone to specifically separate the more constant varieties of *Actinia equina* or of *Cylista undata* from one another simply on the ground of that constancy.

The *nomen triviale* of taxonomy is a great boon to the investigator in biology, but it becomes a burden when it is applied with random pen to every little group of forms, distinguished though they may be, under their particular conditions, by the constant possession of some minute peculiarity. Minute and constant peculiarities are of the greatest interest and importance, and nothing could be, for some time to come, of higher value to the student of organic evolution than their careful recognition and classification, involving also a similar record of the bionomical conditions under which those peculiarities are found to be manifested.

But there is no reason why the specific name should be bestowed upon these minutely isolated groups. They had much rather have a nomenclature of their own within the limits of the species embracing them; and that such a nomenclature can be adopted with success is sufficiently established by a perusal of Mr. Gosse's admirable monograph of the British Actinians,—to go no further.

I will conclude with an attempt, by way of illustration, to record what seem to be the main outlines of variability in the species which has just been discussed.

#### ASCIDIA MENTULA, O. F. Müller.

Var. 1.—**RUBERRIMA.** Body-walls beneath the test of a brilliant red or rose-colour; tentacles (always?) numerous (60 to 80).

Form *a.*—**Erecta.** Area of attachment small, usually posterior and basal; infra-littoral.

*Distribution.*—Off the south coast of Norway; Mediterranean, off Marseille and Naples, rare in Adriatic (= *A. rubescens*, Heller).

Form *β.*—**Depressa.** Area of attachment large, extending over the whole or the greater part of the left side; littoral.

*Distribution.*—West coast of Scotland, west and north-east coasts of Ireland (= *A. rubicunda*, Hancock).

Var. 2.—**RUBROINCTA.** Body-walls tinged with reddish flesh-colour.

Form *a.*—**Erecta.** Attached as described above; infra-littoral.

Naples, Marseille, British seas?



Form  $\beta$ .—*Depressa*. Attached as described above; littoral.

Channel Isles (= *A. rubrotincta* and *A. robusta*, Hancock).

Var. 3.—*RAVA*. Body-walls yellowish, with little or no trace of red; tentacles rarely exceeding 40 in number.

Form  $\alpha$ .—*Erecta*. As above; infra-littoral.

Adriatic. [West coast of Scotland (= *A. lata*, Herdman; but the colour of this race is only known from spirit specimens).]

Form  $\beta$ .—*Depressa*. As above; littoral.

Isle of Wight.

## DESCRIPTION OF PLATES VI AND VII,

Illustrating Mr. W. Garstang's paper "On some Ascidians from the Isle of Wight."

N.B.—All the figures were drawn from preserved material.

### PLATE VI.

FIG. 1.—*Ascidia mollis*, Ald. and Hanc. The largest normal individual, nat. size.

FIG. 2.—*A. mollis*. Culs-de-sac of the test-vessels, magnified.

FIG. 3.—*A. mollis*. Another individual of smaller size, as seen after removal of the test; twice the natural size.

*a.* = View of the right side, showing the musculature.

*b.* = View of the left side, showing the disposition of stomach and intestine.

FIG. 4.—*A. mollis*. Portion of the pharyngeal wall of the same individual; much enlarged. Zeiss, Obj. A. Oc. 2, Cam. luc. The dark portions represent the longitudinal furrows, the light portions the elevations which are caused by the "minute plication" of the wall.

*c.d.* = Connecting ducts between the horizontal and the internal longitudinal vessels.

*h.v.* = Horizontal vessels, forming three complete series and a rudimentary fourth.

*i.l.b.* = Internal longitudinal bars or vessels.

*i.p.* = Intermediate papillæ.

*p.* = Papillæ on the int. long. bars above the connecting ducts.

FIG. 5.—*A. mollis*. The large abnormal individual, nat. size.

*a.* = View from above the dorsal surface. The left side consists entirely of the area of attachment; the right side forms an elevated ridge. The inconspicuous slit-like oral and cloacal apertures are indicated.

*b.* = View of the opposite surface.

FIG. 6.—*A. mollis*. The same with the test removed, in the same position as in fig. 5 a. Nat. size.

- an.* = Anus.
- c.s.* = Cloacal siphon.
- gn.* = Ganglion.
- int.* = Intestine—the descending portion.
- æs.* = Esophagus.
- o.s.* = Oral siphon.
- ov.* = Oviduct.
- pc.* = Pericardium.
- st.* = Stomach, covered with renal vesicles.
- v.d.* = Vas deferens.

#### PLATE VII.

FIG. 7.—*Ascidia depressa*, Alder. The largest individual, twice the natural size.

FIG. 8.—*A. depressa*. The same, with the test removed, viewed from the left side, showing the course of the viscera, and the rather elongated siphons.

FIG. 9.—*A. depressa*. A portion of the test, magnified, showing the papillæ on its surface.

FIG. 10.—*A. depressa*. A portion of the dorsal lamina, magnified, showing the marginal teeth (*m.t.*) and the lateral papillæ which project from its concave surface. Camera lucida.

FIG. 11 a.—*A. depressa*. A portion of the pharyngeal wall, magnified. Camera lucida.

*h.v.* = Horizontal vessels.

*i.l.b.* = Internal longitudinal bars or vessels.

*p.* = Papillæ above the connecting ducts.

*r.i.p.* = Extremely rudimentary intermediate papillæ, here and there present where the meshes are elongated.

FIG. 11 b.—*A. depressa*. An enlarged view of the junction between an internal longitudinal bar (*i.l.b.*) and a horizontal vessel (*h.v.*), showing the form of the disc-shaped papilla (*p.*), with its anterior (*a.b.*) and posterior buttresses.

FIG. 12.—*Ascidia mentula*, O. F. Müller. The peritubercular area in the individual A., showing the double aperture of the dorsal tubercle.

*ep.gr.* = Epibranchial groove.

*p.gr.* = Pericoronal groove.

*p.z.* = Præbranchial zone, studded with minute papillæ.

FIG. 13.—*A. mentula*. Portion of an internal longitudinal bar (*i.l.b.*), seen obliquely from the side, showing the form of the papillæ on its surface; magnified. Camera lucida.

*c.d.* = Connecting duct.

*h.v.* = Horizontal vessel.

*i.p.* = Intermediate papillæ.

*p.* = Papillæ.

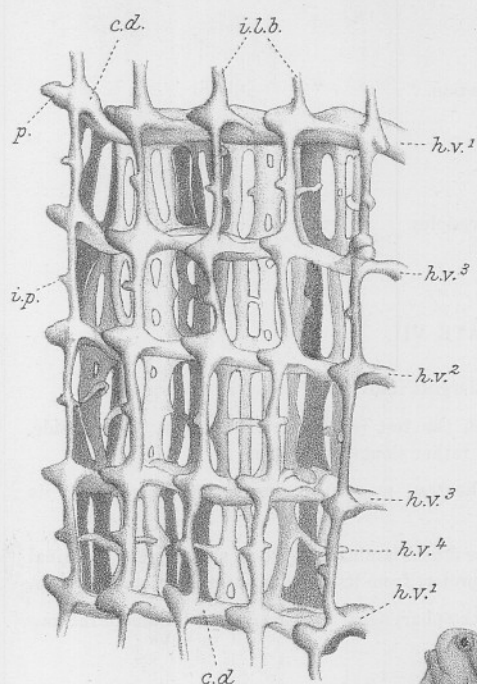


Fig. 4.

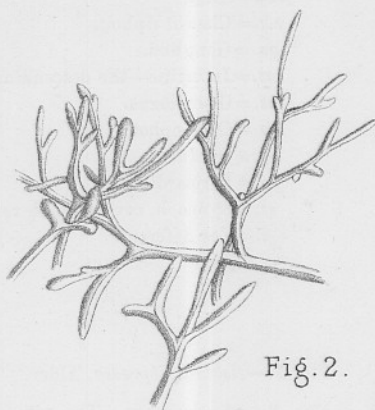


Fig. 2.

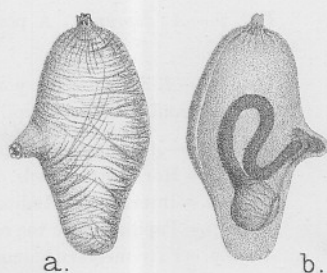


Fig. 3.



Fig. 1.

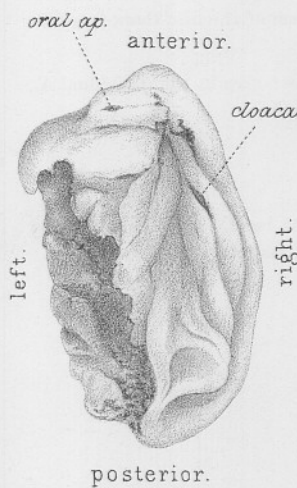


Fig. 5. a.

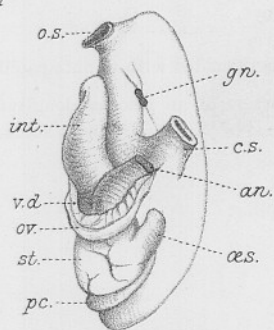


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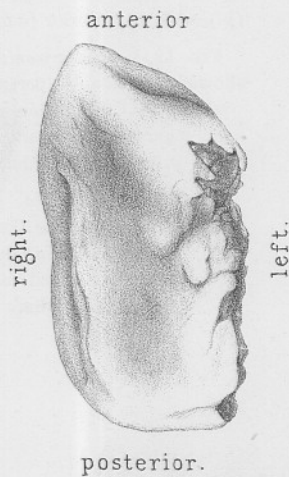


Fig. 5. b.



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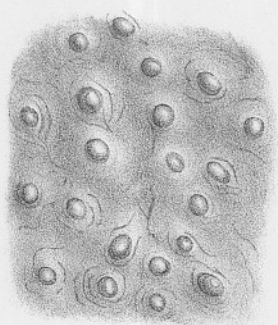


Fig. 7.

Fig. 8.

Fig. 9.

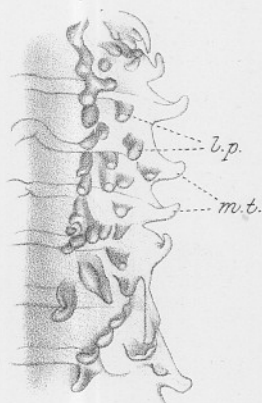
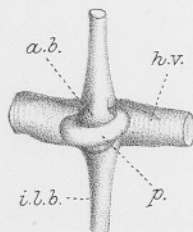
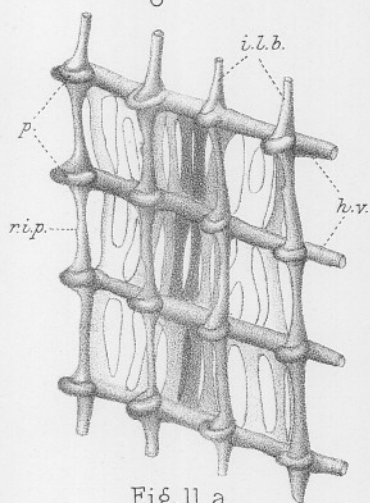


Fig. 11.a.

Fig. 11.b.

Fig. 10.

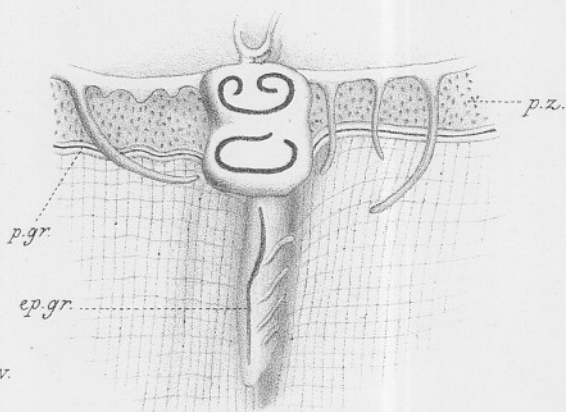
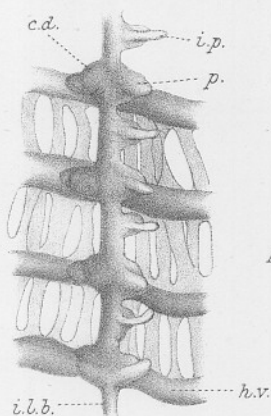


Fig. 13.

Fig. 12.