THE

VOYAGE OF H.M.S. CHALLENGER.

ZOOLOGY.

REPORT on the CIRRIPEDIA collected by H.M.S. Challenger during the years 1873-76. By Dr. P. P. C. HOEK, Member of the Royal Academy of Science of the Netherlands.

ANATOMICAL PART.

INTRODUCTION.

ONE of my principal reasons for wishing to investigate the Cirripedia dredged during the cruise of H.M.S. Challenger was the hope that I should be able by the aid of the deep-sea material to enlarge our knowledge of the morphology of the order. It was possible that among the forms from considerable depths there might be some which on account of their great size, or for other reasons, would be especially favourable for anatomical research, as was the case with some of the Pycnogonids from the abysses. It was possible also that among them a new form might occur, the investigation of which would cast light on details in the organisation which had not hitherto been sufficiently understood. In this respect, however, the study of the deep-sea material has somewhat disappointed my expectations; the new forms for the most part are represented by single specimens only, or are too small to be dissected advantageously. I have therefore been obliged to limit my researches entirely to such forms as were previously known and had served for the researches of former investigators. They belong to the genera *Lepas*, *Conchoderma*, and *Scalpellum* of the pedunculated Cirripedia, and to the genus *Balanus* of the sessile Cirripedia. What I have been able to work out does not form a connected whole, but may conveniently take the form of separate chapters in the morphology of the group.

I. THE COMPLEMENTAL MALES OF SCALPELLUM.

Since 1851, when Darwin issued the first volume of his Monograph on the Sub-class Cirripedia, nothing has been published on the so-called complemental males of *Scalpellum*, though the subject was far from exhausted by his treatment of it. The truth of this assertion in no way diminishes the respect which we feel to be due to the labours of the great master in this department of investigation as well as in so many others. For when we consider that the methods of microscopic research have been greatly improved in the thirty years which have since elapsed, and that the male of *Scalpellum vulgare*, which Darwin investigated, has a size of only 0·7 mm., we can only wonder at the thoroughness of the information which he has given, and at the soundness of the conclusions at which he arrived.

When dissecting *Scalpellum vulgare*, Leach, Darwin observed one or more very minute parasites on the margins of both scuta, close to the umbones. He dissected one or two specimens and at first concluded that they belonged to some new class or order amongst the Articulata. By repeated and more careful dissection he was able to make out the general appearance of the animal, the form of the thorax and abdomen, the generative system, the antennæ and the mode of its attachment; he found that the prehensile antennæ of the little parasite showed an absolute correspondence with the same organs of the hermaphrodite *Scalpellum vulgare*, and that it belonged exclusively to the male sex. From this knowledge, together with its fixed condition and its short existence, he thought himself justified in provisionally considering the little parasite as the complemental male of the Cirriped to which it was attached.

The results of Darwin's investigation of the complemental males of the other species of *Scalpellum* known to him are, shortly, the following:—The complemental male of *Scalpellum ornatum*, Gray, sp., shows a close general resemblance to that of *Scalpellum vulgare;* but as Darwin had only dried specimens of that species, his description is not so exhaustive; he found males of *Scalpellum rutilum*, Darwin, also, but in so extremely decayed a condition that they could not be examined. What Darwin considered to be the complemental male of *Scalpellum rostratum*, Darwin, is a little animal constructed like an ordinary Cirriped and furnished with a mouth, thorax, and cirri, enclosed in a capitulum (with a carina and a pair of scuta), and supported on a peduncle of moderate size. Specimens were found attached to the integument of the hermaphrodite in a central line between the labrum and the adductor scutorum muscle. The complemental male of *Scalpellum peronii*, Gray, sp., is a pedunculated Cirriped with a capitulum of six valves, firmly cemented to the integument of the hermaphrodite in a fold between the scuta, in the middle line a little below the adductor scutorum muscle. Finally, the complemental male of *Scalpellum villosum*, Leach, sp., is attached in the same position as that of *Scalpellum peronii;* it is also six-valved, and it has a close general resemblance to that of *Scalpellum peronii.* Whereas the parasites in the first three species (*Scalpellum vulgare, Scalpellum ornatum,* and *Scalpellum rutilum*) are in such an extraordinarily modified and embryonic condition, that they can hardly be compared with other Cirripeds, those of the other three (*Scalpellum peronii, Scalpellum rostratum,* and *Scalpellum villosum*) are pedunculated Cirripedia, remarkable for their smallness.

These are the facts which were known to Darwin; he then enters into a masterly discussion of the evidence that these parasites are really the males of the Cirripedia to which they are attached. Curious and novel as was the fact, his reasoning was so convincing that this theory has been generally accepted.

With respect to the occurrence and the structure of these complemental males, I believe I have been enabled to augment our knowledge not inconsiderably. Though the principal result of my investigations has been to convince me of the exactness of Darwin's theory, I think the question is important enough to justify me in giving all the information which I possess in the following pages.

I observed the complemental male in nineteen out of the forty-one new species of *Scalpellum* described in my Report.[1] I found them all in or about the same place, viz., at or near the occludent margin of the scutum at the interior side of this valve, a little above the adductor muscle. As a rule they are placed in a pouch formed by the mantle; very often, but not always, I found them on the left as well as on the right hand scutum. In five different species I took either from one or from both scuta two or more specimens, in the other species each, or one only, of the two scuta was furnished with a single male. In one species (*Scalpellum marginatum*) the male was seated at a considerable distance from the occludent margin of the scutum, and hence it happened that at first I did not find it out. In one species (*Scalpellum recurvirostrum*) the only male observed was still in the Cypris-larval or pupa stage; in three other species (*Scalpellum regium, Scalpellum eximium,* and *Scalpellum velutinum*) males in the pupa stage were attached along with full-grown males. The male of *Scalpellum brevecarinatum* could not be studied, being in a very unsatisfactory condition.

In eighteen out of the nineteen cases I was able to form an opinion as to the condition of the male when the testis was ripe, and the little creature therefore full-grown or nearly so. In five of these eighteen cases the condition can be said to correspond with that of the male of *Scalpellum vulgare.* In thirteen the males are still more degenerate. These five are *Scalpellum tritonis, Scalpellum intermedium, Scalpellum parallelogramma, Scalpellum elongatum,* and *Scalpellum triangulare.* I think they correspond with *Scalpellum vulgare* in as far as there are rudimentary valves visible in them. The thirteen remaining species all, no doubt, belong as regards the structure of their males

[1] Zool. Chall. Exp., part xxv. The small species represented by single specimens have not been investigated so thoroughly as would have been necessary to make out whether a male really occurred or not. I often found myself unable to do so without spoiling the specimen.

to one and the same division of the genus. I have been able to study the male of one of these (*Scalpellum regium* [Wyv. Thoms.], Hoek) more in detail; in all essential respects the males of the other twelve agree with it.

The twenty-four species of *Scalpellum*, the males of which are known at present, may be classified with regard to the structure of these males in the following way:—

A. Species, the males of which show a distinct capitulum and peduncle:—

Scalpellum peronii, Gray, sp.
Scalpellum rostratum, Darwin.
Scalpellum villosum, Leach, sp.

All these are shallow water species.

B. Species, the males of which do not show a division of the body into a capitulum and a peduncle, but yet are furnished with rudimentary valves:—

Scalpellum vulgare, Leach.	*Scalpellum parallelogramma*, Hoek.
rutilum, Darwin.	*elongatum*, Hoek.
ornatum, Gray, sp.	*tritonis*, Hoek.
intermedium, Hoek.	*triangulare*, Hoek.

Species occurring in depths varying between shallow water and 700 fathoms.

C. Species, the males of which do not show a division of the body into a capitulum and a peduncle, and are not furnished with rudimentary valves:—

Scalpellum marginatum, Hoek.	*Scalpellum gigas*, Hoek.
strömii, Sars.	*regium* (Wyv.Thoms.), Hoek.
compressum, Hoek.	*darwinii*, Hoek.
nymphocola, Hoek.	*tenue*, Hoek.
velutinum, Hoek.	*dubium*, Hoek.
eximium, Hoek.	*flavum*, Hoek.

Scalpellum pedunculatum, Hoek.

With the exception of three (*Scalpellum pedunculatum*, *Scalpellum strömii*, and *Scalpellum nymphocola*), these species occur in depths of upwards of 1000 fathoms. The depths at which *Scalpellum strömii* and *Scalpellum nymphocola* were collected are less considerable; these species, however, belong to the arctic fauna, which, as is well known, shows numerous instances of deep-sea animals occurring in rather shallow water. *Scalpellum pedunculatum* was taken from a depth of 150 fathoms only.

a. Description and Comparison of Cypris-Larvæ.

At first I experienced great difficulties in identifying the parts of the body of the complemental male; however, I believe I have solved the problem by comparing the full-grown male with a younger stage of its development, and the latter with the corresponding stage of an ordinary species of *Lepas*. The occurrence of a Cypris-larva between the two complemental males at the ordinary place enabled me to make this comparison; from its structure as well as from the place whence it was taken there can be no doubt, I believe, that this latter creature was destined to develop (retrogressively of course) into a complemental male.

The species of *Lepas*, the Cypris-larvæ of which have served me for comparison, was the *Lepas australis*, Darwin. It is not only very characteristic on account of its great size, but it is also the best known Cypris-larva, as it served first for the investigations of Darwin, and again some years ago for the studies of Claus. The latter has given a very good figure of the internal structure of this larva as seen in a sagittal section. My figs. 1 and 2 on Pl. II. very closely correspond to that of Claus. My fig. 1 was drawn from a preparation made by dividing the body of the Cypris-larva of *Lepas australis* into two nearly equal halves by means of a sagittal section. The rounded spot (*A M*) is the adductor muscle of the two valves of the Cypris-larva; the straight line at the under side of the valve represents the ventral side, the convex one the dorsal side; the extremity on the left of my figure the frontal (cephalic), the one facing it the hinder (abdominal) extremity of the body; from the way in which the spines of the legs are stretched out at the ventral side it is clear that there is a slit-like opening between the adductor muscle and the hinder extremity of the body. In fig. 2 of Pl. I., representing a longitudinal section parallel to and at a little distance from the ventral margin, this orifice is also distinct. This is the only place where the interior of the sack or mantle (as Darwin calls it) is in open communication with the surrounding water.

The body of the future *Lepas* is enclosed within the sack and has also a wall of its own; on one side (the right hand side of the figure) this wall is very distinct, and it passes over near the middle of the dorsal margin into a transverse invagination which almost reaches up to the ventral side. It is by this invagination that the division of the body into a capitulum and a peduncle is brought about; what in fig. 1 of Pl. II. is placed on the right hand side of the invagination (*Inv.*) is the capitulum, what is placed on the left hand side the peduncle. As the invagination of the dorsal wall does not reach as far as the ventral side, a direct communication remains between the capitulum and the peduncle. Through this commissure, which is very narrow in the full-grown animal, pass the oviducts and the nerves destined for the peduncle.

On the ventral side an invagination is seen at a distance of about one-fourth of the total length from the peduncular extremity; at the bottom of this invagination, when studied in a sagittal section as figured, the compound eyes—which, according to Darwin, are attached to the basal joints of the antennæ—are visible.

The structure of the interior of the body can easily be made out by the aid of the figure. *M.* is the mouth; it is surrounded by darkly pigmented parts, the exact shape of which is not very distinct; the mouth gives entrance to the œsophagus (*Œ*); the latter has a horizontal direction, is furnished with a pair of cœca (*C*), and leads into a very capacious stomach (*S*), from which a narrow intestine (*Int.*) is seen to start. Œsophagus, cœca, stomach, and intestine are all very darkly pigmented. The six pairs of cirri and the caudal appendages present nothing particularly interesting; the different cirri have only to shed their skin to change into the cirri of the *Lepas*; the caudal appendages will have to undergo a very marked retrogressive metamorphosis to change into the rudimentary, uniarticulate, and smooth appendages of the full-grown *Lepas australis.* The nervous system is already quite distinctly visible; it consists of the supraœsophageal ganglion (*GS*), and the six thoracic ganglia (*G I.–G VI.*). The first is situated very close to the cœca of the œsophagus and has a simple eye (*e*), represented by a small triangular spot of pigment attached to it (fig. 2, *e*). The chain of thoracic ganglia is on the right hand side of the stomach, between this organ and the ventral wall of what is properly the body. The ganglia are not yet separated by commissures, but are placed close to one another; the first has an oval shape, and is much larger than the following ones The ganglionic cells which cover the surface of the different ganglia are extremely small.

In the peduncular part of the body nearly all the room is filled up by a mass of connective tissue with very large meshes; between this mass of reticular connective tissue and the layer of cells which represents the mantle a double layer of muscular fibres may be discerned. The fibres of the two layers are at right angles to each other, and both layers run parallel to the surface of the body and the valves of the Cypris; in the figure, one of these layers is represented by the lines running parallel to each other, and also to the curved frontal line of the larva. This layer is composed of rather broad fibres (each fibre has an oval, not very elongate nucleus) and a breadth of 0·012 mm., which will develop into the layer of longitudinal muscles of the peduncle of the *Lepas.* The other layer is situated between the former and the mantle, and shows much narrower fibres, with very narrow and elongate nuclei (each fibre has a breadth of only 0·003 mm.); this latter layer forms the circular muscular layer of the peduncle in the full-grown *Lepas.* The cells which constitute the mantle are relatively small, and are furnished with large nuclei (0·01 mm.); at different places they are richly pigmented.

Between the fibres and nuclei of the connective tissue numerous fatty bodies are visible which are more like vesicles than grains; they have an elongate shape, are pointed at both extremities, and belong to what still remains of the yolk.

The cell-masses which Claus[1] describes as the cement-glands were very strongly

[1] Claus, C., Untersuchungen zur Erforschung der genealogischen Grundlage, &c., Wien, 1876, p. 87.

developed in the larvæ of *Lepas australis* which I studied. Claus says that these glands consist of groups of cells which have either still the form of a sinuous string ("eines gewundenen Stranges"), or which lie scattered by the side of one another; the latter is the case in *Lepas australis.* Claus has not observed the communication of these glands with the cement-duct which he figures; at least in his figure they are at a very considerable distance from one another. I have not been more fortunate; I even failed to observe the cement-duct. The different cells (Pl. II. fig. 5) do not show much resemblance to the cement-glands of the full-grown animal; yet I think that Claus' supposition as to the nature of these elements is right. As regards the place they occupy in the Cypris-larva, it quite corresponds to the place they occupy in the full-grown animal, viz., in the most posterior (when the animal changes its position, the most superior) part of the peduncle. The Cypris-larva which furnished the drawing fig. 2 is a little older than the one figured in fig. 1. In the former the cement-cells are much more separated from one another than in the latter; moreover, their nuclei are much more easily distinguishable, and many of them are not so richly furnished with fatty granules as was the case in the younger condition. Very delicate and flat fibres in the later Cypris-stage are visible between the cement-cells; probably they represent the canals figured by Claus and considered by him as branches of the cement-ducts.

A pair of club-shaped bodies is situated near the ventral wall of the animal, the thickest part of which is directed towards the front of the Cypris and the narrower part of which can be traced as far as under the cœca of the œsophagus of this larva. These are described by Claus as the ovarium (figs. 1 and 2, *Od*). I observed these bodies also, and I think it very probable that they represent the female genital apparatus; they are especially distinct in the longitudinal section of the body shown in fig. 2. In this figure the valves of the Cypris are not represented; the clear margin round the body represents the chitinous wall of the future *Lepas;* the cells of the mantle serve as a matrix for its formation.

When we look now at the figure of the Cypris-larva of *Scalpellum regium* which is destined to develop into a complemental male, we observe great analogy as well as considerable difference. Pl. II. fig. 3 represents a larva which has probably attached itself lately, and which therefore is exactly in the same stage as the larva of *Lepas australis* which I have just described. It is somewhat different from the latter in general outline, being more elongate and not so high. At the hinder extremity the Cypris of *Lepas australis* is obliquely truncated and bluntly pointed, and that of the male of *Scalpellum* almost entirely transversely truncated. Like the former it is enclosed within a shell consisting of two valves of a very brittle constitution. The antennæ (*An*) are stretched forward out of the ventral slit between the two valves; they have in all essential respects the same structure as those of the full-grown complemental male, which will be described further on. At their base in the interior of the body of the larva a cellular body is visible which, I think, must necessarily represent the cement-gland. However, neither the place it occupies nor its structure shows any resemblance to the same glands—or what we must consider as such—in the Cypris of *Lepas australis.* Nor have these glands in the male of *Scalpellum regium* great conformity with those organs in the younger Cypris-stage of another species of *Scalpellum* (*Scalpellum triangulare*), which I figure in Pl. II. fig. 4. In this stage the antennæ (*An*) are still totally hidden within the valves, and the cement-glands (*C. gl*) form very large cellular masses situated on both sides of the thoracic part of the body between it and the valves. I think it is in this stage that the Cypris-larva leaves the mantle cavity of the mother.

What we called the mantle in the Cypris of *Lepas australis* takes in the male Cypris of *Scalpellum regium* the form of a bag closed on all sides, with only a very small opening at the hinder extremity. This opening no doubt corresponds to the slit-like opening at the ventral side of the Cypris of *Lepas.* It also serves the same purpose. We see the very delicate and slender spines placed at the extremity of the legs come forth from this opening. For want of material I have not been able to study in detail the structure of the mantle, nor its musculature. I can only say that the mantle is composed of flat and pale rounded cells of 0·01 mm. in diameter, with a small clear nucleus, and that these cells are placed at a little distance from each other; that the muscular fibres form a single layer only, and are built up of elongate oval cells placed in longitudinal rows and each furnished with a distinct nucleus (Pl. I. fig. 7). Besides the body the interior of the mantle contains a mass of connective tissue with little grains and small fatty corpuscles scattered irregularly throughout its meshes. With regard to the body it is not difficult to observe the mouth (Pl. II. fig. 3, *M*), the œsophagus (*Œ*), and the stomach (*St*); the nervous system consisting of a supraœsophageal ganglion (*G S*) and a single, rather large thoracic ganglion (*G T*); six pairs of very slender cirri with delicate spines at their extremities; a pair of long and well developed caudal appendages (*C A*). A dark coloured mass, consisting for the most part of yolk-fragments, makes up a great deal of the rest of the true body of the embryo *Scalpellum.*

As for details, I can only say that the parts which surround the mouth are not very distinct, and that the very long œsophagus leads into a blind pouch of an oval shape, and that this pouch represents the stomach. The two branches of each cirrus are indistinctly divided into four segments; the shape of each segment is cylindrical, with the exception of the last joint, which is conical, and slopes into the very long spines placed at the extremity. The first two pairs of cirri are somewhat different from the following pairs, inasmuch as in the first two the lower two segments are the only ones which are filled up with a mass of cellular structure; so, when the cirri have shed the exuviæ which now cover them, the cirri of the first two pairs undergo a considerable diminution in length. The very long caudal appendages in this stage are also represented only by the chitinous skin. After the last casting of skin they will no doubt have disappeared.

The supraœsophageal ganglion is well-developed; in one of the specimens two nerves were indistinctly visible starting from the ganglion and directed towards the antennæ; if my observation be correct there can be little doubt that these are the antennal nerves. I have not observed the commissures which unite the supraœsophageal ganglion with the thoracic ganglion; the latter is large and oval, and probably only represents the first larger ganglion of the thoracic chain of *Lepas*. Neither the small eye near the supraœsophageal ganglion nor the large compound eyes at the base of the antennæ are present; the pigment which is so richly distributed over all the organs and parts of *Lepas australis* is totally wanting in the male Cypris of *Scalpellum*. This no doubt finds its explanation in the circumstances under which the little animal is destined to live.

Of great importance is the fact that the dorsal invagination, which, as we have seen, causes the division of the body of *Lepas* into a capitulum and a peduncle, is totally lost in the metamorphosis of the Cypris of the male of *Scalpellum;* hence there is no trace of this division to be observed in the full-grown males. This want of a peduncle, together with the smallness of the orifice of the mantle and the total absence of valves, form the most characteristic features of the male in question.

The metamorphosis of the Cypris-larva, in its latest stage (as figured), into the full-grown male, is now, I think, easy to understand. In this respect at least it quite corresponds to the metamorphosis of *Lepas*. The difference between the latest stage of the Cypris of *Lepas australis* and the young Cirriped of that species is not greater, nor less either, I think, than that between the attached Cypris of *Scalpellum regium* and the young male; to say that the complemental male of *Scalpellum* is in its Cypris stage, or thereabouts, is not in accordance with the facts.

The valves of the Cypris are first of all shed. The cells of the mantle or sack soon develop a distinct membrane of chitin at their surface, which no doubt is as efficient a protection as the shell was, but which contains no carbonate of lime and therefore is not so brittle. When the wall of the male is quite intact, its impenetrability makes it absolutely unfit for transference from absolute alcohol into oil of cloves; the alcohol leaves the little body faster than the oil enters it, whence the body-wall becomes shrivelled. As the internal structure is best studied in a specimen placed in oil of cloves, and as for its investigation by transverse sections the passing through oil of cloves was also necessary, I found it very useful, when the specimens were quite sound, to make a little opening in the wall before transferring them into the oil. For the rest, this internal structure is very simple. The antennæ and the very delicate thorax with the legs are the only parts which show that the little body belongs to an articulate animal; the whole interior of the body is filled with a mass of connective tissue with very wide meshes, serving to keep the different organs in their places.

b. Anatomy of the Male of *Scalpellum regium.*

I will now proceed to give an anatomical description of the complemental male of *Scalpellum regium* (Wyv. Thoms.), Hoek. I choose this species because it is represented by numerous specimens, and also because it is one of the largest species in the Challenger Collection.

Form and dimensions.—The complemental male of *Scalpellum regium* has an elongated oval shape. Its length varies from 1·6 to 2·4 mm., its breadth is 0·63 to 0·71 mm. The difference in length corresponds to differences in some of the internal parts, especially of the testis. Whether it is occasioned by the growth of this organ I cannot say. The third dimension, the thickness, is nearly equal to the breadth. We may call the extremities of the longer axis the poles of the body, and I propose to call one the peduncular, the other the capitular pole (Pl. I. fig. 1).

The Antennæ.—The only appendages visible externally are the small antennæ, situated close to the extremity of the body corresponding to the peduncle of other Cirripedia; they are seated at a little distance from the extremity, on that side of the body which represents the ventral surface. They have two segments; one cylindrical, and about twice as long as the other, which is flat and triangular. What Darwin calls the third and ultimate segment of the antennæ is very distinct in the case of this little creature (Pl. I. fig. 3). It is articulated to the upper surface of the disk, and directed rectangularly outwards. Whereas the main segments of the antennæ are not furnished with spines, this latter segment bears five spines at the end, and three very slender ones at a notch a little beneath the extremity of this segment.

With the aid of these antennæ the little creatures are attached to the inner surface of the scutum of the hermaphrodite or female. The triangular terminal segment of the antennæ, in all the cases I observed, surrounded the extremity of a transparent mass, which I think can safely be considered as the product of the cement-glands which are in relation with the antennæ. It is by means of this cement that the attachment of the triangular disk takes place. In the case of *Scalpellum regium* the males are attached a little above the adductor muscle, and, as a rule, three of them are implanted so closely together as to touch each other. What I think very peculiar is, that in three different cases observed by me, two of the three males attached to the scutum were much further developed than the third; the first contained a fully developed testis and a well-filled vesicula seminalis, the third was still in the condition of a Cypris-larva (Pl. II. fig. 3), probably only lately attached to undergo its final metamorphosis.

The wall of the body is a chitinous skin, which is comparatively thin and delicate; when a transverse section of the body is made, the chitinogenous epithelium beneath the chitinous outer wall is easily observed. The external surface of the body-wall is clothed with microscopic spines, having a length of about 0·0235 mm., and placed in transverse rows (not quite so regularly as shown in fig. 1 of Pl. I.). As a rule, these spines are narrow and pointed at the extremity, which is attached to the wall of the body and broadest at the other extremity. Here the free margin is deeply toothed, which gives the spines a certain resemblance to the scales of the Lepidoptera. In other places the incisions of the spines are so deep as to divide the scale into two or three narrow spines. A small circular space at the peduncular pole is left free from spines, and at the other extremity the terminal part is so completely covered with minute particles of mud and sand, that it is impossible to distinguish the little spines there. This latter part of the body is the only one which is visible when the little male is in its ordinary place, viz., between the mantle or "sack" (as Darwin calls it) and the scutum of the hermaphrodite. A small rounded part at the capitular extremity of the body is covered by a chitinous membrane of greater thinness. The nuclei of the chitinogenous epithelium are placed here much more closely and are more easily visible owing to the thinness of the chitinous wall. A narrow slit-like opening (fig. 1, *o*) divides this little circular space; it corresponds with the orifice of the capitulum of the pedunculated Cirripedia. It is not easy to distinguish the edges of this slit-like opening, owing, as Darwin suggested for the same orifice of *Scalpellum vulgare*, to their extreme thinness.

The chitinogenous membrane which is found beneath the chitinous outer wall shows the ordinary structure of very flat cells with indistinct limits and with rather distant but conspicuous nuclei. These nuclei are very close to one another at the small circular part at the capitular extremity (Pl. III. figs. 2 and 3). The slit which indistinctly divides this part gives entrance to a cavity which contains the thoracic part of the little male. This cavity is not lined by an epithelium; it is only surrounded by a somewhat more solid layer of the same connective tissue, which fills up the whole interior of the body of the male. This cavity is seen in transverse section in Pl. III. fig. 4. In all the specimens of this species which I investigated the thoracic part was always retracted high up into the interior of the body, so that even the very long spines at the end of the slender limbs never reached the slit-like orifice at the capitular pole. In the males of some of the other species (*Scalpellum intermedium*, *Scalpellum tritonis*) the spines at the end of the thoracic limbs extend beyond this orifice. This was often also the case in the males of *Scalpellum vulgare* as observed by Darwin, which always showed the whole thorax forced outwards through the orifice, a circumstance which perhaps was owing, according to Darwin, to the action of the spirits of wine and consequent endosmose.

Muscles of the body-wall.—Under the cells of the hypodermis a well-developed layer of muscular fibres is everywhere present; these muscular fibres are indistinctly transversely striated; in some of my preparations, however, the transverse striation is somewhat more distinct. Perhaps the indistinctly striated condition of the fibres is the consequence of their being nearly functionless and rudimentary.[1]

From their position close to the body-wall one feels inclined to compare these muscles together with the outer wall of the body with the "Hautmuskelschlauch" of worms, as the Germans call it. The muscular fibres form a single layer only; they have an irregular oblique direction, which in some parts approaches to a transverse, in other parts to a longitudinal, position; their course is imperfectly parallel. Their structure is very simple, and can be best studied in Canada balsam preparations; when seen in oil of cloves their transverse striation is so indistinct as to be hardly visible. It is from such a preparation that the fig. 6, Pl. IV. has been made. When making a preparation of them by means of needles they present themselves like flat bundles of delicate fibrillæ, each bundle having a breadth of about 0·01 mm.; they sometimes show a clear wall as a kind of sheath, and are furnished with nuclei at intervals; the latter are elongate, and, as appears on a transverse section of the muscle, cylindrical; they have a length of about 0·02 mm. and a transverse diameter of about 0·005. In a transverse section of the wall of the body, as in all the figures of Pl. III., the nuclei of the matrix are seen between the chitinous outer wall and the transverse sections of the muscles. In these sections the latter show a very curious structure (Pl. IV. fig. 5); whereas that side of the muscle-fibre which is directed towards the anterior of the animal is smooth and arched, and shows the sheath in the form of a distinct margin; that side of the same fibre which is directed towards the exterior is deeply toothed; here the fibrillæ which compose the fibre seem to part in different ways. As I could observe this phenomenon only in very thin sections, there can be no doubt that this structure does not agree with the natural condition of the fibre. The nucleus of the muscle-fibre is sometimes placed near the outer wall, sometimes almost in the centre of the fibre. As to the development of the muscle-fibre, when comparing it with the condition of the muscular fibre in the Cypris-larva, we may suppose that the oval contractile cells which compose the larval fibre grow out into long fibres, the pointed extremities of which are no longer placed in a longitudinal row, but have been pushed along each other.

The connective tissue is composed of fibres, but also of extremely delicate and finely granulated membranous plates which form the partitions between the large meshes. Its nuclei are round and flat, and have a diameter of 0·008 mm. The fibres are more robust where they form the wall of the cavity in which the thorax is situated; we find also stronger fibres where they run in a straight direction from the organs to the wall of the little animal.

I have not observed a true body-cavity in these little males, and before I had studied the bodies of other Cirripedia by means of transverse sections, I was much

[1] Leydig (Zum feineren Bau der Arthropoden, *Arch. für Anat. und Physiol.*, 1855, p. 394) says that the muscle-fibres of young individuals of *Coccus hesperidum* are distinctly transversely striated, those of full-grown individuals which almost lost the function of locomotion are totally rudimentary (and smooth ?).

puzzled by this fact. A part of the body of this male corresponds to the peduncle of the pedunculated Cirripedia, and as this is also filled up with connective tissue,—with the exception of a rather narrow tubular cavity towards the rostral side,—I at first endeavoured to homologize the connective tissue of the male with that of the peduncle. Extending my researches also over the body of the hermaphrodite or female *Scalpellum*, over *Lepas* and other genera of Cirripedia, I found that the occurrence of a well-developed mass of connective tissue between the different organs within the body is the rule in all the Cirripedia. In the interesting essay on the cœlom-theory by the brothers Hertwig [1] we read that all the Arthropoda possess a very capacious body-cavity, and that in the full-grown animal the intestinal tract passes freely through this cavity, a dorsal mesentery uniting the intestine to the wall of the body being observed only in a younger stage of the development. Whether the plurality of typical forms of Arthropoda have been sufficiently investigated so as to allow of this conclusion to be drawn, I will not decide. Doubtless, however, the Cirripedia have a very rudimentary body-cavity, and a well-developed mass of connective tissue nearly fills up all the space left open between the wall of the body and the internal organs. So the complemental males in this respect also correspond in structure to the female and hermaphrodite animals.

The internal organs consist of the well-developed genital apparatus, the nervous system, the cement-glands, and the totally rudimentary and evidently functionless œsophagus and stomach.

Fig. 1 of Pl. I. shows these parts in their normal position; fig. 2 represents part of these organs more strongly magnified. Testis (*t*), vesicula seminalis (*vs*), and vas deferens (*vd*), can easily be made out in all the specimens. Neither do the other organs (the nervous system, and the œsophagus with the stomach), present any further difficulties after comparison with the structure of the Cypris-larva (Pl. II. fig. 3).

Digestive tract.—The œsophagus and the stomach have nearly preserved their original condition; the mouth has grown totally functionless; its place is indicated by the presence of a group of cells (Pl. I. fig. 2 *m*), which are placed in the connective tissue bordering the cavity in which the thorax is situated. The œsophagus is a narrow tube which imperceptibly widens and passes over into the stomach. The latter is a pyriform pouch closed on all sides, having a rudimentary intestine at the extremity opposite to the cardia. It has a double wall, as can be best studied in the transverse sections (Pl. III. figs. 6 and 7). Probably the internal wall represents a chitinous cuticle which has been shed, but which could not be removed, the mouth being closed. Perhaps the internal wall represents the chitinous tube, or model of the stomach filled with excrement, Darwin describes in the alimentary canal of Cirripedia.[2] In the full-grown male the stomach is almost empty; in a younger condition (Pl. IV. fig. 1), the stomach is filled

[1] O. and R. Hertwig, Die Coelomtheorie, *Jenaische Zeitschr.*, Bd. xv. p. 76, 1882.
[2] Darwin, Balanidæ, p. 86, 1854.

with a yellowish-brown coloured mass of a fatty nature. Between the two walls of the stomach, nuclei of nearly the same size as those of the connective tissue are visible.

Nervous System.—The supraœsophageal ganglion, also, has nearly kept its original position; it is situated against the œsophagus, a little anteriorly to the place where it communicates with the stomach. In Pl. I. fig. 2 it is figured in its natural position and condition; in Pl. III. fig. 5, and Pl. I. fig. 4, it is seen in transverse section; numerous rounded ganglionic cells are placed at the periphery, and the whole interior of the ganglion is occupied by the medulla. Pl. I. fig. 4 distinctly shows the commissures which serve to unite the ganglion with the large thoracic ganglion. In the preparation which is figured (Pl. I. fig. 2) these commissures could not be made out, nor has this been possible in any of the other preparations I made by the aid of needles.

This thoracic ganglion represents alone the whole ventral nerve-cord; together with the thorax, it has changed its place and has been transposed in a direction towards the front of the animal, so as to be now attached before the supraœsophageal ganglion; it has an elongate oval shape with numerous ganglionic cells at the periphery. In a transverse section such as that figured (Pl. I. fig. 5), we observe that the ganglionic cells form a much thicker layer on the side which is directed towards the thorax than on the other side; the lateral symmetry of the ganglion is very distinct, the medulla forming two rounded portions which meet in a straight line in the middle of the ganglion. The nerves given off from this ganglion as well as those from the supraœsophageal ganglion are extremely delicate and are hardly recognisable as such; two somewhat stronger nerves start from the commissures very close to the supraœsophageal ganglion, and a distinct nerve is attached terminally to the thoracic ganglion, but as for other nerves, I found it impossible to distinguish them with certainty from the fibres of the connective tissue.

There are no organs of sense; even the sense of touch can be only very slightly developed, as the whole body is enclosed within a chitinous bag bearing only chitinous spines on its surface. The hairs on the antennæ (Pl. I. fig. 3) no doubt once performed the function of organs of touch, but after the antenna has attached itself the function of these hairs can no longer be of any importance. Close to the supraœsophageal ganglion I always observed two little bodies, which, from their position, I at first felt inclined to consider as belonging to the nervous system. They are kept in their places by the connective tissue, and they are situated near the corner between the stomach and the supraœsophageal ganglion. Their structure is that of an oval bag slightly pointed at one or both extremities, lined by an extremely delicate membrane and filled with a granular substance of a brownish-yellow colour, having numerous nuclei scattered throughout its interior (Pl. I. fig. 2, *gl.*). Most probably these organs represent the remains of the appendages of the œsophagus (Pl. II. figs. 1, 2, *C*) of the pedunculated Cirripedia, which are very distinctly developed in the

Cypris of *Lepas*, and which probably correspond to the salivary glands of Cuvier; that they are here as rudimentary and as functionless as the œsophagus and the stomach itself is an argument, though a negative one, in favour of my interpretation.

In some of the sections and preparations I observed globular elements which I think are blood-corpuscles. I have figured some of them (Pl. IV. fig. 7). They have very distinct dark coloured nuclei and their size varies from 0·015 to 0·02 mm.; by their size alone they can be easily distinguished from the nuclei of the connective tissue.

From the condition of the mouth and the alimentary canal there can, I believe, be no doubt that these little animals never take food at all. For this reason it is necessary not only that the whole of the body with its well-developed genital apparatus develops from the yolk-mass in the Cypris-larva, but it must be supposed also that the little body can only furnish so much of the male genital product as may develop from the testis after it has once arrived at its full size and maturity. Probably therefore each male only once, or in one season with short interspaces, takes part in the act of propagation. And as it is highly probable that the species of *Scalpellum*, like most other animals, spawn only once a year, the male which has once furnished its quantum of the male genital product is to be replaced by another. The objection may be made that it is possible that only one part of the spermatozoid mother-cells develops into spermatozoids in one season, and a second part in a following year; but then it is difficult to understand, with our present knowledge of animal life, in what way the little animal is supplied with the material necessary for its maintenance.

The Male Organs.—The testis is heart-shaped with the incision directed towards the hinder or capitular extremity. Its length in some of the specimens was about 0·5 mm., in others, which themselves were longer, no less than 0·8 mm. In the latter case the incision was more than half as long as the organ.[1] This incision is remarkable, I believe, because it is the only sign of the original duplicity of the male genital gland.

The histological structure of the testis presents no points of special interest; the spermatozoid mother-cells have a size of 0·021 mm. and fill up the whole interior of the gland. They split into extremely small transparent cells with a dark coloured little body for a nucleus. These small cells are 0·004 mm. in diameter and I think each of them develops into a spermatozoid. The wall of the testis is built up of connective tissue with nuclei of 0·01 mm. in diameter; the wall of the vesicula seminalis presents about the same structure. It is an irregularly globular vesicle, having in the full-grown and mature males a diameter of 0·3 mm.; it is very closely pressed against the testis.[2] In younger specimens I did not observe this organ; the vas deferens in them only presented a very small swelling at the place where it communicates with the testis; the

[1] The testis of *Scalpellum darwinii* when young does not show an incision; in older specimens, however, traces of an incision are present. Other species (*e.g. Scalpellum tenue*, Hoek) have the testis triangular with a heart-shaped foot.

[2] In other species (*Scalpellum tenue*, *Scalpellum darwinii*, &c.) the testis is separated from the vesicula seminalis by means of a duct of not inconsiderable length.

vesicula seminalis is no doubt only a dilatation of the vas deferens at the place where it corresponds with the testis. The vesicula seminalis in all the larger specimens was filled with a dense mass of very small spermatozoids; they have the shape of threads, each having a length of about 0·02 mm., and each furnished at the extremity with a very small vesicle (Pl. I. fig. 6). Between the spermatozoids in the vesicula seminalis small empty vesicles are seen, as also others which quite resemble the very small cells of the contents of the testis, probably each one of them contains a spermatozoid.

The length of the canal acting as a vas deferens is not very considerable; it passes freely through the connective tissue for about 0·25 mm. and then enters into that part of the body which represents the thorax of the Cirriped. Figs. 10 and 11 on Pl. III. show sections of the duct before it reaches the thorax, but in the figs. 5 to 8 of Pl. III. the same canal is represented in the middle of each transverse section of the thorax. In fig. 9 the form of the section of the thorax is nearly quadrangular; this is its shape near the place where the vas deferens enters it; in the sections, however, which more approach the other extremity of the canal the thorax is exactly cylindrical, and then its wall is parallel to the wall of the genital canal. The diameter of the thorax itself is about 0·08 mm.; the canal which runs through it longitudinally has a width of 0·03 mm. Whether it be preferable to designate the cylindrical terminal portion of the thorax as "penis" is, I think, difficult to say; morphologically it is hardly to be distinguished from the appendix of that name in the hermaphrodite Cirriped, which is called by some authors a penis, by others an abdomen.

The nuclei of the cells which surround this canal (Pl. I. fig. 5) are slightly larger than those of the connective tissue placed between the canal and the chitinous wall of the thorax; as far as I could distinguish in any of the sections, these cells of the wall of the canal have no distinct shape and do not compose a true epithelium. From the place where it enters into the thoracic part of the body the vas deferens is seen in all the sections which pass transversely through the thorax; it may be traced for about half a millimetre; it then ends abruptly; probably, though this could not be distinctly observed, it now opens into the cavity (Pl. III. fig. 4 *ca*) lined by the connective tissue, which has an outward opening at the capitular pole of the body. The communication with this cavity must be about at the height of the supraœsophageal ganglion. The whole thoracic part of the body can be stretched forward in a direction towards the capitular pole; though I do not believe that the opening of the vas deferens ever reaches the opening at the surface of the body, this stretching forward of the thorax is no doubt brought about in order to approach the opening of the vas deferens as much as possible to the slit at the extremity of the body. Well-developed musculi retractores serve for the retraction of the thorax within the body of the male. I have figured one of them on Pl. I. fig. 1, *mr*. In the transverse section figured on Pl. III. fig. 10 these muscles are also represented.

The Appendages.—As far as the number and the shape of the appendages of the thorax are concerned, it has proved rather difficult to get any certainty; in the first place, because the limbs with their thin chitinous wall refract the light in the same way as the thorax, and are pressed so closely against the body of the thorax as to make it impossible, even in a well-stained preparation, to make out their respective outlines, and in the second place, because of the smallness of the parts in question. After a careful study of sections, as well as from preparations made by dissection with needles, I believe the following facts may be safely relied upon. Only four pairs of legs are relatively well-developed; these are the four posterior pairs, and each of them is composed of two branches. Of the first two pairs of cirri only one very short branch is left. Each branch of the double-branched ones is relatively long and narrow, and terminates in two or three very long spines. In a transverse section each leg is represented by its chitinous wall and by the nuclei of its matrix, which are more or less elongate (Pl. I. fig. 5).

The Cement-Glands.—Finally, I must describe in a few words the structure of the cement-glands. They may be best studied in a section of a not quite full-grown specimen, as shown in Pl. IV. fig. 3. Each male contains a pair of these glands; they are situated a little above the vesicula seminalis (Pl. I. fig. 1 *c. gl.*); they have an oval shape, and measure about 0·15 mm. They are composed of very large cells with granular contents and a large nucleus, kept together by an extremely delicate network of connective tissue with a single rather small nucleus here and there between its fibres. Between the large cement-cells cavities are left open here and there in the connective tissue; each cell has the shape of a wedge, and is placed so that the broader part is directed towards the periphery, the narrower, on the contrary, towards the centre of the gland. The structure of the contents of each cell is rather remarkable, since the larger granules are placed at the periphery, and the contents are much more homogeneous towards the narrower extremity of the cell. In one of the preparations the ducts which run from the gland to the antennæ were rather distinct; they are attached as thread-like appendages to one of the narrower extremities of the gland.

Summary.—I think I have given herewith a full description of the so-called complemental male of a species of *Scalpellum*. With this description, and with the figures on Pls. I.–IV., it is possible not only to prove that this male has a highly degenerated organisation, but also to demonstrate in what this degeneration consists, and how it affects some of the organs very greatly, whilst others suffer less from it, and some are not influenced by it at all.

The state of things in the male under consideration may be summed up as follows:—

1. The external characteristic shape of the species with its capitulum and peduncle, its valves and scales, is lost. The microscopic body consists of an elongate bag closed on

all sides. A very small slit represents the opening between the two scuta. The antennæ are the only extremities which still show their original condition; the cirri have grown straight and functionless; the parts of the mouth have disappeared.

2. The cement apparatus is well developed as long as the male is young; when mature it is no longer so distinct.

3. The intestine has become functionless and is quite rudimentary; circulatory and respiratory organs may be passed by, as they have no distinct organs even in the hermaphrodite *Scalpellum*.

4. The nervous system consists of a relatively small supraœsophageal ganglion, of a not very stout œsophageal ring, and of a large thoracic ganglion. It is probably the latter which alone regulates the functions of the genital apparatus. The peripheral part of the nervous system is not much developed. The eyes (and other organs of sense) have been lost.

5. The genital apparatus is the only well-developed system of organs. The female apparatus, however, is totally lost, and even the male organs show a great deal more concentration than do the same organs in ordinary hermaphrodite Cirripedia. In the first place the testis is single, and has become a rather compact gland, whereas in other Cirripedia it is double and scattered throughout almost the whole interior of the body. In the second place, the vesicula seminalis is also represented by a single vesicle only, hermaphrodite Cirripedia, on the contrary, having always two of them.

In all these respects the little males of other deep-sea species of *Scalpellum* which I have been able to investigate exactly correspond to the male of *Scalpellum regium*. So does the male of *Scalpellum vulgare* (from specimens from the Mediterranean) with the exception of the presence of rudimentary valves, which in that species, as in some of the deep-sea species (*vide* p. 4), represent the so-called primordial valves of the young capitulum of pedunculated Cirripedia.

c. General Observations.

In the case of *Scalpellum vulgare*, Leach, *Scalpellum rostratum*, Darwin, *Scalpellum peronii*, Gray, sp., and *Scalpellum villosum*, Leach, sp., Darwin observed what he considered a penis; in *Scalpellum vulgare*, Leach, and in *Scalpellum villosum*, Leach, sp., he ascertained, moreover, the presence of vesiculæ seminales and testis in the specimens which were also furnished with ovaria. These specimens, therefore, were hermaphrodites, and as little males were found attached to their scuta, these male specimens got the very characteristic name of "complemental" males. On the other hand, *Scalpellum ornatum*, Gray, sp., did not show a trace of a proboscidiform penis in the four specimens which Darwin examined, and he, therefore, supposes that the animals studied by him were females, although it was impossible, as the specimens were dried, to demonstrate the absence of the vesiculæ seminales and testes. The male animals were lodged in a pouch on the under side of the scutum, and in that case should not bear the name of "complemental" males. From the state of the specimens of *Scalpellum rutilum,* Darwin, which Darwin examined, it was quite impossible to ascertain whether the individual was a hermaphrodite or a female; from the analogy of its nearest congener, *Scalpellum ornatum,* the latter, Darwin says, is the more probable.

Darwin's supposition as to the unisexuality of some species of *Scalpellum* proves to be in very striking accordance with the facts. What I at first considered to be the hermaphrodite form of *Scalpellum regium* (Wyv. Thoms.), Hoek, is not furnished with a penis, and does not show a trace either of a testis or a vesicula seminalis. To have full certainty in this respect, I divided the whole thoracic part of the body of a specimen of this species into a series of sections, and in none of them did even the smallest trace of a part of the male genital apparatus appear. The body was stained *in toto* by means of aluminium carminate, a most brilliant staining for the testis and for the spermatozoa within the vesicula seminalis when present. I then repeated the examination of *Scalpellum vulgare,* Leach; I found the animal a true hermaphrodite; it is furnished with a well-developed penis, and the vesiculæ seminales have exactly the structure of these organs in species of the genus *Lepas.* The only difference is shown in their small size. Slightly more developed testes pour out their products into the vesiculæ seminales.

The specimen of *Scalpellum regium,* of which I examined a series of sections, was a full-grown animal; it was furnished with males and there were ova in the ovigerous lamellæ. I got the same results when making a series of sections of *Scalpellum parallelogramma,* Hoek (Pl. IV. fig. 9), and *Scalpellum nymphocola,* Hoek (Pl. IV. fig. 10). So I think that we may safely draw the following conclusions:—

There are species of the genus *Scalpellum,* Leach, which show a very characteristic dimorphism. Some of these consist of large hermaphrodite and small rudimentary male specimens; others have large female and small rudimentary male forms.

However, I do not believe that these are the two most divergent cases in the sexual relations of the genus *Scalpellum.* I think there is still a third category of species in this genus, viz., those which are as true hermaphrodites as other Cirripedia, and in which no complemental males are developed. As a supposed species of this third division I will point out *Scalpellum balanoides,* Hoek. In the descriptive part of my report I have communicated the fact (p. 130) that one of the specimens contained eggs, though no complemental male was present at the place it ordinarily occupies. Though I have studied some more specimens of this species with great care, I have not once observed a male; yet they were nearly all furnished with eggs. I then studied the body of one of the specimens by the aid of transverse sections (Pl. IV. fig. 8, *a–f*); I found that the specimen was furnished with a very largely developed testis greatly surpassing the same organ in *Scalpellum vulgare.* The penis of this specimen was also of considerable size. Suppose I had observed this same organisation in a species of another genus of Cirripedia, then I should never have thought the existence of a complemental male in that species possible, and now in the case of a species of *Scalpellum* I think I may safely infer that in this species the absence of a complemental male is not an accident, but indeed the rule! I think, therefore, that there is sufficient reason to conclude that the genus *Scalpellum* presents the three following stages of sexual differentiation :—

1st. True hermaphrodite species: all the specimens develop male genital products as well as female. Whether these species are also "autogames,"[1] *i.e.*, whether the spermatozoa of a specimen as a rule fertilize the ova of the same specimen, is a point which I do not wish to discuss at present. I will only say that in case "autofécondation"[1] should be proved in the case of other Cirripedia (which at present has not, I think, been done), we can also safely admit it in the case of these species of *Scalpellum*.

Example:—

Scalpellum balanoides, Hoek.

2nd. Large hermaphrodite specimens and small unisexual (male) ones in the same species.

A. Male specimens with a capitulum and peduncle, with a mouth and stomach.

Examples :—

Scalpellum villosum, Leach, sp. | *Scalpellum peronii*, Gray, sp.
(*Scalpellum trispinosum*, Hoek.[2])

B. Male specimens with or without rudimentary valves, without a peduncle, a mouth and stomach.

Examples :—

Scalpellum vulgare, Leach. | *Scalpellum rostratum*, Darwin.
(*Scalpellum acutum*, Hoek.[3])

[1] Robin, Ch., Article "Sexe" in Dictionn. encyclopéd. d. sci. med., Paris, 1880.

[2] The body of this species has not been investigated; so my conclusion is based only on the presence of a well-developed penis, and on the great resemblance of the species to *Scalpellum villosum*, Leach.

[3] This species has not been investigated either; the supposition as to its hermaphroditism is based only on the presence of a well-developed penis.

3rd. True unisexual species; the females are large, the males very small and (probably) short-lived.

Scalpellum ornatum, Gray.	*Scalpellum vitreum*, Hoek.
regium (Wyv. Thoms.) Hoek.	*moluccanum*, Hoek.
parallelogramma, Hoek.	*eximium*, Hoek.
nymphocola, Hoek.	*darwinii*, Hoek.
tritonis, Hoek.	*carinatum*, Hoek,[1] &c.

Of all the genera of Cirripedia, *Scalpellum* is no doubt the one which presents the greatest amount of variety as far as the sexual relations are concerned. In this regard it even surpasses the genus *Ibla*, Leach, of which we know, through the aid of Darwin, that it presents two instances of sexual differentiation only, viz., unisexuality in the one species and hermaphroditism with accompanying rudimentary males in the other. It is well known that the genus *Scalpellum*, by means of *Scalpellum villosum*, Leach, sp., and by means of *Scalpellum trispinosum*, Hoek, blends with the genus *Pollicipes*, Leach, and also that the latter genus is one of the oldest, if not the oldest, of the genera of Cirripedia. All the known species of *Pollicipes* are true hermaphrodites as are other Cirripedia, and, moreover, *Pollicipes* seems to be a genus which only contains shallow water species. With a little imagination it does not appear to be very difficult to trace the way in which sexual differentiation took place in the genus *Scalpellum*. Originally there were only hermaphrodite species, inhabitants of shallow water. They resembled more or less the species of the genus *Pollicipes*. In some of the species specimens attached themselves to each other[2] as well as to other objects, and they developed all into ordinary hermaphrodite specimens. In one of these species, however, young specimens attached to full-grown older ones, though developing into animals of the ordinary shape with a capitulum and a peduncle, did not acquire the size of the older specimens, and lost their female genital apparatus. In a following stage, we see that the little creatures which by their smallness are enabled to hide within the valves of the older hermaphrodite specimens, lose their valves and are reduced to a rudimentary state in all respects, except so far as the male organs are concerned. Finally, we observe in the latest stage that the original hermaphrodite specimen loses its male genital apparatus and becomes unisexual. In the latter species we have large and relatively long-lived female specimens, and small and short-lived males.

I feel sure that some serious objections may be advanced against this reasoning, and

[1] The bodies of *Scalpellum tritonis*, *Scalpellum vitreum*, *Scalpellum moluccanum*, *Scalpellum eximium*, *Scalpellum darwinii*, and *Scalpellum carinatum*, have not been investigated by means of transverse sections. Their unisexuality is based only on the total absence of a penis and on their general resemblance to the investigated unisexual species.

[2] Specimens of *Scalpellum vulgare* are attached to various horny corallines, and occasionally to the peduncles of other individuals. Darwin, Lepadidæ, p. 226, 1851.

one of these I will point out myself. Those species which are unisexual and have very small and rudimentary males, which, therefore, according to the sketch given above, are the youngest of the hypothetical course in which the different stages of sexual differentiation have developed, are at the same time those which closely resemble the species from the oldest geological strata from which species of *Scalpellum* are known. But I think this objection is weakened by admitting that the sexual differentiation in the genus *Scalpellum* was already achieved at the period from which these fossil remains date. The somewhat aberrant shape of *Scalpellum balanoides*—the species in the supposed original condition of true hermaphroditism—is also difficult to explain at first sight. We might have expected to observe the original condition (hermaphroditism without complemental males) in a species as closely resembling *Pollicipes* as possible, as, for example, in *Scalpellum villosum*, Leach, sp.; or *Scalpellum trispinosum*, Hoek.[1] The condition of the genital apparatus and the external shape of the valves (the whole capitulum), however, are two factors which need not necessarily stand in so very close a relation to each other. So it may be easily imagined that the original condition of the sexual apparatus is left in a form in which the external shape of the capitulum has been altered, and, on the other hand, there is no reason why the sexual relations of a form should not become altered without the external shape undergoing considerable changes at the same time.

When, however, all these considerations are weighed I do not believe that there are trustworthy grounds for doubting the exactness of the hypothesis that in the genus *Scalpellum* the hermaphrodite condition is the original, and the unisexual the secondary stage in the development.

[1] I did not observe the male of *Scalpellum trispinosum*. I suppose that this species is furnished with a complemental male with capitulum and peduncle from its resemblance to the species *Scalpellum villosum*. I did not study its genital apparatus. I can only say that it is furnished with a well-developed penis.

II. SEGMENTAL ORGANS IN THE CIRRIPEDIA.

Cirripedia are rich in organs of an unknown or at least problematic function. One instance of these is found in the "olfactory organs" or sacs of Darwin. "In the outer maxillæ," Darwin says,[1] "at their bases where united together, but above the basal fold separating the mouth from the body, there are, in all the genera, a pair of orifices; these are sometimes seated on a slight prominence, as in *Lithotrya*, or on the summit of flattened tubes projecting upwards and towards each other as in *Ibla*, *Scalpellum*, and *Pollicipes*. In *Ibla* these tubular projections rise from almost between the outer and inner maxillæ. It is impossible to behold these organs, and doubt that they are of high functional importance to the animal. The orifice leads into a deep sack lined by pulpy corium, and closed at the bottom. The outer integument is inflected inwards (hence periodically moulted) and becoming of excessive tenuity, runs to near the bottom of the sack, where it ends in an open tube; so excessively thin is this inflected membrane, that until examining *Anelasma*, I was not quite certain that I was right in believing that the outer integument did not extend over the whole bottom. I several times saw a nerve of considerable size entering and blending into a pulpy layer at the bottom of the sack of corium; but I failed in tracing to which of the three pair of nerves, springing from the front end of the infra-œsophageal ganglion, it joined. I can hardly avoid concluding that this *closed* sack, with its naked bottom, is an organ of sense; and, considering that the outer maxillæ serve to carry the prey entangled by the cirri towards the maxillæ and mandibles, the position seems so admirably adapted for an olfactory organ, whereby the animal could at once perceive the nature of any floating object thus caught, that I have ventured provisionally to designate the two orifices and sacks as olfactory."

This supposition of Darwin's has, however, been accepted with great reserve. As far as my knowledge of the literature of the group goes, the same organs have not been studied, nor has another opinion been published about their function since Darwin's.[2] I first tried to get a good insight into the structure of this apparatus by isolating the outer maxillæ. I arrived at the same conclusion as Darwin, viz., that it was composed of a duct with an outward orifice and an internal portion, a kind of sack lined by a layer of cells different in structure from those of the duct. In some of the figures representing parts of the mouth of species of the genus *Scalpellum* (*e.g.* *Scalpellum parallelogramma*, *Scalpellum strömii*, &c.), in the systematic part of my report, the long and very characteristic tubes at the extremity of which the orifices are found have been represented. I then studied the apparatus by the aid of transverse sections of the thorax of the

[1] Darwin, Lepadidæ, 1851, p. 52.

[2] Claus (Lehrb. d. Zool. 3 Aufl. 1876, p. 456, says:—"Gehör- und Geruchsorgane sind nicht mit Sicherheit nachgewiesen, da die von Darwin als solche in Anspruch genommenen Bildungen eine andere Deutung (Oviducte, Drüsenöffnungen) erfahren haben." I do not know where this opinion has been published, so far as Darwin's olfactory organ is concerned.

animals, and I then became certain that Darwin's description was not correct in one very important point. The sack is not closed at the bottom, but gives entrance to the body-cavity of the animal.

For want of material I have been obliged to limit my researches to the pedunculated Cirripedia; in the sessile Cirripedia, however, there cannot be the slightest doubt that the apparatus will prove to have about the same structure; the orifices are here never produced nor tubular.[1] I got by far the best preparations from specimens of *Scalpellum vulgare*, Leach, which I received from the Zoological Station at Naples. The figures on Pl. V., as well as the description, are based upon preparations of these specimens.

Fig. 1 of Pl. V. shows a complete transverse section through the thorax of *Scalpellum vulgare* a little below the first cirrus. The large cavities (*A*) separated in the figure from one another by the band of connective tissue (*B*) represent parts of the body-cavity. An epithelial clothing (a true cœlomic epithelium) cannot everywhere be made out distinctly; yet I think its presence may be safely concluded from the cellular remains which here and there adhere to the connective tissue, in the shape of elongate and rather flat nuclei. The section passes longitudinally through the long and flattened tube which belongs to the right outer maxilla; the duct on the interior is clothed by a thin chitinous tunic, with a chitinogenous epithelium everywhere beneath it; both the chitinous tunic and its matrix are the continuation of the outer body-wall, and are no doubt true epiblastic products. Fig. 3 of Pl. V. represents a longitudinal section of one of the segmental organs. From the outer wall of the flattened tube thin transverse fibres of connective tissue run towards the wall of the duct. Having passed longitudinally through the tube, the duct may be traced for a short distance beneath the surface of the body; it then passes over into a very narrow channel which passes through a compact mass of cells. The whole mass of cells has the shape of a bell; the limits of the different cells are not very distinct, but the different nuclei are. They are oval and their longest diameter is about 0·005 mm. (fig. 2, Pl. V.) The surface of the cells bordering the narrow channel is markedly protuberant, so as almost to meet that of the opposed cells; in very favourable sections only can the presence of the channel be made out. To judge from the great number of nuclei, the cell-mass, at least on one side, is formed of more than a single layer. Whereas the cells of the duct have their nuclei with their longer axis parallel to the surface of the wall of the duct, those of the bell-shaped cell-mass are rather perpendicular to the surface of the very narrow channel. Moreover, the latter are very characteristic on account of their staining much more intensely than do those of the chitinogenous cells or of the surrounding connective tissue. Towards the interior of the body-cavity the thick cell-coating of the narrow channel slopes and soon terminates; from the body-cavity the entrance of the narrow channel is distinctly funnel-shaped. The chitinous membrane which clothes the interior of the duct is not present at the surface of

[1] Darwin, Balanidæ, 1854, p. 97.

the cells which border the narrow channel. (Probably we have here the explanation of what Darwin means, when he says that the outer integument is inflected inwards, and ends in an open tube.)

I propose to call the duct which opens at the extremity of the tubes the "segmental duct," and the bell-shaped cell-mass with its very narrow channel the "segmental funnel." I think we can hardly hesitate to consider these organs as true segmental organs, but before entering into a discussion of the arguments in favour of this suggestion, I will finish the description. To the apparatus belongs also a well-developed set of muscles attached round about to the external surface of the bell-shaped cell-mass, of which especially those directed to the external side of the body, are very strongly developed; they form towards the interior of each organ a nearly triangular mass, the apex of which is directed towards the interior of the body, the broad basis being placed against the outer surface of the bell-shaped cell-mass (Pl. V. fig. 2). The muscle-fibres of the external side of the cell-mass are distinctly divergent, and a part of them continues in a rather strong bundle of muscle-fibres running towards the border of the body-cavity. In my most successful, thinnest, and best stained preparations the muscle-fibres did not show transverse striation; those especially of the external side were remarkable for their clearness and smoothness, resembling thin elastic fibres of the connective tissue. Between these fibres interspaces may be seen everywhere, and in these numerous pale small round cells were visible, which I think were blood-corpuscles. Probably the function of the muscle-fibres is not in the first place to move, but to form a labyrinth of small cavities in which the blood accumulates.

What may be the morphological significance of this organ? Considering that it constitutes an open communication of the body-cavity with the exterior, there can be no doubt that it must be compared with the segmental organs of the Annelida. The high development in the genus *Scalpellum* of the flattened tube at the end of which the orifice is found, shows, I think, that we have not before us a rudimentary organ, but an apparatus of an important functional significance. From a phylogenetic point of view its importance increases with our knowledge of the great age of Cirripedia, of which, *e.g.*, the present genus is already represented in the Lower Greensand. Where the shell has remained exactly the same, we can safely admit that the structure of the animals is sure to have changed very little or not at all since that remote geological period.

A rather curious circumstance is found in the fact that in Cirripedia only one pair of segmental organs has remained. In the oldest Tracheate Arthropoda we know of (*Peripatus*), according to Balfour,[1] there are found nephridia or segmental organs in all the legs; in Crustaceans these same organs have not been observed with certainty; the only instance mentioned in literature is that of terrestrial Isopods, where M. Huet[2]

[1] F. M. Balfour, The anatomy and development of Peripatus capensis, *Quart. Journ. Micr. Sci.*, vol. xxiii. pp. 213–259, 1883.

[2] Huet, Sur l'existence d'organes segmentaires chez certains Crustacés isopodes, *Comptes Rendus*, 1882, No. 12, p. 810.

believes he has observed segmental organs in each of the seven body segments. Whether M. Huet be right in considering these organs "organes glandulaires . . . qui s'ouvrent à la partie supérieure des épimères, de chaque côté, par une ouverture en crible" as segmental organs, I will not discuss. To judge from his description they have not the typical structure of true segmental organs which are to form an open communication between the body-cavity and the exterior.

Two other sets of glands of Arthropoda, and more especially of Crustaceans, are perhaps more nearly related to the segmental organs; they are the antennal glands of the larvæ of many Entomostracans and of the full-grown Malacostracans; and the shell-glands of full-grown Copepoda and Phyllopoda. According to Grobben[1] they have nearly the same structure, and must be regarded as homologous organs (homodynamous they are called, more accurately I think, by R. and O. Hertwig[2]); both are composed of a little terminal sack (Endsäckchen), and a channel (Harnkanälchen) which opens at the surface of the body. Moreover, the cells covering the interior of the little sack in the antennal and shell-glands show a complete resemblance. An open communication with the body-cavity has, however, never been observed in the case of these organs[3]; if they really are to be compared with segmental organs, there can be no question that they have degenerated from their original condition.

Should there ever be discovered an intermediate form between a true segmental organ such as that of *Scalpellum* and a shell-gland as observed in the Copepoda, then in the first place the homology of the apparatus may be accepted; but in the second place it will then also be possible to give a more solid basis for demonstrating the homologies of the extremities of Cirripedia and Copepoda than has been the case hitherto. When treating of the female genital apparatus and its orifice at the base of the first cirrus I hope to point out that there is sufficient reason for admitting that a second pair of segmental organs, though in a slightly modified condition, is present in the Cirripedia also.

Finally, I will not take leave of this subject without stating as my opinion that the segmental organ which I have described is physiologically an organ of an excretory nature. The condition of the material at my disposal did not allow of my attempting a chemical investigation of the contents of the cells, and so it is only from analogy that this conclusion has been arrived at. It is fairly supported, I think, by the presence of muscle-fibres with numerous cavities between them, such as have also been observed by Grobben (*loc. cit.*, p. 105) in the neighbourhood of the antennal glands of the Decapoda.

[1] C. Grobben, Die Antennendrüse der Crustaceen, *Arb. Zool. Inst. Wien.*, Bd. iii. 1880.

[2] R. and O. Hertwig, Die Coelomtheorie, *Jenaische Zeitschr.*, Bd. xv. pp. 1–150, 1882.

[3] According to Sedgwick (*Quart. Journ. Micr. Sci.*, vol. xxiv., N.S., pp. 46, 47, 1884), the nephridia of the Invertebrata are developed from solid masses of cells derived from the wall of the cœlom; a communication with the body-cavity in that case would represent a secondary stage.

III. THE CEMENT APPARATUS.

The cement apparatus and the genital organs of the Cirripedia are in general tolerably well known; in detail, however, our knowledge often proves to be very insufficient. Darwin has the merit of having discovered the presence of the cement-apparatus, but he failed to understand its organisation, partly because he confounded its elements with those of the female genital apparatus.

Krohn[1] gives a much more accurate description of the cement apparatus of *Lepas anatifera* and *Conchoderma virgatum*. He was the first to observe the true cement-glands. In *Lepas anatifera* they are, according to him, situated in the most superior part of the peduncle, and scattered through the connective tissue which envelops the ovary; they are very numerous, and they have the shape of long oval, vesicular little bodies, which are attached to very delicate and richly ramified canals in the same way as berries to their stems. These canals open, before the inferior extremity of the ovary is reached, into the two cement-ducts, the commencements of which are swollen into ampullæ. These cement-ducts have been already observed by Darwin; they run downwards at a considerable distance from one another, one at the right, the other at the left hand side of the peduncle, and they are situated close to the innermost layer of longitudinal muscle-fibres. Finally they penetrate into the chitinous wall of the peduncle near the place where it is attached; they pass through this wall, becoming narrower and narrower, and are then lost sight of. In the deeper layers of the chitinous wall of the peduncle the cement-ducts are invested with rounded swellings of different sizes, which are hollow and which are doubtless in open communication with the ducts; these swellings act as reservoirs to retain the cement before it is evacuated. In *Conchoderma virgatum* the cement-apparatus differs from that of *Lepas anatifera* in the cement-glands being for the greater part placed in the parenchymatous tissue of the mantle and for a very small part only in the superior extremity of the peduncle. The two cement-ducts with their swollen ampullæ reach very close up to the place where the capitulum communicates with the peduncle. The two ampullæ in this genus communicate with one another by means of a transverse and tortuous canal.

I studied the cement apparatus in *Lepas*, *Conchoderma*, and *Scalpellum*. As regards the histological structure of the apparatus my researches are far from satisfactory, the condition of the material at my disposal being, in part at least, the cause of this. The peduncle of the Cirripedia is very difficult to preserve; even in specimens freshly sent over by the Direction of the Zoological Station at Naples, the condition of the tissue has suffered much.

The little bodies which were considered by Krohn as the true cement-glands must

[1] A. Krohn, Beobachtungen über den Cementapparat und die weiblichen Zeugungsorgane einiger Cirripedien, *Archiv f. Naturgesch.* Jahrg. xxv. Bd. i. pp. 355–364, 1859.

indeed be regarded as such. Krohn has not given a description of these glands, nor is such a description to be found in the literature of the group. For *Balanus* I myself published figures of these glands some years ago,[1] when it was my opinion that the ovarian cœca might perhaps develop from these bodies—a serious error pointed out by Claus. My excuse was firstly that these bodies, scattered everywhere between the young ovarian cœca, had never been observed in a sessile Cirriped before, and secondly that Darwin had led me into error by describing the cement-glands as adhering to the basal membrane or basal calcareous plate of the Balaninæ. I should have paid more attention to a footnote in Krohn's paper (p. 357), in which he states his opinion that the true cement-glands of the Balanidæ might also be found between the ovaries or in the connective tissue surrounding the mantle.

The cement-glands of *Lepas anatifera*, of *Conchoderma virgatum*, and of *Scalpellum vulgare* are nearly of the same shape and size. Those of *Lepas anatifera* are a little larger, the longest diameter measuring 0·15 to 0·2 mm., whereas those of *Scalpellum vulgare* are smaller, having a diameter of about 0·125 mm. (The largest diameter of one of the cement-glands of *Balanus improvisus* is not quite 0·2 mm.). The interior of the cells is filled with a plasmatic mass, which shows the curious property of staining rather intensely with aluminium carminate. At the same time, the large nucleus, which occupies nearly the centre of the cell, and which measures half the length of the cell itself, is coloured also and much more intensely. In many preparations the body of the cell shows an extremely delicate granular structure, whereas the nuclei are coarsely granulated, or appear to have a fibrillar structure. In *Lepas* nucleoli have not yet been observed. Pl. II. fig. 5 shows the condition of the cement-cells in the Cypris-larva. I do not quite understand in what way the pear-shaped gland develops from these cells. The size of the latter is about 0·03 mm., at least in the case of *Lepas australis*. Towards one side, and as a rule in the longer axis of the cell, its wall is produced so that the cell assumes the shape of a pear; this produced part slopes into a long and narrow duct (Pl. V. fig. 5). The structure of this duct is very simple; here and there small cells are visible in its wall (measuring about 0·005 mm.), which on the exterior is lined by a kind of thin cuticle.

The ducts of the different cement-glands unite together to form a much more capacious duct; a little before the place where the junction is observed, a transverse short duct often runs from one branch to the other; all the ducts together form an irregular network, the thickest branches finally pour out their contents into two longitudinal ducts. The ducts (fig. 5, *d*), which communicate directly with the glands, have a diameter of about 0·025 mm.; the two longitudinal ducts in which the contents of the narrow ducts are evacuated, measure about 0·05 mm. in width. In a

[1] P. P. C. Hoek, Zur Entwickelungsgeschichte der Entomostraken, I. Embryologie von Balanus, *Niederländ Archiv f. Zool.*, Bd. iii. pp. 47–82, 1876.

large series of sections of the peduncle of *Lepas anatifera*, the presence of the principal cement-ducts can everywhere be ascertained; in the most superior part of the peduncle they run at a somewhat greater distance from the innermost layer of longitudinal muscle-fibres than is the case in the more inferior sections of the peduncle. The ampullæ which would represent the commencements of the cement-ducts I have not observed. The two ducts run in a zig-zag line, whence in many sections parts of them 0·3 mm. in length are represented. I have not been able to follow the cement-ducts quite up to the inferior extremity of the peduncle. The wall of the duct itself is irregularly folded in all my preparations of *Lepas anatifera*; towards the interior of the canal it seems to be invested with a thin cuticle, for, when a transverse section is studied, its interior is always limited by a sharp smooth line; for the rest, I have not a very clear notion of the cellular structure of the canal. The condition of the specimens of *Conchoderma virgatum* at my disposal has only allowed of my making a preparation of the glands. They are very small, measuring not quite 0·06 mm. Their nuclei are nearly circular, and have a diameter of about 0·024 mm. In one of the glands a little nucleolus was visible, though not very distinctly. The thin cuticle which invests the canal that passes away from the gland in *Conchoderma virgatum* was visible also round the glands themselves. I found Krohn's statement as to the occurrence of the cement-glands for the main part in the parenchymatous tissue of the mantle to be quite correct.

In *Scalpellum* I studied the cement-apparatus in two species in greater detail, viz., in *Scalpellum vulgare*, Leach, and in *Scalpellum regium* (Wyv. Thoms.), Hoek. In these two species this apparatus is, curiously enough, not quite built up after the same type. That of *Scalpellum vulgare* has been described already by Darwin.[1] In young specimens, Darwin says, the attachment is performed by cement proceeding exclusively from the antennæ of the larva; in older and full-grown specimens the cement is poured out through a straight row of orifices along the rostral edge, thus causing a narrow margin to adhere firmly to the thin and cylindrical branches of the coralline. "At each period of growth the corium (the soft flesh, the mass of connective tissue with the muscles of the peduncle) recedes a little from the attached portion of the peduncle; of which portion the greater part is thus left empty, &c. . . . The two cement-glands are seated high up on the sides of the peduncle; the two cement-ducts proceeding from them, are $\frac{3}{2000}$ths of an inch (0·039 mm.) in diameter and run in a zig-zag line; at the point where they pass through the corium to enter the lower attached portion of the peduncle they become closely approximated, and partially imbedded in the membrane of the peduncle. They run together along the rostral edge, giving out through each orifice a little disk of brownish cement, and finally they enter the larval antennæ."

The specimen of *Scalpellum vulgare*, whose cement-apparatus I have investigated, had a peduncle of about 9 mm. in length, and was attached by its under surface

[1] Darwin, Lepadidæ, 1851, p. 226.

to the rather broad stem of a horny coral. In order to be able to make transverse sections of the peduncle, I have removed the chitinous wall of the peduncle with its calcareous scales. I stained the peduncle *in toto* by means of aluminium carminate. The ovary in this specimen was very strongly developed, and its cœca extended as far as the most inferior part of the peduncle. The true cement-glands have nearly the same shape and structure as in the other genera; in size they are larger than those of *Conchoderma*, but not so large as those of *Lepas*. They are rather numerous in the superior part of the peduncle, but become scarce lower down (Pl. V. fig. 6). On opening a peduncle of *Scalpellum vulgare* in alcohol, the glands appear as little white grains, and are visible even with the naked eye. Often the glands are not unicellular but composed of two or three cells combined; in that case the body of the gland is larger, and the two or three nuclei of the original cells are distinctly visible. In many of the glands a dark coloured oval nucleolus was present within the circular nucleus (Pl. V. fig. 6*); the size of the gland was 0·11 to 0·125 mm. in diameter, that of the nucleus 0·04, whereas the nucleolus measured 0·013 mm. The ducts at the end of which the glands are observed are very narrow, their diameter being about 0·007 mm.; those of adjoining glands often anastomose, so as to form together a network of ducts. I know these anastomosing canals from a preparation stained with picrocarmine and isolated by the aid of needles. In the transverse sections of the peduncle only very small parts of the ducts are seen attached to the glands.

All the narrow ducts pour their contents into four rather wide canals which, at the rostral side, run longitudinally through the peduncle. Immediately below the place in the superior part of the peduncle, where the two oviducts terminate, the first longitudinal cement-duct begins (Pl. V. fig. 6, *d*). It is closed at its superior extremity, the cement being shed in the canal by means of lateral openings. The blind extremity of the canal is placed a little more towards the centre of the peduncle; the canal slightly changes its direction so as to run parallel with and close to the elongated cavity (fig. 6, *a*), which is visible at the rostral side of most pedunculated Cirripedia (*Lepas*, *Conchoderma*, *Scalpellum*), and which is a continuation of a part of the body-cavity of the animal within the capitulum. The width of the cement-duct is about 0·3 mm. It is surrounded by a chitinous wall—perhaps the chemical composition is different from that of chitin—and it shows traces of an epithelial (or rather endothelial) cell-layer on the internal surface. About half-way along the peduncle a second longitudinal canal begins; it has, when seen in transverse section, a long oval shape, and is divided by a partition into two halves, which soon become independent. A little lower a third—properly speaking a fourth—canal begins (Pl. V. fig. 7). It has an oval shape; its largest diameter is 0·4 mm., its shortest 0·28; its wall is composed of a chitinous (?) outer layer and a regularly developed inner epithelial layer of very small cells with distinctly coloured nuclei. I do not quite understand why this epithelial cell-layer is well developed (at least distinctly visible) in the one duct, whereas it can scarcely be made out in the other ducts.

After the four canals have run independently of one another for about $1\frac{1}{2}$ mm., the first duct unites with one of the two ducts into which the second canal has divided, whereas the other half of the second duct terminates by uniting with the third. In the lowest sections of the peduncle of *Scalpellum vulgare* which I have been able to investigate, two ducts only are present. They run close to one another, and are placed within the wide canal which in the peduncle represents the cœlom. Of course higher up in the peduncle they were situated in this canal also; but at the place where they commence with a blind extremity, as a rule, they are not within this cavity. All the canals have very irregularly folded walls, and are filled up with a solid mass of a granular structure. Probably this is the cement after it has been affected by alcohol and reagents. At many places part of the chitinous (?) and irregularly folded wall is stained also by the aluminium carminate.

The way in which the cement is poured out into the canals has not been observed by me. Everywhere round the canals a dense layer of connective tissue with numerous nuclei is observed, and at the places where the wall of the ducts is open, a spongy mass of this tissue penetrates within the opening. Most probably the connective tissue is charged with the duty of conducting the cement till it comes within the canals. The communication of the microscopic canals, at the end of which the glands are placed, with the cement-ducts—or with the connective tissue surrounding these ducts—has not been observed. I think it impossible to observe this without the aid of very rich and fresh material.

The cement-glands of *Scalpellum regium* (Wyv. Thoms.), Hoek, are not numerous, but they are relatively large. They are placed in two groups in the superior part of the peduncle to the right and to the left side (Pl. V. fig. 8). As a rule, each gland is composed of three or four glandular cells (Pl. V. fig. 11). I measured a gland which appeared to me to be unicellular, and its greatest diameter was 0·5 mm.; another composed of three cells had a length of 0·7 mm. The nuclei in the glands of this species have a very characteristic fibrillar structure; it is, of course, possible that the reagents have caused this. The ducts going off from the cells are narrow (their diameter being 0·016 to 0·02 mm.); the nuclei of the cells forming their walls are very distinct. The walls of these ducts are not quite smooth; globular vesicles adhere to them as small excrescences, and so give the duct, especially when studied in transverse section, a very curious aspect (Pl. VI. fig. 3). The ducts unite together so as to form groups of nearly parallel ducts, but often many of them retain their independence. Often two groups of ducts reunite, to become isolated again after a short time. About the middle of the peduncle I counted more than twenty groups of these ducts; some were composed of three or four single ducts, others of more (Pl. V. fig. 10). In the centre of each group of ducts often a much wider duct is visible; especially wide is a duct which runs at the rostral side of the peduncle close to the innermost layer of muscular fibres (Pl. V. fig. 10; Pl. VI. fig. 3).

This wide duct may be seen to continue as far as the uppermost part of the peduncle, and is nothing else but the cavity (A) which we observed also in the peduncles of the other Lepadidæ, and which can be traced as a continuation of a part of the cœlom. In the superior part of the peduncle (Pl. V. fig. 8) this wide canal (measuring here 0·9 by 0·56 mm.) has an oval shape, and is completely filled with a very delicately granulated mass, which I think more resembles blood serum than any other substance. The connective tissue surrounding this canal, and especially the interior of the peduncle, has a very spongy structure; as I shall point out again when treating of the development of the ovaries within the peduncle, I think the contents of the duct and the tissue which surrounds it serve to nourish the ovaries.

At a short distance—about 3 mm.—from the superior extremity the duct begins to get narrower; the space occupied by the delicately granulated substance measures now only 0·22 mm. in diameter. The spongy mass of connective tissue has grown much thicker, and forms especially towards the interior of the peduncle a very thick wall; for the first time here cement-ducts are seen within this thickened portion of the wall of the duct (Pl. V. fig. 9). Between this wall and the central mass of the granulated substance a layer of vesicles can be distinguished. I think they are formed by the cement poured out into the canal and pressed between the wall and the central mass. One millimetre and a half farther down the duct becomes still narrower; it now has with its wall a diameter of 0·43 mm. only. The granulated substance has almost totally disappeared, but the interior of the wall is everywhere covered with large and small cement vesicles. Below the middle of the peduncle, at numerous places, larger cement-ducts pour out their contents into this canal, which eventually has in all respects the shape of one of the wider cement-ducts such as are found also in the interior of the peduncle. In the undermost part of the peduncle it runs no longer close to the rostral side, but is observed in the centre of the peduncle. It there quite resembles two other larger cement-ducts which run longitudinally through the peduncle. Probably these ducts are open at their inferior extremities, which, so far as I could make out, are not continued up to the base of the peduncle; the latest sections I prepared of the peduncle do not show the ducts in the connective tissue.

So we see that in *Scalpellum regium*, the cement-ducts do not run within the cœlom-cavity, or what I feel inclined to consider as its homologue, but that this cavity in its most inferior part is itself changed into such a cement-duct. The other ducts stand in open communication with the one at the rostral side. A second difference is seen in the structure of the wall of the ducts; the smooth-lined sheath of the ducts in *Scalpellum vulgare*, which made me compare the substance of which that wall is built up with chitin, is nowhere to be observed in *Scalpellum regium*. No doubt the investigation of other species of *Scalpellum* and of other genera of Cirripedia will show that the cement-apparatus of this group of Crustaceans presents many more variations than would have been expected beforehand. The knowledge of these variations is no doubt of great interest, yet it would be of much more importance still, if the morphological significance of the apparatus were more apparent.

IV. DARWIN'S "TRUE OVARIA."

Darwin[1] observed in the Cirripedia two glandular masses resting on the upper edge of the stomach, and touching the cœca where such exist; these were thought by Cuvier to be salivary glands. They are of an orange colour and form two parallel "gut-formed" masses. Darwin was not able to ascertain whether the two main ovarian ducts coming from the peduncle expanded to envelop these glandulæ or what the precise connection was. He says "the state of these two masses varied much; sometimes they were hollow, with only their walls spotted with a few cellular little masses; at other times they contained or rather were formed of more or less globular or finger-shaped aggregations of pulpy matter; and lastly, the whole consisted of separate pointed little balls, each with a large inner cell, and this again with two or three included granules. These so closely resembled in general appearance and size the ovigerms with their germinal vesicles and spots, which I have often seen at the first commencement of the formation of the ova in the ovarian tubes in the peduncle, that I cannot doubt that such is their nature. Hence I conclude that these two gut-formed masses are the true ovaria. I may add that several times I have seen in the two long unbranched ducts, connecting the true ovaria and the ovarian tubes in the peduncle, pellets of orange-coloured cellular matter (*i.e.*, ovigerms) forming at short intervals little enlargements in the ducts, and apparently travelling into the peduncle."

In the second volume of Darwin's Monograph,[2] the same opinion as to the nature of these glandular bodies was given for the sessile Cirripedia. This opinion, however, was not only opposed to that of Cuvier[3] but also to that of Martin-Saint-Ange and of Karsten. Martin-Saint-Ange[4] describes "une espèce d'appendice stomacal, un véritable prolongement renflé et bilobé, communiquant avec la première cavité de l'estomac par un pédicule étroit et fort court. La structure, la forme générale, la coloration et la disposition mamelonnée de la surface extérieure de cette partie sont tout à fait semblables à celle de l'estomac, et doivent être regardées comme faisant partie du même organe." Martin-Saint-Ange, therefore, cannot be said to have considered these bodies as salivary glands, since he points out in his Memoir as well as in the explanation of the figures that these organs communicate with the stomach. So Darwin's objection "that salivary glands have not been positively recognised in any Crustacean" cannot be considered of any consequence.

Krohn,[5] describing the direction followed by the oviducts, says that they approach very

[1] Darwin, Lepadidæ, 1851, p. 57.
[2] Balanidæ, 1854, p. 100.
[3] Cuvier, Mémoire sur les animaux des Anatifes, *Mém. Mus. Hist. Nat.*, t. ii., 1815.
[4] Martin-Saint-Ange, Mémoire sur l'organisation des Cirripèdes, *Mém. Inst. Savans. Étrang.*, t. vi., 1835.
[5] Krohn, Ueber d. Cement- und Zeugungsapparat d. Cirripedien, *Wiegmann's Archiv*, t. xxv., 1859.

close to those organs "die seit Cuvier für die Speicheldrüsen gelten." For the rest he does not say what is his own opinion in regard to the nature of these bodies.

I do not think that since the publication of Darwin's Monograph these organs have been investigated; so I was most anxious to study them, and if possible to make out their structure. They occurred in all the genera in which I sought for them; I studied them in greatest detail in the genera *Lepas* and *Scalpellum.*

Near the place where the œsophagus communicates with the stomach, the outer surface of this latter organ is invested with a pair of oval masses; they are placed at rather a considerable distance from one another, one being found at the right, the other at the left hand side of the stomach. Pl. VI. fig. 7 shows their situation in *Lepas anatifera* when seen laterally, fig. 8 when seen from the anterior (dorsal) side. In both figures *Œ.* represents the œsophagus and *G. S.* the supraœsophageal ganglion; *p. n.* are the two strong peduncular nerves which start from the supraœsophageal ganglion; *oc.* is the curious eye discovered by Leidy, placed close to the surface of the stomach and separated from the external surface of the body by a very darkly pigmented integument and a thick layer of muscles, which are both left out in the figures. The oviducts (*ov*) are also distinct in both figures. They come from the peduncles and for some distance run parallel to the peduncular nerves; a little beyond the eye they are seen to diverge and then may be followed running transversely over or at least close to the surface of the stomach. Dorsally from the oviducts (in fig. 7 beneath them) the most anterior parts of the testis (*t*) can be distinguished. That part of the surface of the stomach which is nearest to the œsophagus is covered all over with rounded and dark-coloured tubercles (*l*) which cause the "disposition mamelonnée" of Martin-Saint-Ange, and which when studied in a transverse section appear to be the arborescent cœca of the surface of the stomach. The internal surface of these cœca is darkly pigmented, and this causes the blackish colour of the rounded swellings at the exterior.

The glandular bodies in figs. 7 and 8 are marked *gl.* They are not always of the same shape and size. Sometimes they are rather regularly oval and compact, having a length of about 4 mm. and a breadth of not quite 2 mm. In other cases, however, finger-shaped excrescences (as observed by Darwin) give the gland a much more irregular appearance. In both cases the surface of the body is uneven owing to the presence of globular swellings; whilst the whole body represents an acinous gland, each of the globules being a distinct acinus.

Before giving a description of the microscopic structure of the gland in *Lepas* I will describe its structure in *Scalpellum.* My best preparations are from *Scalpellum parallelogramma,* Hoek. In this species the gland is relatively small, having a length of little more than one millimetre. It is pyriform; at the narrow extremity it communicates with the interior of the stomach by means of a very narrow duct; at the other extremity its body is rather blunt and rounded. The greatest transverse diameter of the gland in one of my series of sections measured 0·6 mm. In another series, however, it was more oval and measured 0·9 by 0·5 mm. The gland is not situated near the cardia but at a considerable distance, about half-way between the cardia and the dorsal surface of the body. The gland is a true tubular one; its wall consists of a single layer of cells only. The shape of these cells may be seen in Pl. VI. figs. 4 and 5. Each cell is cylindrical or rather conical, its base always being greater than the other extremity, which is directed towards the interior of the gland. The bases of the different cells are parallel to the nearly smooth outer surface of the gland; the other extremities of the cells, however, are as a rule not flat but convex, or even protuberant towards the interior of the canal which runs through the gland. In thin sections the outer surface of the gland is marked by a double line; the outer one is here and there distinctly sinuous, and between the two lines small nuclei are visible, which are rather flat; they are placed in the cavities between the inner and the outer margin. There can be no doubt that in this way a rudimentary *membrana propria* is formed. The connective tissue surrounding the glands has smaller meshes and is very rich in nuclei.

The dimensions of the glandular cells are about 0·1 mm. in length and 0·03 mm. in breadth. Each cell has granular plasmatic contents and a very large oval nucleus. In preparations stained with aluminium carminate the body of the cell as well as the nucleus has taken up the colour. The first is beautifully lilac-coloured, the latter darkly violet. Each nucleus is coarsely granulated and measures 0·036 by 0·02 mm. It contains a smooth and brilliant nucleolus of 0·009 mm. in diameter. In each nucleus the nucleolus is situated in the centre of a clear space, which, as a rule, is placed towards that side of the nucleus which is directed towards the internal surface of the gland. The clear space—which gives the impression of a clear vesicle with fluid, but which has no distinct contour of its own—is on one side separated from the surface of the nucleus only by a very narrow layer of the granular substance which fills the nucleus. The nucleus has a distinct external contour.

All the cells are built after the same type; but there are very characteristic differences between the cells of two different specimens of *Scalpellum parallelogramma*. In the first place there is a very marked difference in size; the length is nearly the same (0·09 mm.); the breadth, however, measures only 0·013 mm. and the nuclei are not, as in the first specimen which I investigated, placed close to the internal surface of the glandular cells, but beyond the middle: they are nearer to the external than to the internal surface. The structure of the nuclei is the same; they are more elongate and slightly pointed towards the outer extremity.

In a series of sections through the cephalic part of the body of *Scalpellum nymphocola*, these glands which I propose to call "pancreatic glands" are also represented. In this species the form of the gland is the same as in *Scalpellum parallelogramma*, the transverse sections are circular or nearly so. The nuclei of the cells of the gland are all situated at the periphery close to the membrana propria which envelops the body of the gland.

The structure of the gland in *Lepas* will now be easily understood. Let the wall of the gland in *Scalpellum* develop excrescences, so that the interior of each excrescence communicates with the interior of the original or main part of the gland, and the tubular gland will have changed into an acinous one. The excrescences have as a rule the shape of globules, but they may also be elongated so as to form finger-shaped appendages. When the gland is divided by transverse and parallel sections in a series of preparations the shape and size of the cells are by no means so uniform as in the case of *Scalpellum*. This, of course, is partly in consequence of the sections not always cutting the cells in the same direction, though parallel. In some of the sections the cells are cylindrical, having a length of 0·1 mm. and a breadth of 0·026 mm. If these same cells had been cut transversely to their longest axis, their length would have appeared much shorter. The size of the oval nuclei is 0·016 mm. In the more tubular parts of the gland the cells are not so high and their walls not so parallel; in the sections, therefore, they are almost triangular or flattened quadrangularly; between them I observed here and there larger cells with very capacious nuclei. I measured one of the cells, the length of which was 0·13, whereas its breadth was 0·9 mm. It was furnished with a nucleus 0·05 mm. in diameter. The only difference which I could make out between the different cells of each gland was, however, in size; in regard to their staining with aluminium carminate, I must point out a very striking correspondence of these cells to those of the cement-apparatus of the peduncle, viz., the body of the cells is always beautifully lilac-coloured, the nuclei appearing dark violet. The latter are remarkable, in the same way also as those of the cement-glands, since coarse granules and even fibres fill their interior. A distinct membrana propria surrounds the body of the gland in *Lepas* as well as in *Scalpellum*.

The gland communicates with the interior of the stomach by means of a narrow duct which opens close to the cardia in an interspace between two of the so-called hepatic excrescences.

As to the function of these glands a few words may suffice. That they are not true salivary glands needs no further proof. At the same time it can hardly be doubted that their function is that of a digestive organ which pours its secretion into the alimentary canal. Whereas the recent interesting researches of Max Weber[1] have cast light upon the structure and function of the digestive glands (Verdauungsdrüsen) of the higher Crustacea (*Isopoda*, *Amphipoda*, *Decapoda*), we are still almost entirely ignorant of their occurrence, functions, structure, &c., in the different orders of Entomostraca. The supposition of Claus, that the name of liver in invertebrate animals has often been used

[1] Max Weber, Ueber den Bau u. die Thätigkeit der sog. Leber der Crustaceen, *Arch. f. Mikr. Anat.*, Bd. xvii. 1879.

where in reality a pancreatic or a chyle-producing gland should be spoken of, has proved to be very important. Weber, however, tries to demonstrate that in the Crustaceans which he studied the digestive glands are built up of two kinds of glandular cells, and therefore are at the same time liver and pancreas, both modified so as to be accommodated to the organisation of the Crustacean body. Now no doubt is left that the glands of the Cirripedia are built up of *one* kind of cells only, and I think we can safely admit that these belong rather to the pancreatic than to the hepatic type. Whether the excrescences of the wall of the stomach (which are very strongly developed in *Lepas* and which are coated in the interior by a cylindrical epithelium with very small cells,[1] the nuclei of which are almost entirely hidden by a dark-brownish pigment) represent a kind of liver, I cannot undertake to say. It is indeed a curious fact—one, however, observed by Darwin thirty years ago—that these excrescences are large and well developed in some genera (*Lepas, Conchoderma*), and almost totally wanting in others (*Scalpellum*).

[1] The height of these cells is 0·03 mm., their breadth only 0·006 mm.

V. THE EYE OF LEPAS.

I believe Leidy was the first who observed in an adult Cirriped an organ of vision.[1] In *Balanus* there are, according to him (and Darwin has confirmed the correctness of his observation), two small eyes which stand apart from each other laterally and, owing to this discovery of the American naturalist, Darwin[2] was led to look for them in Lepadidæ. In *Lepas fascicularis* he found an elongated almost black eye composed of two eyes united together. The eye is innervated by two nerve-cords which extend from the front of the two supraœsophageal ganglia, and which before reaching the eye run into two small, perfectly distinct, oval ganglia. From the opposite ends of these two ganglia smaller nerves run, and, bending in at right angles, enter the elongated eye beyond the middle.

I do not think that any description of this organ has been published since Darwin's. I made preparations of it in *Lepas anatifera* and in *Lepas fascicularis*. The place it occupies in the first species may be seen on Plate VI. figs. 7 and 8. On removing the ligament between the two scuta as well as the muscles which are here placed between this ligament and the widened stomach, the surface of the latter with its black (hepatic ?) excrescences and the white pancreatic glands appear. At a distance of about 6 mm. from the supraœsophageal ganglion in an adult *Lepas anatifera*, a small oval black spot is seen attached by means of connective tissue to the surface of the stomach. This is the eye. Morphologically it represents the small pigment spot which, in the Cypris-larva (Pl. II. fig. 2, *e*), is attached to the upper surface of the supraœsophageal ganglion, and which is the remainder of the simple eye of the Nauplius-larva. In an adult *Lepas anatifera* it measures 0·25 mm. only in length, its breadth being not quite 0·15 mm. I believe its function to be of no consequence, in *Lepas* at least, for I do not understand how a ray of light can ever reach it, but the little organ beautifully illustrates the persistence of an old larval structure.

Most curious, however, is the fact that this rudimentary organ is indeed furnished with a kind of special ganglia (Pl. VI. fig. 9). Between the two broad (antennal) peduncular nerves, four thinner ones separate from the supraœsophageal ganglion. Their thickness is not quite the same ; the two outer ones are slightly stronger than the other two which lie very close to one another, almost exactly midway between the two other nerves. These four nerves can be traced up to a very short distance (about 0·6 mm.) from the small eye. Here the two stronger nerves of the four bend slightly outwards so as to approach a little more nearly to the peduncular nerves and show a distinct swelling, in the interior of which two elongate ganglionic cells are to be observed. I

[1] Leidy, *Proc. Acad. Nat. Sci. Philad.*, No. 1, vol. iv., January 1848.
[2] Darwin, Lepadidæ, 1851, p. 49.

think they can safely be described as bipolar, for their body can be followed up as a very pale process in the direction of the supraœsophageal ganglion as well as in the direction of the eye. In both directions these processes are placed, like the ganglionic cell itself, quite in the interior of the nerve. Close to the eye the nerve shows a second swelling which contains also a distinct ganglionic cell, and it is by this swelling that the nerve is laterally attached to the eye. Each of the two other slightly thinner nerves, which run between the two stronger ones, has also a swelling at about the same distance from the eye. The two nerves unite together where this swelling is thickest and where each contains a ganglionic cell; they then part again and separately run towards the eye, which they reach at its frontal extremity, *i.e.*, that extremity which is directed towards the supraœsophageal ganglion. I have not been able to study the way in which the nerves enter or are attached to the pigment spot. Round about the spot a network of fibres of greater or less capacity can easily be made out; yet it is extremely difficult, not to say impossible, to ascertain with certainty the nature of these fibres. Some of them are no doubt nerve-fibres, while others belong doubtless to the connective tissue.

The way in which the ganglionic cells are placed in the interior of the nerves slightly resembles what Leydig observed in the case of the sympathetic nerve-fibres of insects. He observed[1] (in *Bombus terrestris*) in single fibres of the so-called sympathetic nerves, a nucleus here and there with a granular mass surrounding it, forming a kind of bipolar ganglionic cell "in der Anlage."

Neither in *Lepas anatifera* nor in *Lepas fascicularis* could I distinguish the two little lenses which Darwin says he has observed. Nor do I think that this is owing to any fault in my observation. Darwin may have observed living, or at least fresh, animals, and the lenses may have disappeared under the influence of the alcohol. But I think it is more probable that Darwin, who used only a feeble magnifying power, has mistaken the ganglionic cells for lenses. What he calls the two small perfectly distinct oval ganglia, are probably the swellings of the optic nerves which in *Lepas anatifera* contain two distinct ganglionic cells.

As regards the sessile Cirripedia, and especially different species of *Balanus*, the experiments of different naturalists have shown that they are sensible to a difference between light and shadow. I do not know whether similar experiments have ever been made on pedunculated Cirripedia. Should they give the same result, and I think they very probably would, even then I should hesitate to consider the rudimentary simple eye placed on the external surface of the stomach as the organ of this function.

[1] Leydig, F., Bau des thierischen Körpers, Tübingen, 1864, p. 205.

VI. THE FEMALE GENITAL APPARATUS.

According to Darwin, the female genital apparatus consists of the true ovaria, or glandular bodies seated on each side, not far from the basal edge of the labrum; the main or unbranched ovarian ducts; and the ovarian branching tubes and cœca. The latter in the pedunculated Cirripedia are placed high up in the peduncle, and in all sessile Cirripedia lie between the calcareous or membranous basis and the inner basal lining of the sack. After the most careful and repeated examination of various Lepadidæ and Balanidæ, Darwin became convinced that there were no oviducts; he therefore supposed that the ova were brought to the surface by the formation of a new membrane round the sack underneath them, and by the subsequent exuviation of the old membrane. This supposition of Darwin's has proved to be erróneous. What Darwin called the main or unbranched ovarian duct is in reality the oviduct; it does not run up to the glandular bodies (which I have described in one of the foregoing chapters), but it passes at some distance beneath them (Pl. VI. figs. 7 and 8); it describes a curve and then enters the basal segment of the first cirrus, at the foot of which it opens.[1] Krohn was the first to describe the female genital apparatus accurately; Kossmann, though in the main agreeing with Krohn, differs from him with regard to the significance of the little shoe-shaped sack which is placed in a swelling of the oviduct near its opening. I studied the female genital apparatus in *Lepas*, *Scalpellum vulgare* and *Scalpellum regium*, in *Conchoderma virgatum* and in *Balanus*. In all essential points the results of my researches tend to confirm those of my predecessors; in detail I think I am able to add to our knowledge.

From the existence of two oviducts we may conclude that there are also two ovaries present. In the full-grown animals their numerous and strongly ramified cœca are united so intimately that they seem to form a single mass only. The cœca of the right side, however, communicate with the right oviduct, the others with that on the left.

A study of the way in which the ova are formed has given the following results. The oviduct itself is lined by a very distinct and well-developed epithelium; where the limits of the cells are not distinct, which may be due to the condition of the material at command, the nuclei are placed so regularly along the wall that even the dimensions of the epithelial cells can still be made out. Where the oviduct passes over into a cœcum of the ovary, the epithelium of the wall is no longer so distinct, and in its place nuclei are seen rather irregularly along the wall; of the true body of the cell there are only traces here and there. The ovigerms or future ovarian eggs are seen in the interior along this wall. When the ovary is mature or nearly so, we observe in the first place the large ovarian eggs, each having a nucleus with a sparkling nucleolus (Pl. VI. fig. 2) about

[1] Zool. Chall. Exp., part xxv. p. 12, pl. i. fig. 2.

the centre of the egg, and in the second place, rounded groups of very small ovigerms, forming together what the Germans call the "Keimlager." One or two of these ovigerms are often slightly larger than the rest, and these will be the first to develop into ovarian eggs after those which are already mature are evacuated.

In a ripe or nearly ripe ovarian egg of *Scalpellum vulgare* which had a diameter of 0·3 mm., a nucleus of 0·036 mm was present, having a nucleolus of 0·009 mm. The nuclei of the cells placed along the wall of the ovary are oval and measure about 0·01 by 0·005 mm.; the small ovigerms are nearly circular and have a diameter of about 0·013 mm. Their nuclei, of course, are a great deal smaller than those of the ripe ovarian eggs. One of the ovigerms was considerably larger; it was rounded oval, its diameters being 0·03 and 0·023 mm.; its nucleus was about 0·012 mm. A ripe ovarian egg of *Scalpellum vulgare* is filled with a coarsely granulated vitelline mass (Pl. VI. figs. 1*A*, 2*x*). Between the larger granules, which in the microscopical preparations appear like vesicles, a much more delicately granulated mass of plasma is here and there visible; sometimes a layer of this is placed in the centre round the nucleus. The wall of the ovarian egg seems to be a very thin and structureless membrane, and neither in the case of *Scalpellum*, nor of any of the other genera observed, was a follicular epithelium present. The mature ovarian eggs of *Scalpellum regium* are about 0·6 mm. in diameter. They are very coarsely granulated; they do not quite fill the interior of the ovarian cœca, but between them, and also between each egg and the wall of the cœcum, a layer of a much more delicately granulated mass of plasma is visible (Pl. VI. fig. 3). Here the ovigerms form groups of little cells, the dimensions of which nearly correspond to those of *Scalpellum vulgare*. In one of these groups I counted about 20 of these ovigerms. Here again one of these ovigerms was developed into a young ovarian egg. The wall of the cœca shows the same cellular elements as in *Scalpellum vulgare*; its outer surface is formed by a distinct membrana propria, which may be composed of stronger fibres of connective tissue, but which often looked as if composed of circular muscular fibres. The wall of the oviducts, however, did not show the same stronger outer wall; it is composed of a distinct epithelium and a very narrow or thin membrana propria.

Whereas in *Scalpellum vulgare* each oviduct gives off a cœcum only once, and this cœcum, which starts from the oviduct at the superior extremity of the peduncle, divides again and again, the oviduct in *Scalpellum regium* penetrates into the interior of the peduncle for about one-third of its whole length. In different places each oviduct in this species gives off cœca, and these form together so voluminous a mass that the peduncle is filled with it up to its inferior extremity.

The oviduct of *Scalpellum vulgare* appears in a transverse section as an exceedingly narrow slit, and 0·2 mm. in length. The oviduct of *Scalpellum regium* (Pl. V. figs. 8 and 9), in a transverse section shows an irregularly folded wall; its largest diameter is about 0·55 mm., its smallest 0·15 mm. I calculated that for *Scalpellum regium* the surface of the lumen of the oviduct was about 0·09 square millimetres, whereas a section of one of the nearly ripe ovarian eggs was not less than 0·28 square millimetres. Therefore, it is either necessary that the walls of the oviducts be very elastic, or that the eggs pass through the oviduct when it is much distended. Perhaps both circumstances favour the passage of the ova.

The number of eggs laid by *Lepas* is immensely larger than by *Scalpellum.* In some of the species of the latter genus it is not even a hundred; in *Lepas anatifera* it amounts, on the contrary, to many thousands and tens of thousands. In accordance therewith, the eggs of *Lepas* are very small; I measured eggs from an egg mass of this species, and their length was only 0·24 mm. The cœca which form the ovary are very narrow and elongate, and contain rows of numerous and relatively small eggs. The ovarian egg when ripe is not so elongate as after its fecundation; I measured eggs in the oviduct, the length of which was only 0·14, their breadth being 0·1 mm. The nuclei of the eggs in the ovary are again nearly circular, and have a diameter of about 0·02 mm.; they may be seen as a rule in the centre of each ovarian egg, and contain a single very distinct nucleolus. In the cœca of younger specimens of this genus, the groups of ovigerms can be very distinctly made out. The number of ovigerms composing such a group in this genus, however, is much larger than in the genus *Scalpellum;* their dimensions do not show any considerable difference.

In *Conchoderma virgatum* the form of the cœca corresponds to that in *Lepas.* The eggs are numerous and small. I do not think it of much use to give any details as to their dimensions.

When comparing young ovarian cœca, such as are observed in the peduncles of younger specimens, with those which are gorged with numerous and larger eggs, one feels convinced that a considerable increase in bulk has taken place. This can only have been brought about by a regular and abundant supply of food. Yet it is not so very easy to understand in what way the nourishment of the peduncle is brought about. The only way is, of course, that the blood—or the fluid which in Cirripedia acts as blood—passes through the narrow band which in the pedunculated Cirripedia runs from the capitulum to the peduncle, at the rostral side near the place where the two scuta meet with their occludent margins. The two strong peduncular (antennal) nerves and the oviducts pass through this narrow commissure; but so does also a rather wide cylindrical tube which has no distinct wall of its own, and therefore is lined only by connective tissue, and which here represents the body-cavity. In those cases in which I found the ovarian eggs ripe or nearly ripe, I always found this canal totally filled up by a delicately granulated mass, which much resembled blood plasma. I therefore think it highly probable that by means of this elongate canal a regular nourishment of the peduncle and the organs placed in it is carried on. In *Scalpellum parallelogramma* I have been successful in tracing this canal, or cylindrical cavity, to within the body of the animal. When a transverse section of the body is made near the mouth, the alimentary canal in the middle of its dorsal surface is found attached to the wall of the body by means of a rather strong band of connective tissue. Towards the hinder extremity of the body this band grows broader still, and then it appears to be perforated by a central cavity. Towards the anterior end of the body the band grows narrower, yet it may be followed up in all transverse parallel sections, as long as these contain a section of the stomach. Those sections which pass through that part of the body contained between the stomach and that stripe of the mantle which unites the two scuta, only show the band of connective tissue as a loose band attached only on one side, viz., on the dorsal internal surface of the body-wall. The two large cavities which were separated from one another by means of this band are now united. An excrescence of this cavity penetrates this part of the body in a direction vertical to the original dorsal surface, and this part of the body-cavity has one of the two sections of the oviducts on each side. It advances considerably towards the original ventral surface of the body, and now meets the two sections of the oviducts on the dorsal aspect; after having described a curve it runs longitudinally close to the rostral surface of the narrow part between the two scuta. The two oviducts are now on that side of the cavity which is directed towards the interior of the mantle-cavity, and in the same place they remain visible in the superior part of the peduncle.

The course of the oviducts through the true body of the Cirripedia can be followed up by making a dissection of it by the aid of needles. To make out its position with regard to the place occupied by the other organs a series of sections serves the purpose still better. In *Scalpellum* transverse sections through the cephalic part of the body show the oviducts on both sides about midway between the intestinal tract and the wall of the body (Pl. VI. fig. 4). It is surrounded on all sides by the connective tissue, and, as a rule, one of the larger cavities of the connective tissue is separated from the duct only by a very narrow strip of the tissue. In *Scalpellum*, as well as in *Lepas* and *Balanus* (the three genera in which the course of the oviducts has been investigated), the oviducts pass beyond the first pair of cirri. They then run upwards, *i.e.*, towards the ventral surface of the body, and bending outwards, *i.e.*, towards the lateral surface of the body, and forwards, they enter what Darwin considers the basal articulation of the first cirrus. In some of the genera (*e.g.*, *Lepas*, *Alepas*) this swelling belongs doubtless to the first cirrus; from analogy we may safely conclude that it belongs also to that pair of extremities in those cases in which (as in *Scalpellum*) no distinct relation to it can be made out. The oviduct enters this articulation at a considerable distance upwards from its base; it now describes a curve for the last time, and leads into the curious sack which Darwin considered an acoustic organ, and which opens by means of a transverse slit-like orifice at the proximal part of the basal articulation.

The structure of the wall of the oviduct may be briefly described as epithelial;

the limits of the cells are never very distinct, and their height is inconsiderable; the contents of the cell are a nucleus about 0·005 mm. in diameter and quite clear protoplasm. A very thin membrana propria covers the outer surface of the oviduct.

The way in which the oviduct corresponds with the sack in the basal articulation of the first cirrus in *Scalpellum* is different from *Lepas*. In *Scalpellum vulgare* (Pl. VI. fig. 10), and *Scalpellum parallelogramma*, the oviduct, once arrived in the basal articulation, expands so as to form a kind of funnel, which with its wide opening embraces a large portion of the curious sack which opens at the base of the swelling. The wall of this funnel closely resembles that of the oviduct. In some of my preparations the funnel is placed exactly opposite to the genital opening, in others it is attached to the sack in a more oblique direction. The curious sack, in *Scalpellum*, communicates with the genital opening by means of a long duct, the length of which equals and sometimes even surpasses that of the sack itself. At the other extremity the sack is open also and its wall round about the opening turned outward, the opening of the funnel closing exactly on the margin of the part which is turned out. In one of my series of preparations of *Scalpellum vulgare* the funnel-shaped widening of the oviduct is in close relation with a bag of connective tissue surrounding the whole sack, so that it may be traced up to where the sack goes over into the duct; at first it was my opinion that the eggs passing through the oviduct and the funnel arrived in this bag and then passed into the duct by a lateral opening situated beneath the sack, without entering the curious sack at all; but I failed to make out the existence of this opening, and since I afterwards observed the direct transition of the oviduct into the curious sack in the genus *Lepas* (Pl. VI. fig. 11), I have given up this supposition, which I must confess was rather hazardous.

The structure of the cells which compose the wall of the curious sack is that of a high cylindrical epithelium. In *Scalpellum vulgare* their dimensions are 0·02 by 0·006 mm.; each cell has a very distinct oval nucleus which, in the full-grown specimens, measures 0·006 by 0·005 mm., and which is seated very close to the free extremity of the cell. The outer surface of the sack is lined by a membrana propria with very flat nuclei. The shape of the sack in *Scalpellum* is that of a pear, the part which communicates with the duct being as a rule narrower than the other extremity. In *Scalpellum vulgare* the duct shows a small swelling near the place where it communicates with the sack, and the length of the duct is exactly equal to that of the curious sack. The wall of the duct has the same structure as the outer wall of the body, as an inflected part of which it must be necessarily considered. The limits of the cells which compose it are not distinct, its nuclei are relatively oval and large, their longest diameter being 0·009 mm. The surface of the duct is covered by a thin chitinous cuticle.

In none of the species of the genus *Scalpellum* in which I investigated this curious sack did I find it empty (*Scalpellum vulgare*, *Scalpellum parallelogramma*, *Scalpellum nymphocola*, *Scalpellum regium*, and *Scalpellum balanoides* have been investigated by means of sections). I always observed in its interior the "flattened sack of singular shape" which Darwin called "the acoustic sack." As long as I knew this sack only from preparations of *Lepas anatifera*, young specimens of which I cut into series of sections some years ago, I really considered it with Darwin and Krohn[1] as a sack. Guided by this opinion, I wrote the passage[2] in which I gave it as my opinion that the interpretation of Krohn was more in accordance with the facts than Kossmann's; for Kossmann called the sack a "Klumpen," *i.e.*, an irregularly-shaped mass, which is sometimes quite solid, sometimes is only furnished with very irregular cavities. A glance at Pl. VI. fig. 10 will easily convince the reader that Kossmann's suggestion is now indeed mine also; the curious body looks like a compact mass, being composed of smooth layers which have probably been more or less parallel to the wall of the sack, and a granular substance binding these layers together. All the cells bordering the sack, as also those forming the part which is turned outward, participate in the act of secreting the fluid, which hardens to compose the compact body. Hence it is suspended as by two short arms in the opening which leads from the funnel of the oviduct into the curious sack. The compact body must be evacuated before the eggs can pass through the curious sack and the narrow duct, and I think that this is done by the retraction of the margin of the opening which leads from the funnel into the sack. In one of my series of preparations of *Scalpellum vulgare* the opening of the sack is as wide as that of the funnel; the arms of the compact body form a transverse partition between funnel and sack, the remaining part of the compact mass being suspended in the middle of this partition. Regarding the structure of this same apparatus in other genera of Cirripedia I have little to add. In *Lepas anatifera* and *Lepas hillii* the structure of the oviduct is the same as in *Scalpellum*. The funnel at the end of the oviduct where it communicates with the sack seems to be wanting; in a very complete series of preparations of *Lepas hillii* the oviduct can be followed up to where it communicates with the sack. Its structure is very markedly different from that of the sack, so that the place where the one ends and the other begins can easily be seen (Pl. VI. fig. 11). It widens only very inconsiderably to meet the opening of the sack. The wall of the sack is composed of very high and narrow cells (0·05 mm. high and 0·003 mm. wide), having an oval nucleus about half way up. The length of the sack itself in *Lepas hillii* is about 0·8 mm. In *Lepas anatifera* it is a great deal more; in a specimen, the capitulum of which measured 38 mm., the greatest diameter of the sack was 3 mm., the shoe-shaped mass in its interior measuring about 2 mm. I observed the curious sack at the end of the oviduct also in *Balanus corolliformis*, Hoek, and in *Balanus tintinnabulum*, Linné. Its size in the first species is about 0·5 mm.; the way in which the oviduct communicates with the sack in this species is very like that in *Scalpellum*,—the oviduct is considerably swollen at the extremity which meets the sack.

[1] Krohn, *loc. cit.*, p. 361.

[2] Zool. Chall. Exp., part xxv., p. 12.

The sack of *Balanus tintinnabulum* was studied in transverse sections; its diameter was about 0·9 mm. I have been unable to investigate the way in which the oviduct communicates with it.

If Kossmann's explanation as to the presence of the irregular mass in the interior of the curious sack at the end of the oviduct be right (and I have no sufficient ground to doubt its correctness), the function of the cells which form the wall of the sack is to produce a viscous fluid which envelops the eggs. The thick mass which sometimes, and even very often or *as a rule*, is found in the interior of the sack is formed because the secretion continues incessantly, even when no eggs pass through the oviduct. The quantity of this viscous fluid which is secreted by these cells must indeed be rather large; for when a *Lepas* is furnished with ovigerous lamellæ and the interior of its sacks studied, large masses of the secreted substance are present. This must necessarily have been formed after the eggs passed through it, and cannot have been produced very long ago, for in the Cirripedia the evolution of the eggs in general does not take long. The very regular shape of the mass in some genera, as *e.g.*, in *Lepas*, where it is shoe-shaped and has a very smooth surface, must be ascribed to its being modelled, at least in part, after the internal surface of the sack; it remains, however, in my eyes a curious fact which, perhaps, has an analogy in the presence of a chitinous bag within the stomach in this same group of Cirripedia. I observed it in the stomach of all the Cirripedia of which I prepared transverse sections; according to Darwin it is a model of the stomach, filled with excrement and expelled by the rectum entirely in a single piece, as he observed in some living specimens of *Balanus balanoides*.

To understand the physiological meaning of the apparatus at the end of the oviducts, a second difficulty arises from the circumstance that we do not know the place where, and the way in which, the eggs are fecundated. If Kossmann's supposition be correct, the eggs are evacuated after being united together by means of the fluid secreted by the cells of the curious sack. These eggs, however, are ovarian, not yet fecundated eggs! I think it is difficult to understand how they are fecundated after they are united together by a fluid viscous glue. Of course, the only way of investigating successfully physiological questions of this kind is to study fresh and living material. But this study can only give trustworthy results when the anatomical structure is sufficiently well known. I think I have contributed to a more accurate knowledge of the anatomical structure.

I will not take leave of this subject without pointing out the great probability that the apparatus at the end of the oviduct morphologically represents a second segmental organ. Krohn[1] has already shown that, of all Crustaceans, the female genital openings are placed nearest to the cephalic part of the body in the Cirripedia; and even at present, though our knowledge of Crustaceans has been considerably increased since the year 1859, it is still true that they are the only Crustaceans which show this

[1] *Loc. cit.*, p. 360, note at the foot of the page.

peculiarity in their structure. The curious animal which Prof. Lacaze-Duthiers has described as *Laura gerardiæ*, and which according to him belongs to a distinct group of abnormal Cirripedia, has the female genital openings also in the basal segment of the first pair of legs. The peculiar position of these openings in this group would, however, not be so strange, if it could be shown that the female genital apparatus in the case of Cirripedia made use of a segmental organ. Now, I think everybody, who will study preparations of the curious sack and the oviduct in relation to it, will be struck by the totally different structure (1) of the oviduct, (2) of the sack itself, and (3) of the canal or duct, short in *Lepas* and long in *Scalpellum*, at the end of which the genital opening is placed. To call the sack a widened part of the oviduct is not in accordance with the condition of these parts at the place where they are in communication with each other. Even in *Lepas*, where the communication is much more gradual than in *Scalpellum*, the place where the oviduct terminates and the sack commences is very distinct. Since the duct by the aid of which the sack opens is a true epiblastic product, and is lined by a thin chitinous cuticle, the sack, which is placed between it and the oviduct, probably represents the funnel of the original segmental organ. Of course, this suggestion is based on the occurrence of the other pair of segmental organs opening at the base of the second pair of maxillæ, as previously described (p. 23). The first pair of segmental organs furnishes a direct communication of the body-cavity with the surrounding medium, the second serves for the evacuation of the female genital products. The cells of the funnel of the first pair, probably, have an excretory function; those of the second pair have a more special function,—that of producing a viscous fluid for uniting the eggs into egg masses.

I hope I shall soon be able to continue these investigations, and if possible to enlarge them with the aid of fresh material.

PLATE I.

PLATE I.

An. stands for antennæ.
c.gl. ,, cement-glands.
f. ,, muscular fibres.
gs. ,, supraœsophageal ganglion.
gt. ,, thoracic ganglion.
gl. ,, gland of unknown nature.
l. ,, thoracic appendages.
m. ,, mouth.
mr. stands for retractor muscle of the thorax.
o. ,, orifice of the sack.
œ. ,, œsophagus.
r. ,, œsophageal ring.
st. ,, stomach.
t. ,, testis.
vd. ,, vas deferens.
vs. ,, vesicula seminalis.

Fig. 1. Male of *Scalpellum regium* (Wyv. Thoms.), Hoek; magnified 94 diameters.

Fig. 2. Nervous and alimentary systems of this male; magnified 275 diameters.

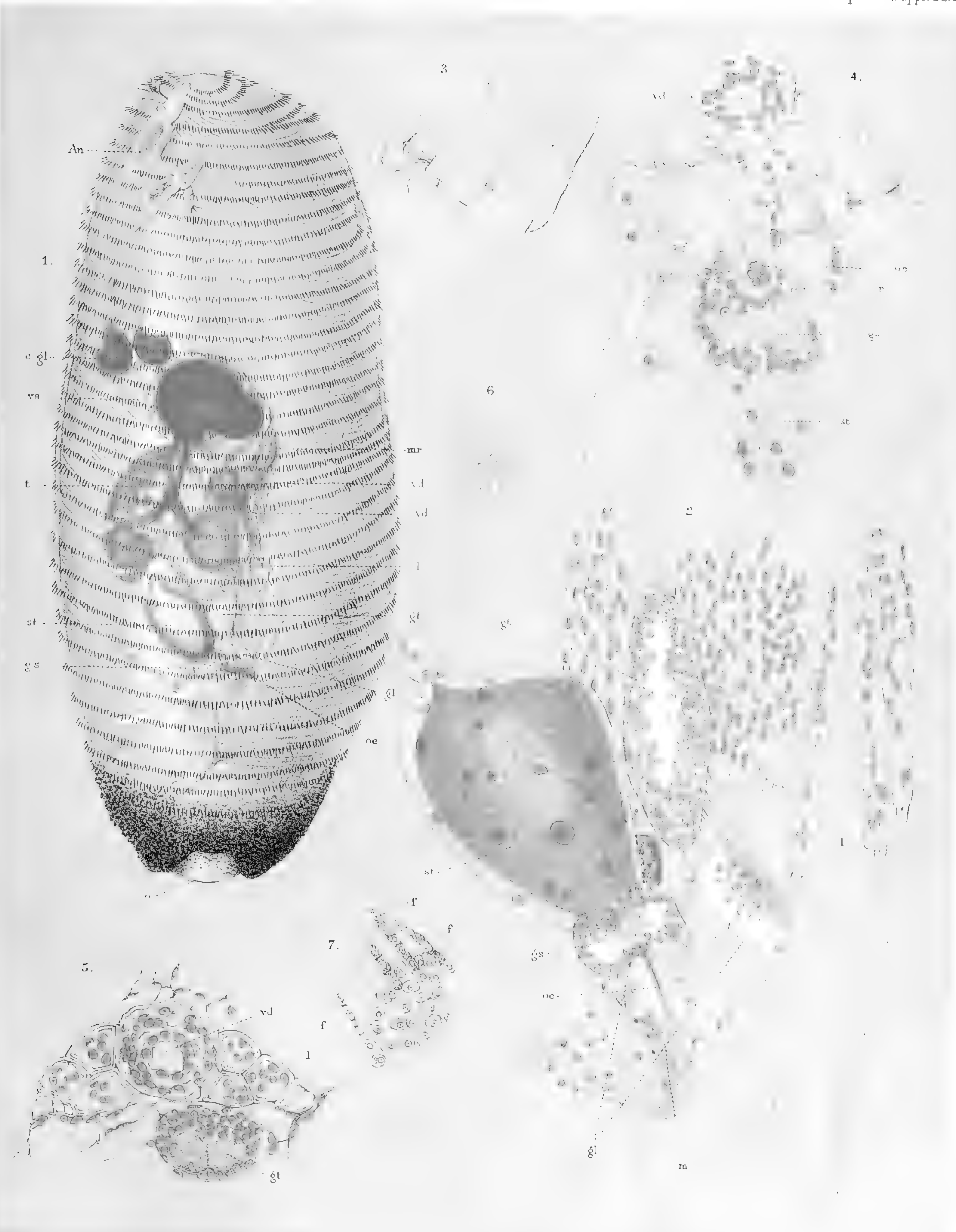
Fig. 3. Antenna of the male; magnified 275 diameters.

Fig. 4. Transverse section of the supraœsophageal ganglion where it is in relation with the œsophageal ring; magnified 275 diameters.

Fig. 5. Transverse section of the thoracic ganglion and the thorax with its appendages; magnified 275 diameters.

Fig. 6. Spermatozoa and spermatozoid mother-cells; magnified 575 diameters.

Fig. 7. Epithelium of the sack and muscular fibres in a young stage of development; magnified 275 diameters.



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MALE OF SCALPELLUM REGIUM.

PLATE II.

PLATE II.

AM. stands for adductor muscle.
An. ,, antennæ.
C. ,, cœca attached to œsophagus.
C I.–C VI. thoracic appendages.
C.A. ,, caudal appendage.
C.gl. ,, cement-glands.
E. ,, the large compound eye.
e. ,, the simple eye.
G I.–G VI. thoracic ganglia.
GS. ,, supraœsophageal ganglion.
GT. ,, thoracic ganglion.
Int. stands for intestine.
Inv. ,, invagination dividing the body into a capitulum and peduncle.
M. ,, mouth.
Ma. ,, mantle.
Od. ,, ovarium with oviduct.
Œ. ,, œsophagus.
Op. ,, orifice of the mantle.
Sh. ,, shell.
S or *St.* stomach.

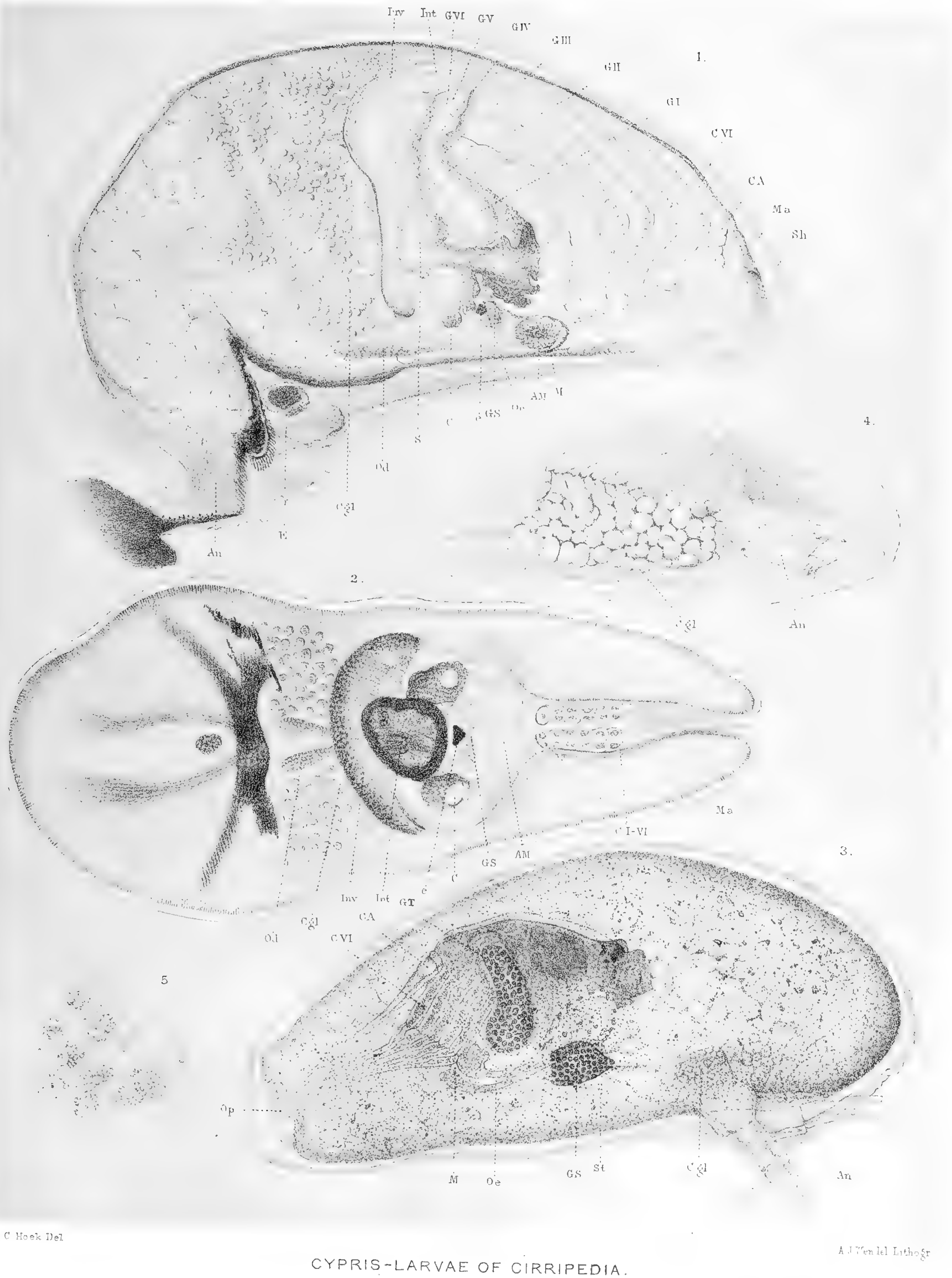
Fig. 1. Cypris-larva of *Lepas australis*, Darwin, sagittal section ; magnified 70 diameters.

Fig. 2. Same larva in a slightly older stage, longitudinal section ; magnified 70 diameters.

Fig. 3. Cypris-larva of *Scalpellum regium* (Wyv. Thoms.), Hoek, which is destined to develop into a male ; magnified 94 diameters.

Fig. 4. Cypris-larva of *Scalpellum triangulare*, Hoek, which is also destined to become a male ; magnified 94 diameters.

Fig. 5. Group of cement-cells with their ducts and pale yolk-elements of the Cypris-larva of *Lepas australis*, Darwin ; magnified 275 diameters.



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CYPRIS-LARVAE OF CIRRIPEDIA.

PLATE III.

PLATE III.

ca.	stands for	cavity in which thorax is lodged.
gs.	,,	supracesophageal ganglion.
gt.	,,	thoracic ganglion.
in.	,,	intestine
l.	,,	thoracic appendages.
m.	,,	longitudinal muscles of body-wall.
mr.	,,	retractor muscle of the thorax.
o.	stands for	orifice of thoracic cavity.
st.	,,	stomach.
t.	,,	testis.
th.	,,	thorax.
vd.	,,	vas deferens.
vs.	,,	vesicula seminalis.

Eleven sections out of a series of about eighty through the body of the male of *Scalpellum regium* (Wyv. Thoms.), Hoek.

Fig. 1. First section. Transverse section near the capitular pole.

Fig. 2. Second section. The outer wall is covered by particles of mud; where it is taken away, the nuclei of the chitinogenous epithelium are distinctly visible.

Fig. 3. Third section. To the left the orifice is visible surrounded by a dense mass of cells of the chitinogenous epithelium; to the right the connective tissue is visible with its small nuclei and with the longitudinal muscles of the body-wall.

Fig. 4. One of the following sections, passing transversely through the cavity in which the thorax of the little body is lodged, and which opens outwards by means of the orifice in figs. 1 and 2.

Fig. 5. One of the following sections about the place where the vas deferens opens into the cavity of the foregoing figure.

Fig. 6. Section passing through one of the lobes into which the testis is divided at its capitular extremity, through the stomach, the supraœsophageal ganglion, the thoracic ganglion, the thorax with its central canal, the vas deferens, and the legs.

Fig. 7. In this section both lobes of the testis are represented.

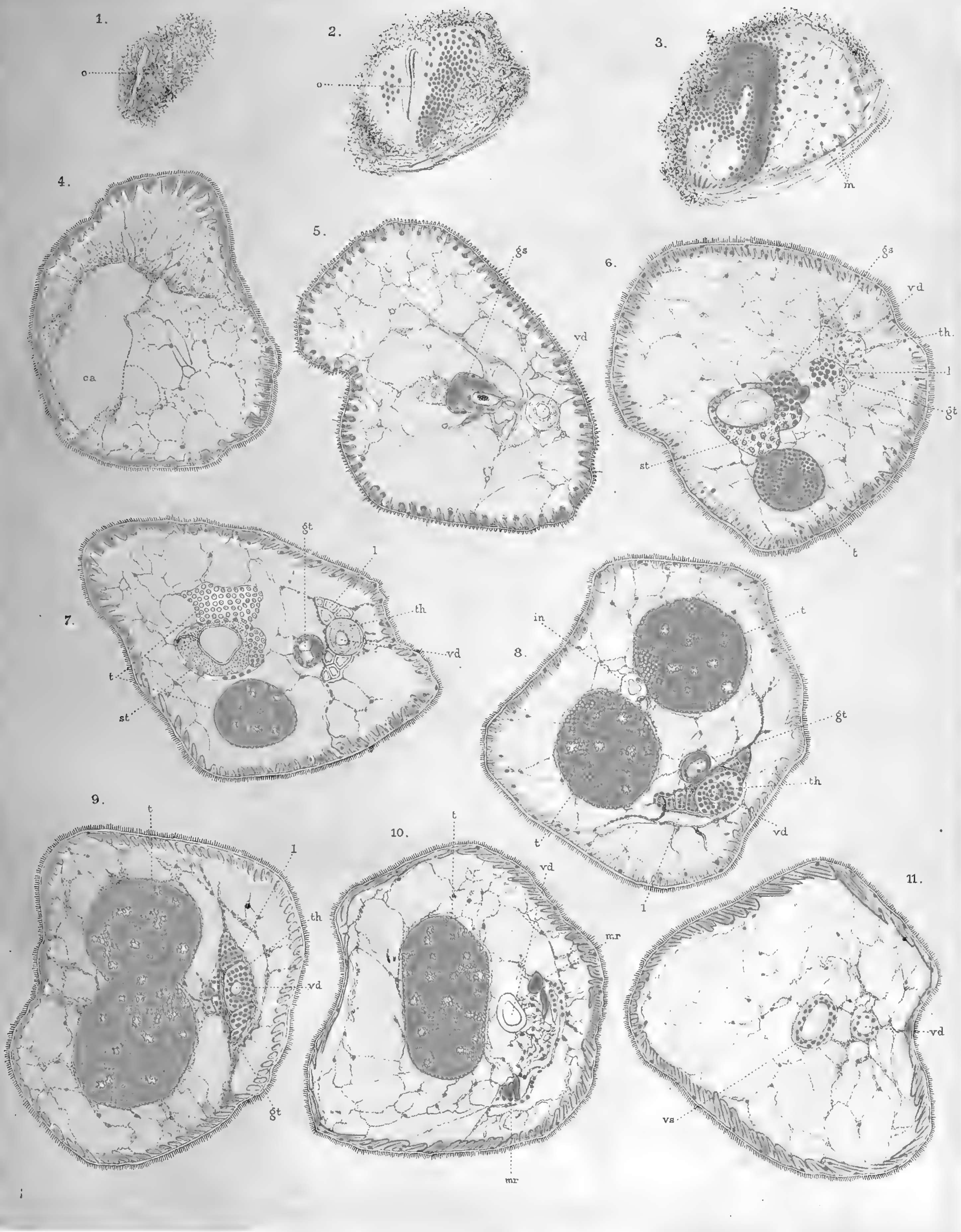
Fig. 8. Between the two sections of the testis the narrow blind sack of the stomach which represents the intestine is visible.

Fig. 9. The two lobes of the testis have united; the thoracic ganglion is only indistinctly represented.

Fig. 10. Section passing through the upper extremity of the thorax.

Fig. 11. Section passing through the vesicula seminalis and vas deferens before the latter enters into the thoracic part of the body.

All the figures magnified 94 diameters.



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MALE OF SCALPELLUM REGIUM.

PLATE IV.

PLATE IV.

an. stands for anus.
c. ,, chitinous wall of the peduncle.
ca. ,, caudal appendages.
cf. ,, connective tissue fibres.
ct. ,, connective tissue nuclei.
cg. ,, cement-glands.
g–g′–g″ ,, first and second thoracic ganglion.
g.a. ,, female genital aperture.
gl. ,, glands of unknown function.
gt. ,, thoracic ganglion.
i. ,, intestine.
mf. stands for muscular fibres.
n. ,, nuclei of the chitinogenous epithelium.
p. ,, penis.
s. or *st.* ,, stomach.
t. ,, testis.
th. ,, thorax.
vd. ,, vas deferens.
vs. ,, vesicula seminalis.
x. ,, widened portions of the oviducts near the genital aperture.
I.–VI. ,, first to sixth cirrus.

Figs. 1–7. Anatomy of the male of *Scalpellum regium* (Wyv. Thoms.), Hoek.

Fig. 1. Transverse section through a male of *Scalpellum regium,* which is in a young stage; stomach filled almost entirely with nutritive yolk.

Fig. 2. Section passing through the vesicula seminalis and a narrow portion of the testis.

Fig. 3. Section passing through a younger male at the level of the cement-glands.

Figs. 1–3 magnified 94 diameters.

Fig. 4. Section through one of the cement-glands; magnified 275 diameters.

Fig. 5. Section of the wall of a male; magnified 575 diameters.

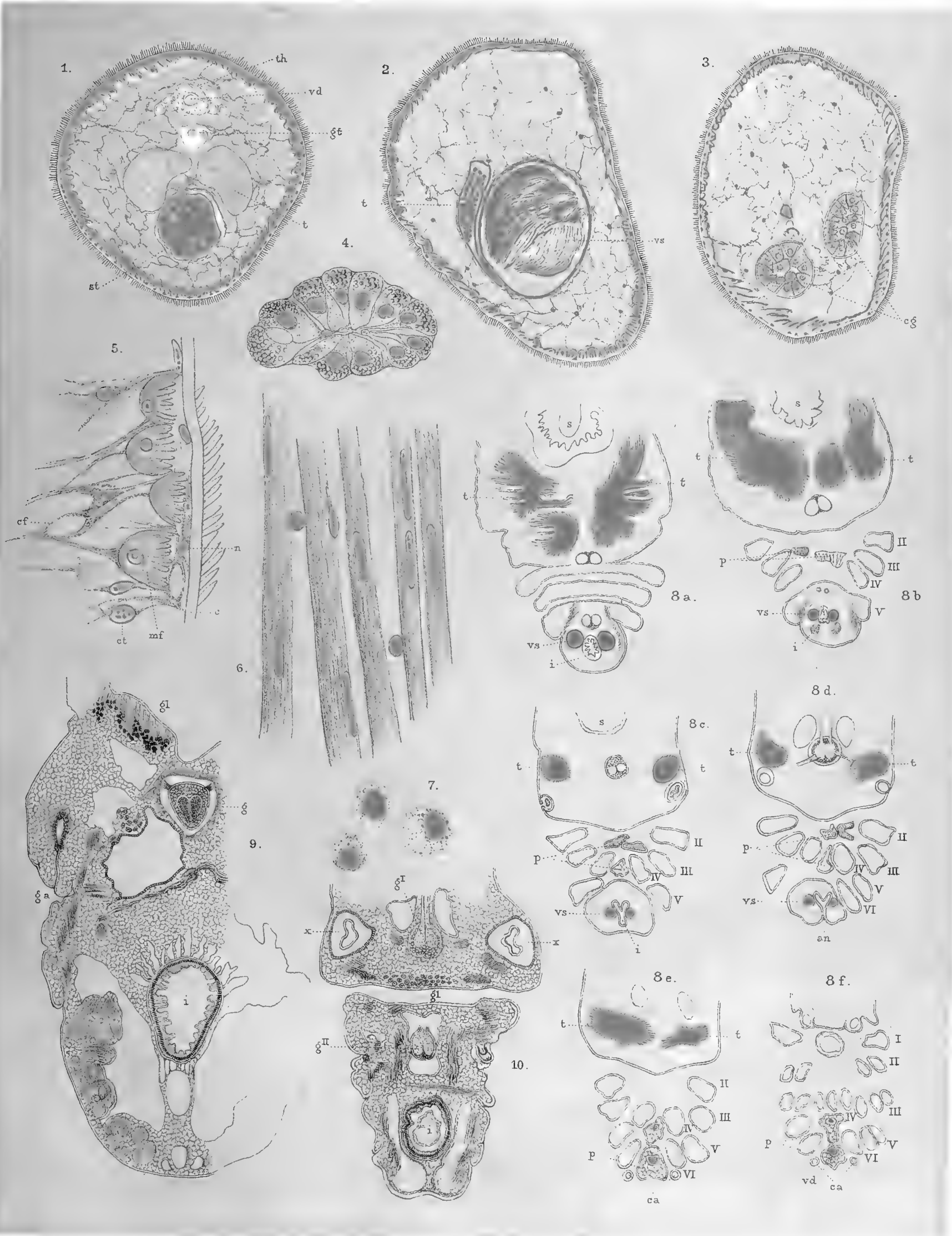
Fig. 6. Muscular fibres; magnified 575 diameters.

Fig. 7. Supposed blood-corpuscles; magnified 575 diameters.

Figs. 8*a*–8*f*. Six out of a series of transverse sections through the body of *Scalpellum calanoides,* Hoek; magnified 41 diameters.

Fig. 9. Part of a section through the body of *Scalpellum parallelogramma,* Hoek, at the base of the first pair of cirri; magnified 26 diameters.

Fig. 10. Part of a section through the body of *Scalpellum nymphocola,* Hoek; magnified 41 diameters.



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1–7 MALE OF SC. REGIUM. 8 SC. BALANOIDES. 9 SC. PARALLELOGRAMMA. 10 SC. NYMPHOCOLA.

PLATE V.

PLATE V.

A.	stands for	body-cavity.
a.	,,	outer layer of (longitudinal) muscles.
B.	,,	band of connective tissue.
b.	,,	second layer of (circular) muscles.
C.	,,	organ of unknown function.
c.	,,	inner layer of (longitudinal) muscles.
C.gl.	,,	cement-glands.
Ch.	,,	chitinous outer wall of peduncle.
D.	,,	main cement-duct.
D′–D‴	,,	branches of the main cement-duct.
d.	,,	initial cement-ducts.
e.	stands for	darkly pigmented epithelium.
in.	,	intestine.
M.	,,	outer maxilla.
m.	,,	muscle masses.
n.	,,	nerve cords.
O.	,,	ovarian cœca.
od. or *Od.*		oviduct.
t.	stands for	testis.
s.	,,	segmental organ.
Sd.	,,	segmental duct.
x.	,,	(elastic) fibres of the connective tissue.

Figs. 1–3. Segmental organ of *Scalpellum vulgare*, Leach.

Fig. 1. Transverse section of the body of *Scalpellum vulgare*, Leach, about the second pair of maxillæ; magnified 27 diameters. The band of connective tissue (B) contains cœca of the testis.

Fig. 2. Section of the segmental funnel; magnified 305 diameters.

Fig. 3. Section of the segmental organ; magnified 106 diameters.

Figs. 4, 5. Anatomy of the peduncle of *Lepas anatifera*, Linn.

Fig. 4. Transverse section near the upper extremity; magnified $8\frac{1}{2}$ diameters.

Fig. 5. Part of a section near the upper extremity; magnified 58 diameters.

Figs. 6, 7. Anatomy of the peduncle of *Scalpellum vulgare*, Leach.

Fig. 6. Part of a section at about 5 mm. from the upper extremity; magnified 33 diameters. The chitinous outer wall with the scales removed.

Fig. 6*. One of the cement-glands; magnified 192 diameters.

Fig. 7. Part of a section near the lower extremity; magnified 33 diameters.

Figs. 8–11. Anatomy of the peduncle of *Scalpellum regium* (Wyv. Thoms.), Hoek. (The chitinous outer wall with the scales removed.)

Fig. 8. Part of a section near the upper extremity; magnified $8\frac{1}{2}$ diameters.

Fig. 9. Section at about 1 cm. from the upper extremity; magnified $8\frac{1}{2}$ diameters.

Fig. 10. Section about half the length of the peduncle; magnified $8\frac{1}{2}$ diameters.

Fig. 11. Group of cement-glands in the upper extremity of the peduncle; magnified 58 diameters.

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1–3 SCALPELLUM VULGARE. 4–5 LEPAS ANATIFERA. 6–7 SC. VULGARE. 8–11 SC. REGIUM.

PLATE VI.

PLATE VI.

A. (in fig. 1) stands for matured ovum.
A. (in fig. 3) ,, body-cavity.
A. (in fig. 6) ,, musculus adductor scutorum.
B. stands for ovum, not fully matured.
C. (in fig. 1) stands for young ovarian eggs.
C. (in fig. 10) ,, outer sack of connective tissue.
c. stands for inner layer of longitudinal muscular fibres.
D. ,, genital duct.
d. (in fig. 1) stands for epithelium of ovarian wall.
d. (in fig. 3) ,, cement-ducts.
gl. stands for pancreatic gland.
GS. or *G.* supraœsophageal ganglia.
GA. ,, genital aperture.
L. ,, labrum.
l. ,, cœca of the so-called liver.
M. ,, mouth.
O. stands for ovarian cœca.
oc. ,, eye.
Od. or *ov.* oviduct.
Oc. ,, œsophagus.
o.n. ,, four optic nerves.
P. ,, pancreatic gland.
p.n. ,, peduncular nerve.
S. (in figs. 4 and 6) stands for stomach.
S. (in fig. 10) stands for funnel at the end of the oviduct.
S'. stands for curious sack.
t. ,, testicular cœca.
W. ,, body-wall.
X. (in fig. 2) stands for yolk-elements of egg.
X. (in figs. 10 and 11) stands for unknown mass.
I.–III. stands for small optical ganglia.

Fig. 1. Part of one of the cœca of the ovarium of *Scalpellum vulgare*, Leach; magnified 685 diameters.

Fig. 2. Nucleus with nucleolus of a nearly ripe ovarian egg of *Scalpellum vulgare*, Leach; magnified 685 diameters.

Fig. 3. Part of a section of the peduncle of *Scalpellum regium* (Wyv. Thoms.), Hoek, in its lower half; magnified 33 diameters. Body-cavity, acting as the main cement-duct.

Figs. 4, 5. Pancreatic gland of *Scalpellum parallelogramma*, Hoek.

Fig. 4. Part of a transverse section through the cephalic part of the body; magnified 33 diameters.

Fig. 5. Section of the gland where it has its greatest diameter; magnified 106 diameters.

Fig. 6–9. Anatomy of *Lepas anatifera*, Linné.

Fig. 6. Sagittal section of the body; magnified 1·5 diameters.

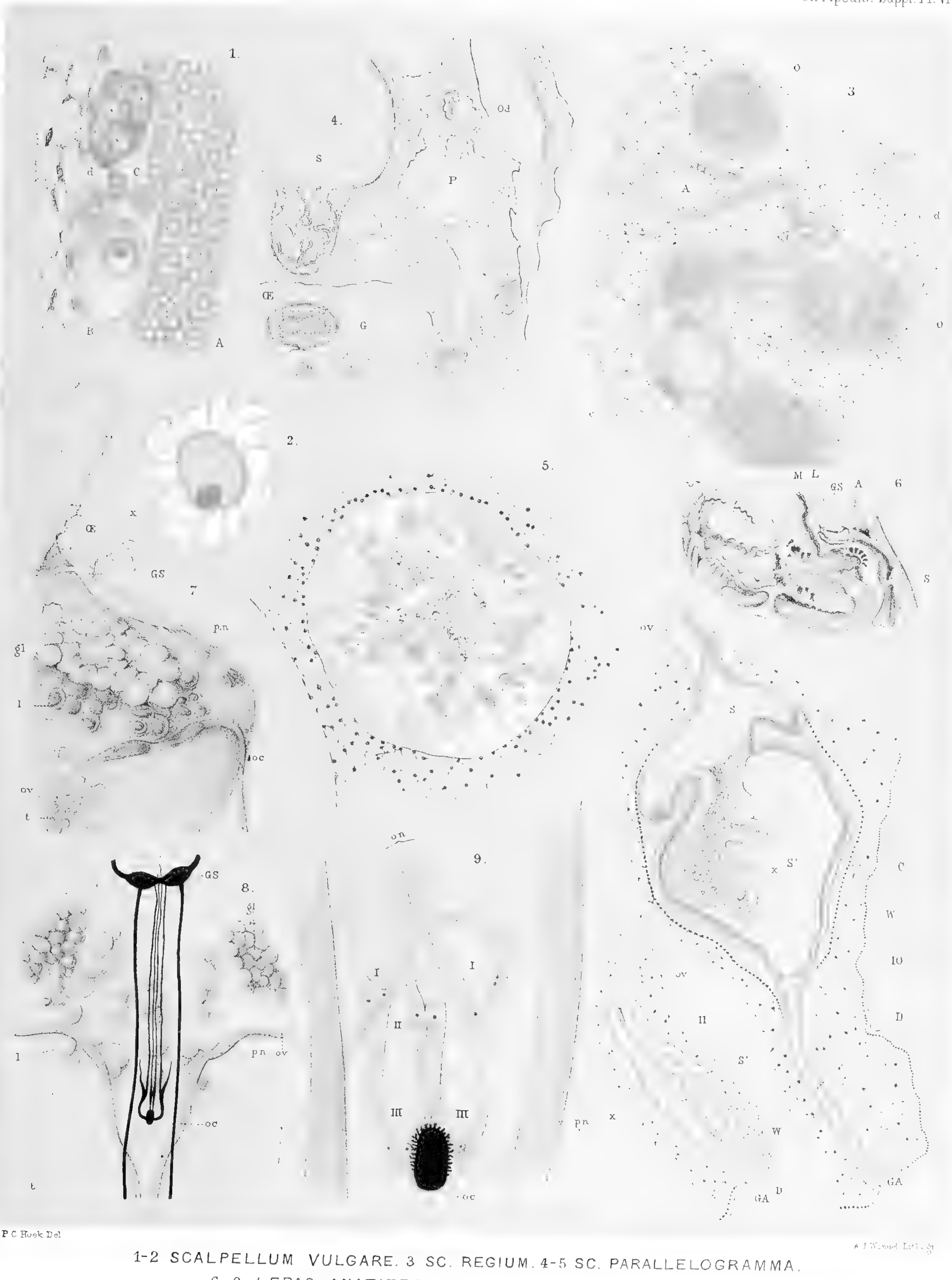
Fig. 7. Lateral view of the upper and front part of the stomach, after the muscles have been removed; magnified 8 diameters.

Fig. 8. Frontal view of a part of the stomach with the supraœsophageal ganglia; magnified 8 diameters.

Fig. 9. The eye and its innervation; magnified 58 diameters.

Fig. 10. The apparatus by means of which the oviduct opens in *Scalpellum vulgare*, Leach; magnified 106 diameters.

Fig. 11. Same apparatus of *Lepas hillii*, Leach; magnified 58 diameters.



P P C Hoek Del.

1-2 SCALPELLUM VULGARE. 3 SC. REGIUM. 4-5 SC. PARALLELOGRAMMA.
6-9 LEPAS ANATIFERA. 10 SC. VULGARE. 11 LEP. HILLII.