XXII. *On the Structure and Development of* Peripatus capensis. *By* H. N. MOSELEY, *M.A., Naturalist to the 'Challenger' Expedition. Communicated by* Professor WYVILLE THOMSON, *M.A., F.R.S., &c., Director of the Scientific Civilian Staff of the Expedition.*

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Introduction.

AT the outset I wish to express my obligations to Prof. WYVILLE THOMSON, by whom this paper is communicated to the Royal Society. Prof. THOMSON kindly examined a series of preparations of various structures in *Peripatus*, and gave me the benefit of his long experience in such matters, and especially confirmed my views as to the identity of the tracheæ, which, of course, I had some hesitation at first in admitting as such, since they occurred in an animal in which, from what was at that time known concerning it, such structures were so little to be expected. Prof. THOMSON further gave every encouragement to the prosecution of my further investigations on the subject.

Peripatus has always been regarded as of such especial zoological interest that no apology is necessary for the present paper. *Peripatus* was naturally the first animal sought after by the naturalists of the 'Challenger' expedition on their arrival at the Cape of Good Hope, and I was lucky enough to find a considerable number of specimens on the very first occasion of searching for them. My intention had been only to try to keep the animals alive so as to obtain their eggs and watch their development, but on opening one large specimen I immediately recognized the presence of tracheæ, and found the animal to be viviparous and full of far-advanced embryos. I therefore commenced as careful an examination of the structure and development of *Peripatus* as my available time during our stay at the Cape allowed; and although the investigation is far from complete, the results embody so much that is novel and important that I consider it better to publish them now, leaving the gaps to be filled in by other observers, or by myself by further work at the subject during the Antarctic cruise of the 'Challenger,' should such work be then found practicable.

Literature.

No original papers on *Peripatus* are available to me here at the Cape of Good Hope, but from such text-books as CLAUS'S 'Grundzüge der Zoologie,' SCHMARDA'S 'Zoologie,' GEGENBAUR'S 'Grundzüge der vergleichenden Anatomie,' tolerably complete information about what is known or believed concerning the structure and affinities of the animal can be gathered. The following are the papers quoted on the subject:—

L. GUILDING, "An Account of a new Genus of Mollusca," Zool. Journ. ii. 1826.

M. GERVAIS, "Études pour servir à l'histoire des *Myriapodes*," Ann. des Sc .Nat. 1837.

E. BLANCHARD, "Sur l'organisation des Vers," Ann. des Sc. Nat. 3 sér. tom. viii. 1847.

DE BLAINVILLE, Suppl. au Dict. des Sc. Nat. t. i.

M. DE QUATREFAGES, "Anat. des Hermelles," Ann. des Sc. Nat. 3 sér. tom. x.

E. GRUBE, "Ueber den Bau des *Peripatus Edwardsii*," MÜLLER'S Archiv, 1853.

GRUBE, whose paper on the subject is the best known and most searching, came to the conclusion that *Peripatus* was hermaphrodite, probably from want of sufficient material, or because his specimens were not collected at a period when the reproductive functions were in activity. He further failed to see the tracheal system, as could hardly be avoided, since it becomes almost invisible when the air has been removed from the tracheal tubes by long soaking of the animal in spirit. GRUBE thus placed *Peripatus* (amongst the Bristle-worms) in a separate order, Onycophora; and he is followed by CLAUS and SCHMARDA and most zoologists, although the position of *Peripatus* has always been considered doubtful. GEGENBAUR (Grundzüge der vergleichenden Anatomie, p. 199) speaks of the placing of *Peripatus* amongst the worms as by no means certain, but adds that *Peripatus* certainly connects the Ringed worms and Arthropods with Flat worms. The older writers on the subject come nearer the mark. NEWPORT* says, "DE BLAINVILLE first connected Myriopoda with Annelida by means of the bristly genera, the Annelida Errantia; but subsequently remarked a closer connexion between the two classes in the singular *iuliform* genus *Peripatus*."

DE QUATREFAGES† does not place *Peripatus* with the worms, but in his 'Histoire Nat. des Annelés' gives a short account of these animals in the Appendix. He dwells on the fact that *Peripatus* has feet armed with nails, to which muscles are attached, and not bristles lodged in a follicle. He considers that DE BLAINVILLE‡ was near the mark when he formed a special class "*Malacopodes*" for *Peripatus*, but that M. GERVAIS was most in the right when he placed the group in affinity with the Myriopods.

M. DE QUATREFAGES was evidently quite right in following M. GERVAIS in this matter. The affinities of *Peripatus* will be discussed shortly at the close of this paper.

DE QUATREFAGES† gives a list of four species of *Peripatus*, viz. *P. iuliformis* of Cuba with 33, *P. d'Edwards* of Cayenne with 30, *P. Blainville* of Chili with 19, and *P. brevis* of the Cape with 14 pairs of feet.

The specimens obtained and examined by me here cannot be of the species "*brevis*," since, instead of 14 pairs of feet, they invariably, whatever their size, have 17 pairs of ambulatory members besides the labial and anal papillæ, and the young embryos very

* "Monograph of the Class Myriopoda, Order Chilopoda, with Observations on the General Arrangement of the Articulata, by George NEWPORT," Linn. Trans. vol. xix. 1843, p. 268.

† Hist. Nat. des Annelés, Paris Libraire Encyclopédique de Roret, 1865, t. xi. Appendice, pp. 675–6.

‡ Suppl. au Dict. des Sc. Nat. t. i.

early obtain the full number of members possessed by the adults. The largest specimen found was about 7 centims. long when in a state of rest, the smallest 1·6 centim. in length. In no specimen, however, were the reproductive organs immature. Most of the smallest specimens were found to be males, but one of only 2 centims. in length contained embryos in a far advanced condition. A species of *Peripatus* from the Cape is, I believe, described, in the zoological publications of the 'Novara' expedition, by GRUBE as *Peripatus capensis*. Probably there is only one species at the Cape, *P. capensis* and *P. brevis* being the same badly described. Specimens of the one here treated of are forwarded with this paper for determination of the species.

Locality.—The specimens made use of were all found at Wynberg, a village situate on the road between Simon's Town and Cape Town, and not far from Constantia, and all in one spot in that place. This was a plantation surrounding the house of Mr. MAYNARD, and situated just behind Cogill's hotel. These particulars are given because *Peripatus* seems to be remarkably local, and is not by any means easy to find. A single specimen was found in Dr. BLEEK's garden at Mowbray, and a further locality is known to Mr. TRIMEN, the Curator of the Cape Museum.

Habits of Peripatus.

Peripatus is to be sought for in places where the soil is rich in vegetable matter and kept constantly moist and shady by a thick growth of trees and the proximity of some stream or source of water. The first and largest specimen found was resting under a piece of half-rotten board; others were met with under fallen logs; but the greatest number were found by tearing to pieces stumps and fallen logs of willow-wood, which were very damp, half buried in the ground, and in the condition known as touchwood. As many as twelve specimens of various sizes were thus found in one log. The willow-wood seemed to be preferred to the poplar-wood, of which there was a large quantity in the locality, but which was always unproductive. The animals were always met with in a quiescent condition, with the tentacles retracted and feet drawn together, the body being thus arched above. The animals are roused into activity with some little difficulty at first. They avoid the light, and crawl away to the first dark corner. They are easily kept alive in confinement amongst damp earth and pieces of dead wood; but if the supply of moisture be not kept up, they shrivel up and die at once. They are nocturnal in their habits, remaining concealed amongst the earth and dead wood, with which they are kept during the day, but leaving this and crawling about their box at night. When suddenly handled or irritated, they shoot out fine threads of a remarkably viscid and tenacious milky fluid. The threads of fluid are emitted with such remarkable suddenness that it is almost impossible to observe their passage from the animal's head; but on close observation with a lens, especially in the case of large specimens, they may be seen to be projected from the tips of the oral papillæ. The threads cross one another in various directions, and form a sort of meshwork, often of considerable complexity, which suddenly appears, as if by magic, suspended from objects lying in front of the animal, and having the appearance presented by a bit of spider's web with the dew upon it. When examined under the microscope the threads are seen to be fine and hyaline, with variously sized highly refractile spindle-shaped globules situate at intervals upon them (Plate LXXIII. fig. 4). They are thus very like the viscid threads of the spider's web. The fluid of the globules is seen under a high power to contain a few fine granules. As it dries under the microscope, it forms into a tenacious mass, showing extremely fine lines pervading the threads in the direction of their length, and giving them a fibrillated appearance. The fluid is not perceptibly irritant when applied to the tongue, but has a slightly bitter and at the same time somewhat astringent taste. Small specimens of *Peripatus* soon exhaust their immediate supply of the fluid, and cannot be induced to make more than two or three discharges at one time even when squeezed hard; but large specimens can make at least a dozen discharges one after another. The animals evidently use the fluid as a means of defence; for when they are pricked with a needle or forceps about the side or middle of the body, they turn their head round and aim their discharge at the place at which the injury is being received. The tenacity of the threads formed by the fluid is so great and their viscidity so remarkable, that the meshwork of them thrown out over an insect or other such enemy would entangle it, and render it powerless for some time, even if it were of considerable size. The fluid adheres most tenaciously to the fingers, just like bird-lime; and when a large *Peripatus*, when first found and handled, shoots out its fluid over its own back and the fingers of the finder, it requires a very hard shake to free it from the hand. Whilst I am writing several flies have walked into some of the fluid which I caused a large *Peripatus* to discharge upon a glass slide in order that I might test the action of the fluid on my tongue. The flies are helplessly stuck fast; and I believe that the fluid is quite sticky enough to hold small birds, though it dries too rapidly to be used for that purpose. The glands containing the fluid give some little difficulty in dissection of the animal, when this is conducted under water or in the dry condition, since they protrude out of the first incision, adhere tightly to forceps, scissors, or scalpel, and can hardly be disengaged without being torn, or very often without carrying away, together with themselves, the surrounding viscera, intestine, generative ducts, &c.

Peripatus coils itself up, often, like *Iulus*, in a spiral with the head in the centre of the coil; and small specimens always assume this posture when they are severely pricked or maltreated. When in motion the animal extends its tentacles and body to their full length, thus becoming of nearly twice the length which it measures when at rest and proportionately narrower. The tentacles are kept in motion in search of obstacles, and the feet are moved rapidly in pairs, the alternate pairs moving together with considerable regularity, but at the same time with the peculiar progressive movement of a caterpillar. The gait is, in fact, extremely like that of a caterpillar. There is never any wriggling or sinuous movement of the body like that in worms. The ventral surface of the body is entirely supported free of the ground by the feet. The animals are readily killed by immersion for four or five hours in water; and when thus treated they die in an extended condition, and are obtained in the most favourable condition for dissection or preservation in alcohol as museum specimens. They are apparently paralyzed after immersion for only a quarter of an hour in water, and remain extended and motionless, but they soon recover when placed again in the air. They can also be killed in an extended condition by being placed in a weak solution of chromic acid; and this is the best method of commencing to harden them for the preparation of sections.

Anatomy.

Only those points in the anatomy of *Peripatus* will here be dwelt upon in which correction of former accounts appears to be necessary, or those which have been hitherto entirely unnoticed. No attempt will be made at a description of the whole structure of the animal.

Digestive System.—The intestinal tract of *Peripatus* is described by GRUBE as straight and enlarged in each segment of the body. This is far from being the case, at least in the Cape species. The digestive tract is here longer than the body, and in all the specimens which I have examined has been considerably distended, so that it protruded itself in a loop, together with the attached slime-glands, from the first incision. The digestive tract is displayed in Plate LXXII. fig. 1 *. It commences as an ovoid muscular pharynx, which is separated by a short contracted œsophagus from the elongate and capacious stomach, from which a very short piece of intestine or rectum leads to the anus.

From the posterior part of the lateral surfaces of the pharynx arise a pair of small muscles, which probably are protractors of the pharynx, and serve to push forwards the jaws. The under surface of the pharynx, and also of the rectum, receive a large and conspicuous supply of tracheæ: these are shown in the figure. The division between the stomach and intestine is much more marked in some specimens than others, and is best seen in quite fresh ones, where the stomach is distinguished by its pale pink colour. In some specimens there is a distinct shoulder at the point of junction. The wall of the stomach is plicated, and the organ has a convoluted appearance. In many specimens the stomach was folded in a single short dorsal loop, at about the junction of its first with its second third. The loop lies folded flat over the upper surface of the succeeding part of the stomach. It lies in the middle line, and is not at all inclined to either side. It was only about half an inch long, and was not observed in all specimens, but is probably always present when the body is in the contracted condition, since the excess in length of the intestinal tract over that of the body necessitates a folding of some kind. As Mr. TRIMEN, Curator of the Cape Museum, who long ago watched the habits of *Peripatus*, has pointed out to me, the great power of extension of

* The beautiful drawings in Plate LXXII. were made for me from my dissections by Mr. J. J. WILD, Artist to the 'Challenger' Expedition.

its body is very remarkable in *Peripatus*. When the animal is crawling, the body is extended to about twice the length which it has when the animal is at rest. When the body is thus fully extended, the digestive tract is probably quite straight, becoming looped again when the body is drawn together. The convolutions and folds of the stomach do not in any way correspond to the segments of the body. The outer surface of the stomach has upon it a pattern composed of small hexagons, which is shown by Mr. WILD in the figure. This appearance is caused by the glandular follicles of the mucous lining of the organ, which are seen through its outer wall. The glandular lining of the stomach has always a light pinkish colour * (in the embryo the digestive tract is red). It is very thick, and composed mainly of large cells (Plate LXXIII. fig. 3, *a*) with a polygonal outline, usually pentagonal, showing a granular structure with a distinct nucleus and nucleolus. These cells probably have an hepatic function. Besides them there are slime-cells and masses made up of aggregations of small fat-particles (Plate LXXIII. figs. 3, *b* and *c*) in abundance in the stomach. Vegetable cells and portions of woody fibre in small quantity were found in the stomachs of two specimens; and there can thus be little doubt that their food, like that of *Iulus*, is the decayed wood amongst which they are so constantly found. The stomachs of several specimens were quite empty. It is very possible that the animals feed very little or not at all during the breeding-season, but rest, as does *Iulus* according to NEWPORT, at the time of the production of the eggs.

Some very small encysted Gregarinæ were found in the stomachs of all the specimens examined.

The separation between the stomach and rectum is marked by the difference of colour in the fresh state, the rectum being pink. The alteration in diameter of the tube is more sudden in some specimens than in others.

Slime-glands.—The glands, which are those described by GRUBE as the testes, are present in both sexes; they lie on each side of the digestive tract, and stretch down nearly its whole length. The glands are shown in Plate LXXII. fig. 1, *s.g, s.g.* They consist of a series of elongate ramified tubes, which twist round the stomach in a sort of meshwork, and entangle themselves around the male or female generative organs. The ramified tubes terminate in ducts, which open one on each side of the body in the tips of the oral papillæ. Along the greater part of their course these ducts are enlarged into wide sacs, which serve to store up the secretion of the gland, and to eject it in the form of the viscid thread as already described. These reservoirs or ejaculatory sacs (Plate LXXII. fig. 1, *e.s*) are represented in the figure in a collapsed condition, the animal dissected in this instance having been killed by immersion in alcohol vapour, and having discharged its store of viscid fluid. When distended the sacs appear as cylindrical bodies, with a tense transparent wall, very like the sacs on the ducts of the salivary glands in *Blatta* and several other Orthoptera. The sacs are provided with spirally arranged muscular fibres, disposed in two layers and twisted in opposite directions.

* Just the colour of the excreta constantly voided by moths immediately after leaving the pupa-case.

The interior of the sac is lined with large flat endothelial cells, with a polygonal outline, and resembling the well-known endothelial cells of the frog (Plate LXXIII. fig. 6). The secreting tubes of the gland itself (Plate LXXIII. fig. 7) are covered externally with a layer of hexagonal plaster-cells (not shown in the figure), and internally are lined with a thick layer of slime-cells, which are elongate, often pear-shaped, disposed transversely in the gland-tubes, with their narrower bases resting on its wall and their pear-shaped ends projecting into its cavity. The cells have the usual granular structure and a very distinct nucleus and nucleolus. The riper cells become transparent and almost free from granules. An irregular space leading down the axes of the tubes is filled with fluid containing fine granules. The slime-cells probably swell gradually to the transparent condition, and then bursting, discharge their contents into the cavity of the gland. The glands exhibit all the viscous properties of the fluid ejected by the animal, and are so sticky as to be of considerable hindrance in the dissection of the animal in the fresh condition or under water. The oral papillæ in which the glands open, as will be seen in the sequel, are modifications of the second pair of body-members of the embryo. The glands are probably homologous with the silk-glands of caterpillars and the poison-glands of *Scolopendra.* There are no excretory glands representing the Malpighian tubes of insects and Myriopods in *Peripatus.*

Fat-bodies.—The lateral bodies (*x*, Plate LXXII. fig. 1) were described as two canals imbedded in the muscular wall of the body, which might perhaps belong to the vascular system (CLAUS, Zoologie, p. 387). These bodies vary very much in different specimens. In some they are narrow and terminate about the middle of the body; in others they are much longer and broader, and stretch to the very end of the body. They are composed of small round oily particles, and apparently are homologous with the fat-bodies of other Tracheata.

Circulatory System.—The dorsal vessel, when examined in the fresh state or in glycerine, appears to be of very simple structure. As in insects, it is imbedded in fatty tissue. I have been unable as yet to see any valvular arrangements in it or system of transverse fibres. I intend to examine its structure more carefully by means of sections &c. When the vessel is dissected away from the body-wall, a series of openings are seen in the middle line of the body-wall, directly above it, exactly like those which exist on either side of the ventral wall of the body along the line of origin of the feet. The ventral openings were described by GRUBE. They are figured in Plate LXXII. fig. 2, where they are seen situate on either side, immediately externally to the ventral nerve-cords (*v.c*, *v.c*).

Respiratory System.—The tracheal system in *Peripatus* renders itself conspicuous at once when the animal is opened in the fresh condition. The tracheæ have the characteristic pearly lustre given by all fine transparent tubes when filled with air and seen by reflected light. In specimens which have become saturated with spirit, the air becomes entirely removed from the vessels, and they are consequently hardly to be seen at all, and, in consequence of the great imperfection of their spiral fibre, are with great difficulty to be made out, even with a high power, under the microscope. It is thus easy to understand how they escaped the observation of GRUBE. The tracheæ arise from the skin all over the surface of the body, but are specially developed in certain situations. When the animal is opened under water in the fresh state, the groups of them appear to the naked eye as pearly white dots scattered over the inner surface of the body-wall, and, when viewed with a lens, show themselves as small tree-like ramifications coming up through the tissue and ramifying on the surface. These are shown in Plate LXXII. fig. 2, where they are represented as dark on a light ground for convenience of drawing: in reality they appear glistening and pearly.

Especially large and conspicuous groups of tracheæ are supplied to the rectum and pharynx (Plate LXXII. fig. 1, *tr*, *tr*). These tracheæ arise from the middle line of the ventral surface.

The structure of the tracheal system resembles very much that of *Iulus*. Plate LXXIII. fig. 5 shows the mode of origin of the tracheæ from the skin-surface. A short wide tube leads from a simple opening between the cells of the epidermis directly inwards through the skin. The tube is contracted at its opening, and swells out somewhat at its inward termination. From the inner end of this tube arise all together a vast number of fine tracheal vessels in a sort of brush. The vessels run for the first part of their course in a densely packed cylindrical mass, apparently united together side by side, running parallel, but never communicating. The cylindrical mass of vessels soon divides into several trunks, which again subdivide, and so give off the bundles of vessels which are distributed to the viscera, &c. The tubes never anastomose in any part of their course. In the first part of their course, where they are closely packed together, they run in almost straight lines; but as soon as they pass into smaller bundles, or are distributed to their destinations, they take a tortuous or zigzag course (Plate LXXIII. fig. 2). The closely packed masses of tracheæ at their origin, when filled with air and viewed by transmitted light under the microscope, are very conspicuous objects, and appear quite black, transmitting no light. In order to see the mode of origin of the tracheæ well, a vertical section of the body-wall of a *Peripatus* must be made in the fresh condition, and placed in glycerine for examination. It should be rather thick, or otherwise most of the air-vessels are cut across, the air escapes, and the vessels become almost invisible. When a thick section is thus prepared, and pressure is brought to bear on the covering-glass, several small bubbles of air may be caused to pass out from the spiracular opening of one of the tracheal bundles. Sections prepared from specimens hardened in spirit show almost nothing of the tracheal system, and it is hence difficult to get transverse sections to show the structure of the primary short air-tube. It must, however, terminate internally in a finely perforated plate. Some few tracheal vessels are given off at once from the large primary mass to the immediately surrounding tissue; but the larger part run a long course in parallel bundles before they separate for their final disposition. All the iscera are supplied richly with tracheæ. Their manner of distribution is shown in Plate LXXIII. fig. 2, *a*, which shows the arrangement on one of the secreting-tubes of the slime-gland.

The vessels run in bundles of two, three, or sometimes as many as six together in an irregular zigzag course, crossing one another in all directions, so as to form a tangled irregular meshwork. They usually run separately for the last part of their course, and they terminate simply without enlargement, apparently with closed ends. The vessels are very fine, being only about ·003 millim. in diameter, but are very conspicuous when filled with air and viewed by transmitted light. When examined with very high powers they show transverse markings, which appear to indicate the existence of an imperfectly developed spiral fibre within them (Plate LXXIII. fig. 2, *b*). The fibre, or rather band, is broad in proportion to the diameter of the vessel; it is apparently very imperfectly differentiated, and not tenacious enough to be partially uncoiled when a vessel is torn across, as is the case in the tracheæ of insects.

The distribution of the tracheæ to the uterus and oviducts is seen in Plate LXXIV. fig. 1. The tracheæ very rarely branch; but branching does occur. Plate LXXIII. fig. 2 represents an instance of branching in the tracheæ of the uterus.

The spiracles, or openings of the tubes from which the tracheæ take origin, lie in the depressions between the conical warty excrescences with which the skin is covered. They are small and difficult to see when the epidermis is spread out and examined with the microscope. They seem to be mere cracks between the superficial epidermic cells; and no definite arrangement of these cells around them was observed, although most carefully sought for. The skin contracts when removed from the body and placed on a slide, and the spiracles close up and are most difficult to find. If a large specimen of *Peripatus* be killed by drowning, the animal dies in a state of extension, and the spiracles remain patent. A row of minute oval openings may then be seen with a lens extending along the median line of the ventral surface of the body. The openings are situate with tolerable regularity in the centres of the interspaces between the pairs of members, but additional ones occur at irregular intervals. Other similar openings occur in depressions on the inner sides of the conical foot protuberances. If the skin in which these openings occur be dissected off and spread out under the microscope no definite arrangement of cells around them is to be observed, and they collapse at once, having no chitinous ring or such structure.

Generative Organs.—Peripatus was described as hermaphrodite by GRUBE, that observer having mistaken the slime-glands of the animal for testes; in reality the sexes are distinct. There appear to be no outward characteristics by which a male can be distinguished from a female. Out of about thirty specimens dissected two thirds were females. All the males but one were very small, not more than 2 centims. in length; and it was at first concluded that the males were always smaller than the females; but one female was met with of only 2 centims. in length; and the last specimen dissected, which was 5 centims. in length, turned out to be a male. The animals vary in colour, some being of a dusky brick-red, with a narrow black dorsal stripe, whilst the majority are entirely black; but both males and females were found of the light-coloured variety. Of the twenty female specimens dissected only one was found which did not contain embryos in some stage of development. In this one the ova were immature, and there were no spermatozoa in the ovary. The breeding-period of *Peripatus capensis* is thus probably the months of November, December, and January, the three Cape summer months. Observations are required on the mode of congress of the sexes, and on the time and manner of the birth of the young.

Female Organs.—The female organs were described by GRUBE as consisting of a pair of tubular ovaries running on the ventral surface of the intestine, and opening by a common aperture in the last segment but one. The organs are much more complicated than this in *Peripatus capensis*. They are figured in Plate LXXII. fig. 1. They consist of an ovary and pair of oviducts, which in the lower part of their course are dilated and perform a uterine function.

The ovary is a small elongate body, divided by a median septum into two lateral halves, which lies underneath the lower part of the stomach, and between that viscus and the ventral wall of the body. The position of the ovary varies somewhat. It is sometimes higher up the body than at others; but it is usually situate distant from the hinder extremity of the body about one sixth of the animal's length. The ovary is usually bound to the under surface of the intestine by tracheæ and the meshes of the slime-gland. From the ovary lead a pair of oviducts, connected with it in some cases by an elongate pedicle, as in Plate LXXII. fig. 1, in others (as in that figured in Plate LXXIV. fig. 1) arising directly from the base of the organ. The oviducts are slender tubes which pass upwards in the body-cavity, and then turn downwards again to run to the vulva, forming thus a loop.

At a short distance, but one very variable in length from their commencement, the oviducts become enlarged and perform the function of a uterus, and when filled with embryos have the appearance of a string of sausages, each dilatation containing one embryo. The ducts, finally passing inwards towards the middle line under the nerve-cords, unite under the rectum into a very short common tube, which terminates in the vulva. The embryos are contained in the duct up to its very termination. The number of embryos present varies greatly. In the specimen figured (Plate LXXII. fig. 1) there were fifteen embryos on one side, and seventeen on the other. One small specimen had only ten embryos altogether, and another only eight.

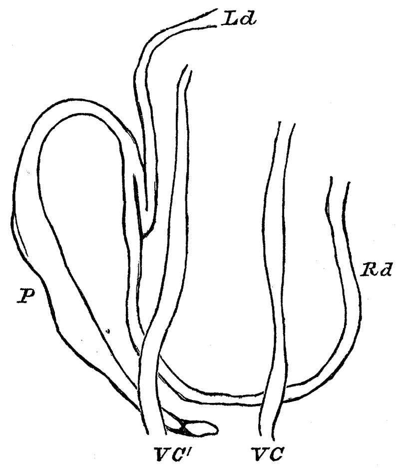
The oviducts and uterine tubes are not attached to the body-walls, but lie loosely in its cavity; hence the loops become twisted about into various postures, and a most extraordinary condition exists with such frequency and regularity that it must almost be considered normal. This is one in which the oviduct, or sometimes the uterine tube itself, is tied in a knot round its own loop. The knot, which is shown in Plate LXXII. fig. 1, *k*, is what is called by sailors an "overhand knot on a bight," and is, of course, such a one as can be tied on a loop of string which has both ends made fast. The formation of the knot is evidently connected with the great power of extension of the body already referred to as possessed by *Peripatus*. The body being constantly protracted and then again shortened, the loops of the oviduct must be constantly pushed up and down inside the body-cavity, and thus get knotted. In order that the knot should be formed, the primary loop requires to receive a single twist, and then through the loop thus closed by the twist a second loop of the part of the duct beneath the twist must be pushed up. The movements of the body soon draw the knot tight. In the first specimen of *Peripatus* dissected, the knot was found on both sides of the body, in each case drawn so tight that it had to be very carefully loosened with forceps before its exact nature could be made out. In the one drawn for me by Mr. WILD there was a knot only on one side of the body as figured; but it is represented much looser than it was in reality, in order to show the way in which it runs. The knot was found in about ten other specimens, in some cases on one side, in others on both. It is evident at once to what pathological complications such a knotting of the duct must give rise. As the embryos swell, the uterus will become constricted at the knot, and the embryos will be unable to be extruded. In one of the largest specimens dissected this very thing had occurred, and in consequence the loops of the uterus on both sides had become dilated into wide sacs, which had lost all the normal successive constrictions originally separating the embryos from one another, and were filled with the decomposed remains of embryos and masses of fatty matter. The two sacs had lost all connexion with the lower parts of the uterine canals, these having apparently mortified off at the knots, and were attached only to the ovary. The remnants of the lower parts of the uterine canals were short and empty, having probably discharged their ripe contents before their upper portion perished.

The structure of the ovary is shown in Plate LXXIV. fig. 1, *a*. It is composed of a stroma, fine fibres with numerous small rounded nucleated cells containing granules, and other clear round cells, with neither nucleus nor granular contents, and other elongate nucleated cells like those seen in the figure in great abundance in the oviduct. The ovary has in it two elongate sacs separated from one another by a median septum; and in nearly all the pregnant specimens examined, the sacs were found crammed with spermatozoa felted together into masses, as seen in the figure. Pear-shaped sacs hang from the margins of the ovary in which the ova are developed.

The ripe ovarian ova are about ·17 millim. in diameter. They have a thin transparent vitelline membrane, which encloses them within the sacs. They have an abundant finely granular yelk, a large, very transparent clear spherical germinal vesicle, and a finely granular germinal spot, which has a somewhat irregular outline. Some of the full-sized ovisacs are to be seen containing irregularly shaped masses of yelk, without any germinal vesicle. The ovary contains between thirty and forty ova. The ova appear to ripen all at about the same time. Stages in the development of the ova were observed in one female specimen which contained no spermatozoa, in which none of the ova had reached maturity. These are represented in Plate LXXIV. fig. 1, *b*, *c*, *d*.

The young ovisac (*b*) is filled with the peculiar round clear cells described as existing in the stroma of the ovary, and with a small quantity of coarsely granular yelk-matter, derived probably from the granulated cells of the ovary, which are to be seen occasionally in the necks of the ovisacs in a semidisintegrated condition, appearing as mere aggregations of granules around a clear spot representing the nucleus. In the next stage (*c*) the vitelline membrane is drawn across the cavity of the ovisac, separating off a space containing the relatively large germinal vesicle and the small quantity of coarsely granular yelk which float in the clear fluid which fills the greater part of the cavity. The germinal spot is composed of small rounded particles, and is irregular in form. In the next stage (*d*) the fine granular yelk entirely fills the cavity within the vitelline membrane. In all the ovaries examined, spermatozoa were found attached in tangled groups and masses amongst the ovisacs on the exterior of the ovary, and apparently in some cases the long filaments of the spermatozoa penetrated the ovisacs with one of their ends, whilst the other was in active motion. The filaments are, however, so fine and hyaline, that they are difficult to follow when lying amongst other tissue; and the supposed cases of penetration observed may have been merely cases of superposition. Free spermatozoa were also met with amongst the tissue of the lateral bodies termed here fat-bodies; indeed they were found first of all in this situation: only two were seen; they probably commonly escape amongst the viscera. Spermatozoa were found in abundance in the ovaries, even in specimens containing far advanced embryos. The uterine portion of the oviduct is very richly supplied with tracheæ, which appear to be more abundant in a uterus with advanced embryos than in one which is empty or has very early embryos. Perhaps the tracheal supply increases with the growth of the embryo and consequent increased development of the uterine wall.

Male organs.—The male generative organs consist of the prostates, the testes, with their vesiculæ seminales and vasa deferentia, and a pair of bodies, apparently accessory glands. The male organs are displayed in fig. 3, Plate LXXII., which is a drawing made by Mr. WILD from a dissection. The testes (*t*, *t*) are ovoid bodies of large size, which, as well as their ducts, prostates, and vesiculæ seminales, are of a glistening white colour and very conspicuous. A short but wide convoluted tube, the prostate (*pr*), surmounts each testis, and communicates with it by means of a narrowed neck, which springs from a spot on the somewhat flattened surface of the testis, and not from its apex, but is situate somewhat below that point. The vas deferens arises as a fine thread in the same manner from the same surface as the vesiculæ seminales lower down, but above the inferior margin of the organ. The thread-like duct enlarges directly after quitting the testis, and forms a spiral coil, which probably serves as a reservoir for the semen, and may be called vesicula seminalis. From this coil the long continuation of the duct, somewhat reduced again in diameter, twisting about in all sorts of irregular loops and turns, passes down to the hinder end of the body. Here the duct of one testis passes transversely across the body underneath the ventral nerve-cords, passes back on the other side, up the body again a short distance, and then turns down again, forming a loop to reach the male generative opening, which lies in the same position as that of the female. The duct thus passes under one of the ventral cords again. The lower part of the duct, from the loop downwards, is enlarged, muscular, and supplied much more richly than the remainder with tracheæ. It is therefore an ejactulatory duct, and perhaps is somewhat exerted in copulation as a penis. In only two specimens of males were the terminal ducts dissected out with care. In one case the terminal duct was that from the right testis, in the other that from the left. The vas deferens of the other testis of the pair, after leaving its vesicula seminalis, becomes twisted up with the spiral coil of the testis of the other side, and after coiling about in the lower part of the body-cavity like its fellow, passes to that side of the terminal loop of its fellow duct which is opposite to that which is enlarged into the penis-like organ, and is there bent itself into a sharp loop, which is closely applied against the side of the large terminal loop and fused to it, the two ducts here anastomosing. This arrangement was observed to be exactly similar in both the dissections made, though the sides were reversed. The enlarged part of the duct or penis (*p*) appears, as described, to be a continuation of one of the ducts only, the other duct being cut short and entering from the side. But from the way in which one duct passes under the nerve-cord and not the other, and from the curious sharply turned loop formed by this latter duct on entering its fellow, it would appear that the original condition had been almost exactly similar to that existing in the female organs. A common duct (now the lateral penis) lay in the middle line on the inner surface of the ventral wall of the body, the tube being much longer in the male than in the female. The two vasa deferentia passed inwards, one on each side under the nerve-cords, to enter the common median tube together at its upper extremity, as do the oviducts in the female. The common duct, however, in the male has become longer and longer, and thus formed an upward loop in the body, which looping has necessarily brought about the sharp turn in the one vas deferens; the large loop at the same time slipped out sideways under the nerve-cord, and lay in future always on the side of the body; and the other vas deferens following it was dragged under the second nerve-cord, and thus now passes in the present singular manner under both nerve-cords. The diagrammatic woodcut may serve to make this plain:—*VC′*, *VC* are the ventral nerve-cords, *P* the penis or enlarged common terminal duct. The right vas deferens (*Rd*) passes right across the body at its very end under the ventral cords, and, turning up, is apparently continued in a sweeping curve into the penis. The left vas deferens (*Ld*) enters the loop of the penis with its peculiar sharp



bend. If the right duct (*Rd*) were gradually pulled upon and every thing supposed free, the original condition of affairs would be restored, the penis would lie in the middle line, and the sharp turn be taken out of the left duct; both ducts would pass under a single nerve-cord, one on each side. The present arrangement appears to be a commencement of the unilaterality found in Scolopendridæ. In two of the males opened, merely to observe the sex, one testis with its accessory gland and vesicula seminalis was much larger than the other, showing a further step towards unilaterality. The testes are packed in the body one a little way above the other beside and behind the intestine.

The convoluted tube above the testis contains no spermatozoa or vesicles of evolution, but only large fine granulated or transparent gland-cells, being, in fact, very like in structure to the slime-glands of the animal. These tubes are probably diluent accessory glands of the testis, and might be called "prostates."

The testes examined contained abundance of vesicles of evolution, with spermatozoa in various stages of development. The structures observed are shown in Plate LXXIV. figs. 2, 3, & 4. The earliest forms of the cells which produce the spermatozoa appear to be those seen in fig. 2, connected together in a row and filled simply with fine granules. The cells are flattened by mutual appressure, and probably multiply by division. The cells enlarge and acquire a transparent nucleus. In the next stage observed the cells are again enlarged, and contain from three to as many as six vesicles of evolution, sometimes only one or two; these are shown in fig. 3, *a*, *b*, *c*, as seen with a HARTNACK's No. 10, ocular 4. The large cells have perfectly transparent contents without granules. The contained vesicles of evolution are ovoid in form, and have a fine granulated ovoid nucleus: they are transparent over the greater part of their area, but arranged irregularly; about one pole is a single layer of fine distinct granules. In the next stages the vesicles of evolution are full of granules, and the filaments of the spermatozoa are formed curved around the ovoid nuclei. This stage is represented very much enlarged in fig. 3, *d*. The short tails of the spermatozoa project from the parent cell. *a*, *b*, *a*, fig. 4, show further stages, these being the most abundant forms in the testis. The granular matter and wall of the vesicles of evolution have almost disappeared. The tails of the spermatozoa are longer. The number of spermatozoa developed in each cell is very variable; cells with only one, as in Plate LXXIV. fig. 4, *a*, are very common. In the next (fig. 4, *c*, *d*, and *e*) stage the spermatozoon is free from the cell; the nucleus of the vesicle merely remains attached to it laterally within its loop. Some fine granules are often to be seen in the space between the nucleus and the loop of the spermatozoon, the remnants of the granulation of the vesicle of evolution. None of the spermatozoa are found freed from their nucleus within the testis, and most of them retain the nucleus in the vesiculæ seminales. In the mass of spermatozoa contained within the penis or terminal ejaculatory duct, about half of the spermatozoa had thrown off the nucleus, and the other half retained it still. Free nuclei abounded in the mass. The ripe spermatozoa met with in the ovary of the female are always simply filamentary, like those of insects and Chilopods, and never retain a nucleus; they are about ·5 millim. in length; but their length is very difficult to estimate, since the excessively fine undulating terminations of their filaments are only to be followed with high powers and by constant alteration of focus.

The spermatozoa met with in the ovaries were, wherever space allowed it, in constant motion. The long tails showed an undulating movement, accompanied by a spiral corkscrew-twisting motion. As the filaments turned round partially or wholly on their axis, it could be seen that they are, in their broader median part, not cylindrical and circular in section, but flat bands, much broader along one transverse axis than the other. The spermatozoa are found always twisted up into loops, which show all kinds of varieties of form. The commonest form is a simple loop near one end of the ribbon-like part of the long filament, the spermatozoon thus having one long and one much shorter tail (Plate LXXIV. fig. 5, 1). In other cases a double loop is formed at one end of the ribbon (2). Sometimes the ribbon forms a loop at one end, and the two ends twist round one another spirally in opposite directions (3). In other cases, not so common, the loop is near the centre of the ribbon (4).

Besides the glands already described there are in the male a pair of simple rod-like bodies lying at the hinder end of the body outside the nerve-cords, and running down towards the generative aperture. These bodies (Plate LXXII. fig. 3, *a. g*) are in the fresh state conspicuous from their pearly whiteness. When examined under the microscope they appeared to consist of simple tubes lined with a single layer of gland-cells. They are probably accessory generative glands; but their mode of termination was not made out, nor was much attention paid to their structure.

Development.—When the uterus filled with embryos was found in the first specimen of *Peripatus* dissected, it was hoped that all the stages in development, or many of them, might be observed amongst the many embryos in the one specimen. It was, however, found that the whole of the thirty or more embryos were in exactly the same stage, which is that shown in Plate LXXV. fig. 3.

In only two cases were embryos found in the same mother, some of which were more advanced than others. In these two the period of pregnancy appeared to be just the same, and the embryos were just in that condition in which the first pair of members were turning in to become the jaws (figs. 6, 7, 8). A regular gradation showing this change was found in each case. No serial arrangement of the embryos of various stages in the uterine tubes was observed. The youngest stages in development were not met with in the twenty specimens dissected, though, as before mentioned, one still virgin female was found, and therefore the earliest stages should still have been to be met with. The stage apparently youngest, and in which the ovum was smallest, is that shown in Plate LXXIV. fig. 1, *a*; but the embryos in this case, or ova, appeared to have perished or become injured. There were very few in the uterine tubes, and they all appeared somewhat collapsed. In several cases embryos which had perished and become formed into opaque masses of fatty and fibrous tissue were met with situate in their somewhat shrunken uterine enlargements between other perfectly healthy embryos.

The embryos lie within the ovoid cavities of the uterine tube, quite free and unattached. They are enveloped in a single very thin pellucid envelope, which encloses an ovoid cavity within which the embryo lies coiled up.

The earliest stage observed is that shown in Plate LXXV. fig. 1. The embryo is worm-like; the hinder part of the body is coiled up spirally with the ventral surface inwards, the anterior extremity being free and nearly straight. The body shows a distinct segmentation about its middle, but there are no transverse lines of segmentation between the large rounded cephalic lobes and the next segment, nor in the hinder part of the body. The three layers of the embryo are already differentiated, and the body-cavities closed in. A line following the contours of the body shows the line of separation of the cutaneous layer. The future intestinal tract is represented by a dark elongated mass of pigmented matter stretching from a pointed anterior extremity, which protrudes within the cephalic lobes, all along the body. The intestine shows bulgings corresponding to the segmental elevations of the cutaneous layer. Three rounded elevations of the cutaneous layer, marking the commencement of the three first pairs of members, are distinctly to be seen projecting from the under surface of the body on its ventral aspect. There is as yet no trace of antennæ, and no trace of the mouth was to be found. The as yet rudimentary members marked 1, 2 probably correspond to those marked 1, 2 in fig. 2.

The next stage is to be seen in fig. 2. The antennæ have budded out and show themselves as broad, blunt-ended, unsegmented processes arising from the upper surfaces of the cephalic lobes. In rising up from the lobes they carry processes of the cephalic cavity with them. In the roof and sides of the cephalic cavity a fold rises up and indicates a separation of the cavity into two. The mouth appears as a simple opening situate between the cephalic lobes inferiorly, and bounded by a line of thickened tissue. The lateral members become more and more developed serially from before backwards; they do not bud off from the end of the body, but transverse lines of segmentation first appear between the terminal portion of the body and the already formed members. A lateral rounded swelling gradually forms above these lines, becomes more and more prominent, and thus forms at last a projecting fold of tissue, the basis of the future member. The transverse lines disappear as the members become formed. The second pair of members is larger and longer than the rest. The first pair is larger than the remainder, and becomes a conspicuous mark by which to determine the identity of those on each side of them in further stages. The intestinal tract shows an enlargement at its anterior extremity; it sends out processes of its lateral wall to meet the tissue at the interspaces of the feet. Between the first pairs of members it shows a slight bulging. There is as yet no anus formed. The lateral undulations or swellings of the body-wall, which are the first stages of the limbs, are hollow, a somewhat oval cavity being formed between them and a corresponding but opposite inward curve of the digestive tract (Plate LXXIII. fig. 9). The undulation of the limb itself is built up of two layers of cells, separated by a very distinct line. The inner layer is composed of small rounded or spindle-shaped cells. The lateral projections of the digestive tract adhere to the inner layer at the interspaces between the undulations. The wall of the digestive tract is covered with a layer of cells continuous with and similar to those of the inner layer of the members, and probably a reflection of the same layer. The members as they project further and further outwards become hollow loops, which later become solid by proliferation of the cells of the inner layer. The large cavity in the cephalic lobes corresponds exactly to the cavities formed in the members. The digestive tract is in this stage filled with darkly pigmented rounded particles and fine granules. The tract assumes gradually a brick-red colour, which increases in intensity, and eventually in later stages renders the embryo very conspicuous.

In the next stage observed (Plate LXXV. fig. 3) the embryos have reached a length of from 5 to 5·5 millims. Since the most fully developed specimen was no longer than this, it is probable that this is about the length of the young when born. All the pairs of members are formed, but the anterior are more perfectly shaped than the posterior. The antennæ show a commencement of jointing; the cephalic lobes show a line of depression, indicating more plainly a division into two segments. The second pair of members is still the largest, but the first is somewhat smaller than the third. A bifid saddle of yelk is seen on the dorsal surface of the embryo opposite the seventh, eighth, and ninth pairs of members. More investigation is required about this yelk-mass; it was not observed in the early stage (fig. 1) at all. It was observed in one specimen of the very late stage (fig. 10), but often not in intermediate stages. It may have been overlooked, but possibly is not constant. The embryo in the stage shown in fig. 3 is coiled up within its envelope in the manner shown in fig. 4, and retains this posture till the latest stage observed. The body is bent round in an oval form, and the posterior extremity bent up and applied against the front of the cephalic lobes between the pair of tentacles. The full number of body-members having been attained at this early age, the further advance of the front segments only will be followed, viz. those which form the parts about the mouth. Buds (fig. 5, *m*) grow out backwards from the hinder part of the cephalic lobes. In one case, shown in fig. 5, the buds appeared double; at all events, only the larger one develops. The first pair of limbs have shrunk a little in proportion to the rest, though the second still remains very large, as is seen in fig 6, which represents a lateral view of nearly the same stage as fig. 5. When the members are said to shrink, it is intended of course that the other members outgrow them. The first pair of members gradually turn inwards (fig. 7, 1), and are overlapped by the elongations of the processes of the cephalic lobes (*m*). A rounded process grows downwards over the mouth from the front wall of the head in the median line; a transverse elevation arises beneath the mouth opposite to this and between the upper edges of the second pair of members. The eyes appear (*e*) at this stage as oval aggregations of cells derived from the internal masses of cells of the head, and covered externally by transparent rounded elevations of the epidermic layer, the future corneæ.

The first pair of members pass further inwards (fig. 8), and their claws appear. The head-processes (m) grow right down over their bases; the superior and inferior median projections (labrum and labium) become more prominent, the labrum covering the mouth gradually over. At the bases of the second pair of members (oral papillæ) are seen through the skin the openings of the ducts of the slime-glands, which will eventually terminate at their tips.

A defined secondary cavity or mouth is already shut in around the true mouth by the rising up of surrounding structures. The head-processes become lengthened or raised into tumid folds on their inner margin, the future tumid lips of the adult; they grow on and fuse with the structures about the bases of the oral papillæ (Plate LXXV. figs. 9 & 10), and the first pair with their developing claws become shut entirely within the secondary mouth. The head-processes extend their inner margin up on to the front of the head, where there rise up tumid processes which swell up above the labrum, and eventually shut it out from view, join the swellings on the inner margin of the head-processes, and thus complete the characteristic tumid lip-ring of *Peripatus*. The latest stage observed is seen in fig. 10. A sulcus persists in the lips of the adult *Peripatus*, which probably represents the line of separation between the lips of the mouth-processes and the structures with which they fuse. The antennæ become gradually more slender in proportion to their length, and acquire a greater and greater number of joints. The number of joints in the antennæ is a sure indicator of the stage of development of the parts of the mouth. The most developed embryo observed possessed seventeen joints in the antennæ; in the adult certainly as many as thirty are present. It would be of interest to observe whether the embryos at the time of birth possess the full number of joints in their antennæ.

The members which become ambulacral in function and the oral papillæ, become in development at first two- or three-jointed and eventually five-jointed. They thus have the number of joints so remarkably constant in insects. In the adult five joints can also be made out in the ambulacral members, the first joint or coxa being very long proportionately to the rest, and marked with closely approximated rings. The other joints are short, except the last claw-bearing joint or tarsus, which is fine and neat like that of many insects. In *Scolopendra* the first pair of feet, modified into prehensile jaws, has five joints, including the claw, and perhaps the more numerous joints of the other feet are derived by secondary jointing from a like number.

The claws are developed at the bottom of depressions or invaginations formed at ends of members, and are derived from the epidermic layer (Plate LXXV. fig. 12). They appear late, having been first observed in the latest stage which was found. The mouth-claws, or jaws, are represented in fig. 11, from an embryo in the stage shown in fig. 10. I have no papers at hand in which the development of the parts of the mouth in Myriopods or Insects are described at length, but am only able to refer to NEWPORT'S conclusions on the subject in his well-known papers already quoted *.

* NEWPORT, Linn. Trans. vol. xix. 1843, p. 265.

NEWPORT came to the conclusion that the head in *Scolopendra* was built up of eight segments, with appendages and outgrowths as follows:—

First segment.		Antennæ.
Second	„	Eyes and labrum.
Third	„	Dental plates=" mandibles" of modern writers.
Fourth	„	First pair of maxillæ.
Fifth	„	Second pair of maxillæ.
Sixth	„	Mandibles=" foot-jaws" of modern writers.
Seventh	„	0
Eighth	„	0

The actual mode of development of the parts is not described. The eye-segment may be disregarded, the eyes of Arthropods being now for so many reasons not regarded as homologous with appendages. The cephalic lobes, as already described, show early traces of a division into two segments, anterior and posterior. The downward growths of the hinder parts of the head would appear, then, to be homologous with the mandibles of *Scolopendra*, and the process between them with the labrum. The oral papillæ or shrunken second pair of members must most probably represent the foot-jaws of *Scolopendra*, their glands representing their poison-glands, and probably also the silk-glands of caterpillars. If this be the case, then the jaws developed from the first pair of members must be maxillæ; but we have two pairs of jaws developed from one pair of appendages, the jaws being evidently merely the modified claws of the ambulacral members. In *Scolopendra*, according to NEWPORT, the biting-parts of the maxillæ are sternal and episternal in origin, the claws terminating the palpi. Are these two pairs of jaws homologous with the two pairs of maxillæ of *Scolopendra*, or do they only represent one pair? If only one pair, then do the oral papillæ represent the second? On these questions appears to depend the homology of the mesially indented line showing a ridge stretching between the bases of the oral papillæ. This, if the oral papillæ are homologous with the foot-jaws of *Scolopendra*, represents the second under lip of that animal, which is formed of the fused sternal and episternal plates of the segment to which the foot-jaws belong, and is slightly notched anteriorly as here.

CONCLUSION.

In the present state of our knowledge concerning the structure of *Peripatus*, the most remarkable fact is the wide divarication of the ventral nerve-cords. The fact was considered remarkable and dwelt upon in all mention of *Peripatus* before the existence of tracheæ in the animal was known, and when it was thought to be hermaphrodite, but it is doubly remarkable now. The fact shuts off at once all idea of *Peripatus* being a degenerate Myriopod, the evidence against which possibility is overwhelming. The bilateral symmetry and duplicity of the organs of the body, the absence of striation in the muscles, the absence of periodical moults of the larval skin in development, and the absence of any trace of primitive three-legged condition, taken in conjunction with the divarication of the nerve-cords, are conclusive. The parts of the mouth are not to be regarded as degraded to any great degree; and homologies for some of them, at least, may perhaps be found amongst the higher Annelids. The structure of the skin is not at all unlike that in some worms, especially in its chitinous epidermic layer, which strips off in large pieces occasionally as a thin transparent pellicle. The many points of resemblance of *Peripatus* to Annelids need not be dwelt upon; they led to its former placing in classification; but it is difficult to understand how the very unannelid-like structure of the foot-claws did not lead others, like DE QUATREFAGES, to draw a line between the two. In being unisexual, *Peripatus* is like the higher Annelids, as well as the whole of the higher Tracheata. To Insects *Peripatus* shows affinities in the form of the spermatozoa, and the elaboration, structure, and bilateral symmetry of the generative organs, though there is a very slight tendency towards the unilaterality of Myriopods in the male organs.

To Insects, again, it is allied by the five-jointing of the feet and oral papillæ and the form and number of its claws. It should be remembered that spiders' feet are two-clawed, and those of some Tardigrades, and that some of these latter forms have two-clawed feet in the early condition, even when they possess more claws in the adult state. In NEWPORT'S well-known figure of the young *Iulus* with three pairs of limbs, the tips of these latter are drawn with *two* hair-like claws; these are not mentioned in the text.

To the ordinary lepidopterous larva the resemblances of *Peripatus* are striking—the gait, the glands (so like in their function and position to silk-glands), the form of the intestine, the less perfect concentration of the nervous organs in larval insects. To Myriopods *Peripatus* is allied by the great variety in number of segments in the various species and in its habits, and especially in these to *Iulus*. The parts of the mouth perhaps show a form out of which were derived by modification those of *Scolopendra*; but the resemblance may be superficial. Our knowledge is not yet sufficient to determine such points. The usual difficulties occur in the matter. Segments may have dropped out or fused, and their original condition may not be represented at all in the process of development. In structure *Peripatus* is more like *Scolopendra* than *Iulus*, viz. in the many joints to the antennæ (Chilognaths having never more than fourteen), in the form of the spermatozoa, and in being viviparous, as are some Scolopendras; in the position of the orifices of the generative glands, and in the less perfect concentration mesially in *Scolopendra* of the nerve-cords. *Peripatus* thus shows affinities in some points to all the main branches of the family tree of Tracheata; but a gulf is fixed between it and them by the divarication of the nerve-cords, and borne out somewhat by such facts as the non-striation of the muscles, great power of extension of the body, arrangement of the digestive tract in the early stage, persistence of metamorphosis, and in the parts of their mouth, the full history of the manner of origin of these being reserved.

Speculations as to the mode of origin of the tracheæ themselves in the Tracheata are many. Prof. HAECKEL * follows GEGENBAUR, whose opinion is expressed in his 'Grundzüge der vergleichenden Anatomie,' 2nd edit. p. 441. GEGENBAUR concludes that tracheæ were developed from originally closed tracheal systems through the intervention of the tracheal gills of primæval aquatic insects now represented as larvæ. If *Peripatus* be as ancient in origin as is here supposed, the condition of the tracheal system in it throws a very different light on the matter. *Peripatus* is the only Tracheate with tracheal stems opening diffusely all over the body. The Protracheata probably had their tracheæ thus diffused, and the separate small systems afterwards became concentrated along especial lines and formed into wide main branching trunks. In some forms the spiracular openings concentrated towards a more ventral line (*Iulus*); in others they took a more lateral position (Lepidopterous larvæ, &c.). A concentration along two lines of the body, ventral and lateral, has already commenced in *Peripatus.* The original Protracheate being supposed to have had numerous small tracheæ diffused all over its body, the question as to their mode of origin again presents itself. The peculiar form of the tracheal bundles in *Peripatus*, a number of fine tubes opening into the extremity of a single short common duct leading to the exterior of the body, seems to give a clue. The tracheæ are, very probably, modified cutaneous glands, the homologues of those so abundant all over the body in such forms as *Bipalium* or *Hirudo.* The pumping extension and contraction of the body may well have drawn a very little air, to begin with, into the mouths of the ducts; and this having been found beneficial by the ancestor of the Protracheate, further development is easy to imagine. The exact mode of development of the tracheæ in present forms must be carefully studied; there was no trace of them in the most perfect stage of developing *Peripatus* which I obtained.

Prof. GEGENBAUR'S † opinion on the position of *Peripatus* is, that the placing of it amongst the worms is not certain, but that, at any rate, it connects ringed worms with Arthropods and flat worms. The general result of the present inquiry is to bear out Prof. GEGENBAUR'S opinion, but points to the connexion of the ringed and flat worms, by means of this intermediate step, with three classes only of the Arthropods—the Myriopods, Spiders, and Insects, *i. e.* the Tracheata. From the primitive condition of the tracheæ in *Iulus*, and the many relations between *Peripatus* and *Scolopendra*, it would seem that the Myriopods may be most nearly allied to *Peripatus*, and form a distinct branch arising from it, and not passing through Insects. The early three-legged stage may turn out as of not so much significance as supposed. If these speculations be correct, the Crustacea have a different origin from the Tracheata. *Peripatus* itself may well be placed amongst Prof. HAECKEL'S Protracheata; GRUBE'S term Onychophora becomes no more significant than DE BLAINVILLE'S Malacopoda. Some notions of the actual history of the origin of *Peripatus* itself may be gathered from its development.

In conclusion I would beg indulgence for the many defects in this paper, due to the hurry with which it is written (all available time, almost up to the last moment of our

* Biologische Studien, p. 491.

† Grundzüge der vergleichenden Anatomie, p. 199.

sailing for the Antarctic regions, having been consumed in actual examination of the structure of *Peripatus*), and due, further, to the impossibility of referring in any scientific library to original papers. At all events it is hoped that *Peripatus* has been shown to be of very great zoological interest, as lying near one of the main stems of the great zoological family tree, and that further examination of the most minute character into the structure of this animal will well be repaid.

Description of the Plates.

(The whole of the Plates represent structures occurring in *Peripatus*.)

PLATE LXXII.

Dissection of *Peripatus*, drawn by Mr. J. J. Wild.

Fig. 1. Female laid open from the back, to show the general arrangement of the viscera. *a.* Antennæ; *c. g.* Cephalic ganglia; *v. c.* Ventral nerve-cords; *op.* Optic nerve; *n.* Nerve to the papilla, in which the ejaculatory duct of the slime-gland terminates.

x. Lateral canals of Grube = "fat-bodies."

s. g. Slime-glands = testes of Grube.

e. s. Muscular ejaculatory sacs of these glands.

r. m. Retractor muscles of the head.

p. Pharynx with a pair of small linear protractor muscles on its upper surface. *œ.* Œsophagus.

s. Stomach.

i. Intestine.

an. Anus.

o. Ovary.

od. Oviduct.

u. Tubular uterus. The successive constrictions separate off sacs, each of which contains an embryo in process of development.

k. Overhand knot formed by the oviduct over the bight of the uterus. The two tubes of the uterus join into a common canal behind the intestine close to the vulva.

On the inner surfaces of the reflected walls of the body are seen the numerous minute bunches of tracheæ. Especially large groups of tracheæ (*tr. tr.*) pass to the underside of the intestine and of the pharynx from the middle line of the ventral surface.

Fig. 2. Inner surface of a portion of the ventral and lateral walls of the body spread out flat and magnified four times, to show the manner in which the tracheæ form tree-like appearances.

The tracheæ here are represented, for convenience of drawing, as dark on a light ground; in reality, when observed by reflected light, they have the usual pearly lustre so characteristic of tracheæ when full of air. Exteriorly to the ventral nerve-cords (*v.c. v.c.*) are seen the rows of openings communicating with the feet, and probably vascular, described by GRUBE.

Fig. 3. Hinder part of the body of male *Peripatus*, laid open from the back. The stomach and short intestine have been turned down, in order to show the arrangement of parts behind them.

v.s. Vesiculæ seminales; *t.* Testes; *pr.* Prostate; *v.d.* Vasa deferentia; *p.* Enlargement of azygos terminal portion of male duct, ejaculatory duct, or penis? *a.g.* Accessory gland; *v.c.* Ventral nerve-cords; *s.* Stomach; *i.* Intestine.

PLATE LXXIII.

Fig. 1. Tracheal twig from the wall of the uterus, to show the manner of branching. Branching, however, is very exceptional.

Fig. 2. *a.* Arrangement of the tracheæ on wall of one of the fine tubes of the slime-gland. There is here no branching.

b. Small portion of one of these tracheæ as seen with HARTNACK'S No. 8, ocular 3. Transverse lines indicate the existence of an internal spiral band, which is broad in proportion to the diameter of the tube. Actual diameter of the tube ·003 millim.

Fig. 3. Cells from the mucous surface of the stomach.

a. Liver-cell; *b.* Slime-cell; *c.* Aggregation of oil-globules. Actual diameter of liver-cell ·04 millim.; others in proportion.

Fig. 4. Portion of one of the viscid threads which are shot out by *Peripatus* and form meshworks.

Fig. 5. Vertical and transverse section through the ventral wall of the body, to show the origin of the tracheæ.

a. Epidermis, by reason of the thickness of the section, showing to the left two of the warty protuberances with which the surface of the animal's body is covered.

b. Region occupied by oblique or decussating muscular fibres.

c. Layer of transverse muscles.

From a pit at the base of one of the cutaneous warts arises a simple short tube, from the inner end of which pass off an enormous number of fine tracheæ. These latter do not branch, but arise all directly from the end of the tube, and at their origin are so closely packed as, with their contained air, to prevent the transmission of any light. Some of the tracheæ of the bundle are distributed at once to the skin and muscles.

Fig. 6. Polygonal flat endothelium lining the ejaculatory sac of the slime-gland. Length of one of the longest cells ·06 millim.

Fig. 7. Structure of one of the ultimate ramifications of the slime-gland. Actual diameter of the tube ·2 millim.

Fig. 8. Muscular fibres.

a. Fibre in state of contraction, which has taken a somewhat spiral form. The shading gives somewhat the appearance of transverse striation.

b. Portion of a fibre as seen under HARTNACK'S No. 10, ocular 3.

Fig. 9. Portion of an embryo *Peripatus* in the condition seen in Plate LXXV. fig. 5, viewed in optical section to show the cell arrangement. The figure is taken from the hinder portion of the body, and represents one of the undulations of the lateral margin constituting the commencement of a member.

a. External or epidermic layer.

b. Middle layer.

c. Dark mass of pigmented granules and oil-globules, out of which is to be formed the intestine.

The middle layer is reflected over the intestine, which projects outwards to meet the body-wall in the interspaces between the members.

PLATE LXXIV.

Fig. 1. *a.* Ovary, oviducts, and commencement of uterus. The oviduct, as represented, is somewhat too short. Actual diameter of the ovarian ova ·175 millim. The ovary is divided by a median longitudinal partition into two sacs. The dark longitudinal masses within these sacs are composed of felted spermatozoa. Other groups of spermatozoa are seen at the margins of the ovary in relation with the ova. The oviducts at a short distance from the ovary are well supplied with tracheæ, which are, however, wanting on the ovary itself. On the left in the commencing uterus is seen a developing ovum; its peculiar shape is believed to be due to partial collapse.

b, c, d. Successive stages in the development of the ovum from a female specimen the ovary of which was not yet ripe and contained no spermatozoa, and in which there were no embryos in the uterus.

Figs. 2, 3. Cells from the testis of a male specimen, as seen in the fresh state, showing the mode of development of the spermatozoa.

Fig. 4. Further development of the spermatozoa.

a, b. Vesicles of evolution, with the heads of the spermatozoa coiled within them and the long tails projecting freely. Each spermatozoon has its nucleus attached.

c, d, e. Spermatozoa freed from the vesicle of evolution, but with the nucleus still attached. A slightly granular substance is visible, in most cases intervening between the nucleus and edges of the loop in which it lies.

Fig. 5. Spermatozoa without a nucleus, from the ovary of a female specimen, and as they occur in the lower part of the vas deferens of the male, mingled, however, there with others retaining the nucleus and free nuclei.

The actual length of the ripe spermatozoa appears to be about three times that of an ovarian ovum, or about ·5 millim.

PLATE LXXV.

Various stages in the development of *Peripatus*, from embryos taken from the uterus of various female specimens.

Fig. 1. Earliest stage of the embryo observed, as seen within its envelope; the cephalic lobes are formed; the anterior part of the body shows a definite segmentation. On the three segments immediately succeeding the cephalic, the outer layer is rising up to form the members.

Fig. 2. Embryo, somewhat more advanced, removed from the envelope and viewed from the ventral surface by transmitted light in optical section.

a. Antennæ. *c*. Cephalic lobes. 1. First pair of body-members, forming later the maxillæ. 2. Second pair, perforated later by the ejaculatory duct of the slime-gland. 3. Third pair, afterwards first pair of ambulacral appendages.

o. Mouth. *i*. Intestine. (The same numbers and letters in the succeeding figures have the same signification.)

The second pair of members are the longest, and continue so for a considerable period; ultimately in the adult each is represented only by a small papilla.

The cephalic lobes are hollow; a fold rising up in the roof of their cavity divides them into two. Their structure is identical with that of the posterior members (see Plate LXXIII. fig. 9). The limbs first appear as undulations of the body-wall; they form from before backwards, and anteriorly to the segments of the body. Before the appearance of the members segmentation of the body is marked by a transverse line. The segmentation disappears after the members are formed. The intestine is connected by lateral projections with the folded interspaces between the limbs (see Plate LXXIII. fig. 9).

Fig. 3. Embryo in a further state of advancement removed from the envelope, and as seen by reflected light: *a*, from behind; *b*, from in front. The number of body-members is complete, viz. nineteen, of which the first becomes the oral and the nineteenth the anal papilla. A saddle-shaped mass of yelk remains on the dorsal surface opposite the seventh, eighth, and ninth pairs of members. The mouth and anus are sketched out; the cephalic lobes (*c*) show a lateral depression dividing them into two regions, anterior and posterior. The anterior members are most perfectly formed; the antennæ (*a*) already show jointing. Actual length 5·5 millims.

Fig. 4. Embryo in the same stage as the preceding, to show the manner in which it lies coiled up in its envelope within the uterus. The tip of the posterior extremity rests in the space between the antennæ and against the front of the cephalic lobes.

Fig. 5. A very slightly more advanced stage, much magnified.

m. The buds which form the processes corresponding to the mandibles of Myriopods.

Fig. 6. Slightly further advanced stage, seen from the side. *m* as before.

Fig. 7. More advanced. The first pair of body-members (1) is turning inwards towards the mouth, and is overlapped by the down-growing processes (*m*). The labrum (*l*) begins to cover over the mouth.

Fig. 8. Further stage. The processes (*m*) have come further down over the members (1). These members have turned further inwards towards the mouth; and on each there is seen one claw of the pair of claws which they bear in common with the ambulatory members, and which are modified into the horny jaws = maxillæ.

e. Commencement of the eye; *d*. End of duct of slime-gland.

Fig. 9. Further stage. Both masticating claws are visible on each side. The process (*m*) is much folded on its inner margin, and its folds extend up on to the cephalic lobes. It has fused with the superficial structures about the base of the first and second pair of members (1 and 2), and thus the formation of the tumid plications surrounding the external oral aperture in the adult is nearly completed.

Fig. 10. The plications extending from the base of the processes (*m*) are continuous across the cephalic lobes, and the labrum is thus shut in with the maxillæ within the external oral aperture. The antennæ exhibit a very advanced state of jointing.

Fig. 11. Maxillary claws from the specimen figured in fig. 10.

a. Anterior; *b*. Posterior claw.

Fig. 12. Ambulatory member from the same, showing the way in which the claws appear in induplications of the extremities of the members.

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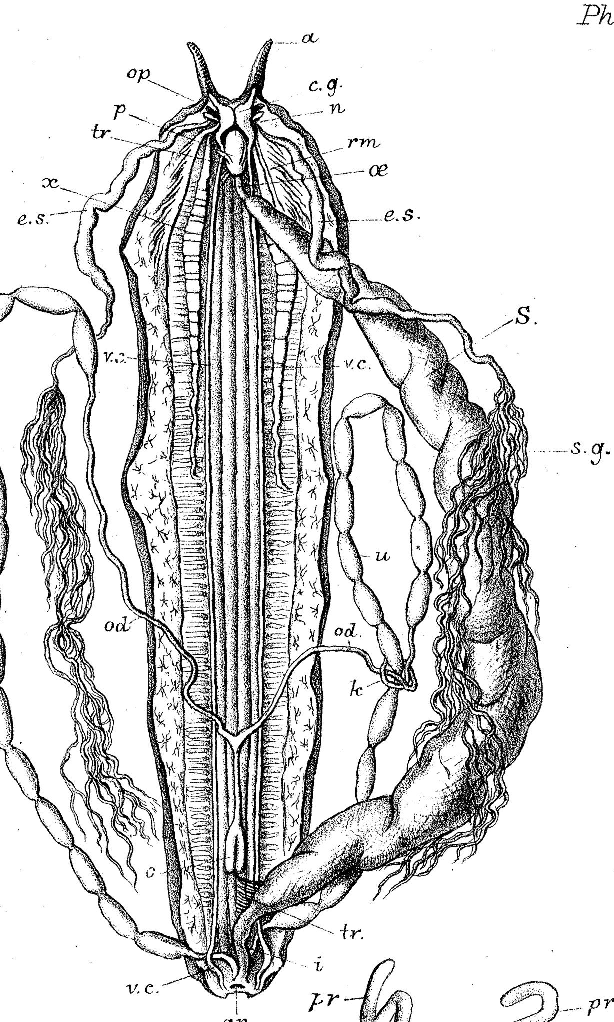
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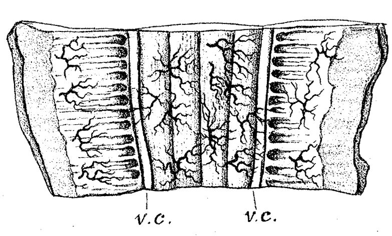
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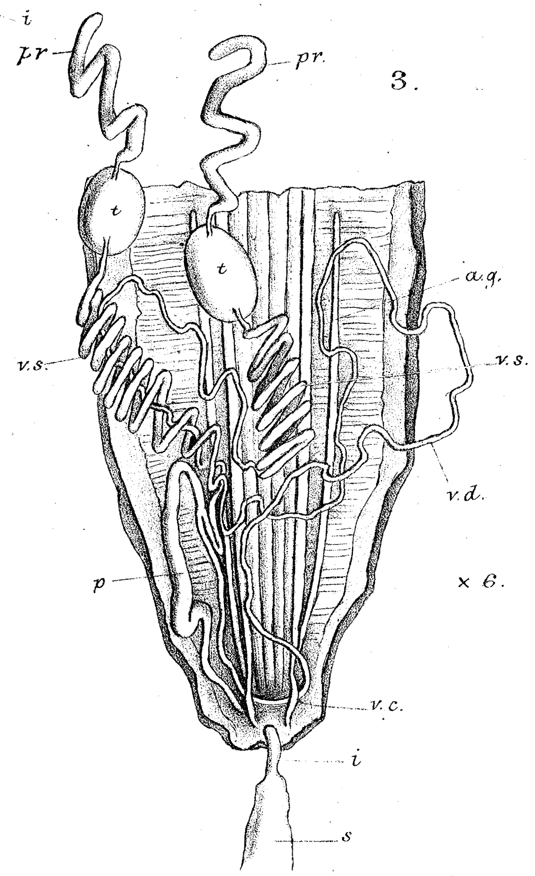
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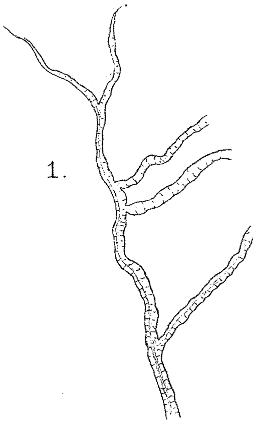

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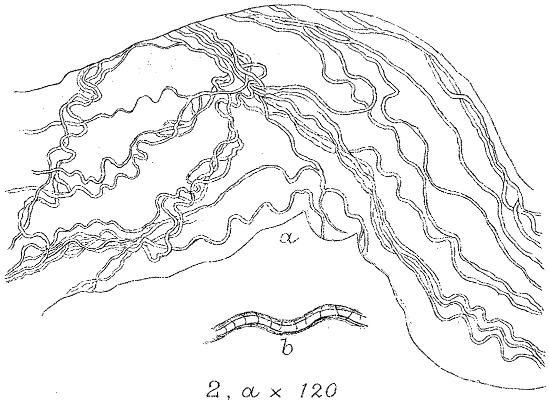

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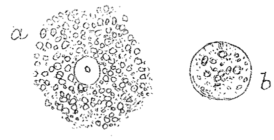

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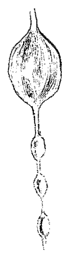

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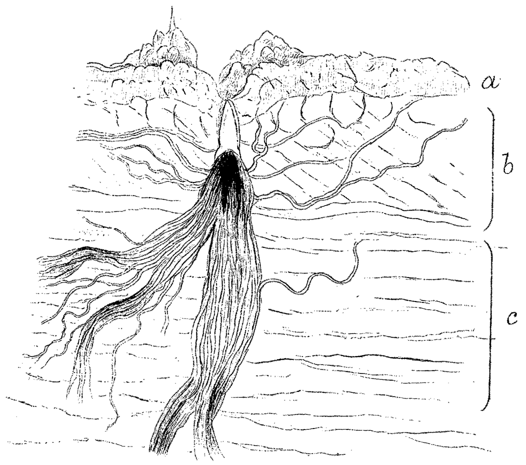

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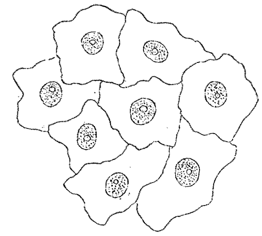

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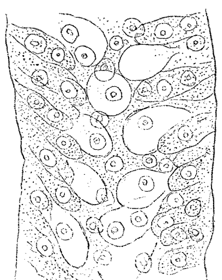

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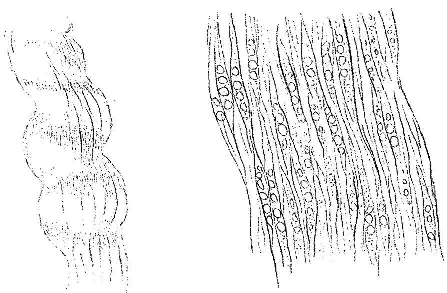
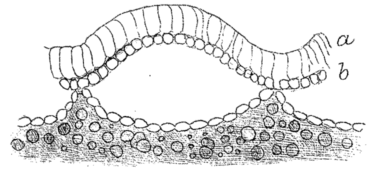


a × 200 8. b × 500



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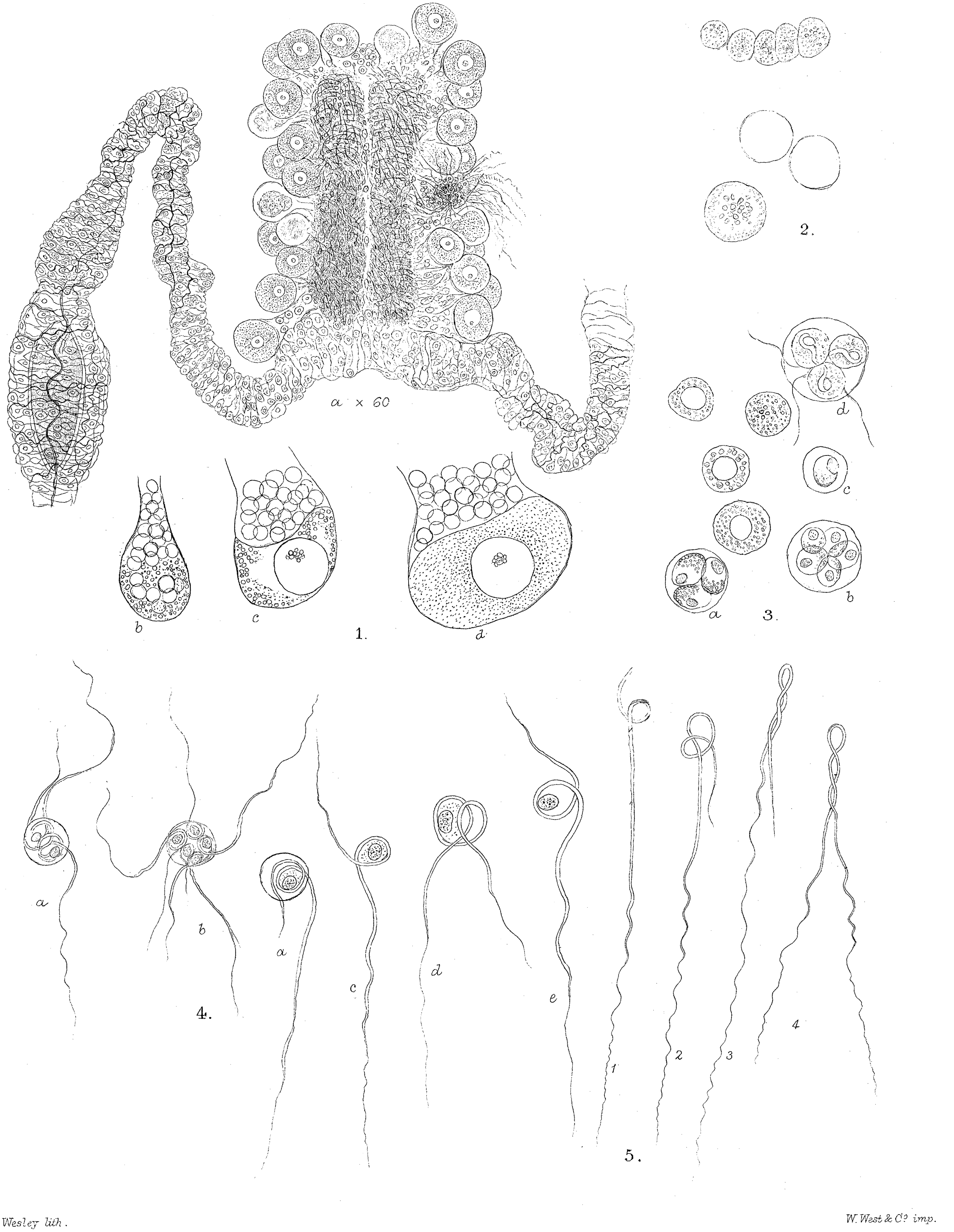

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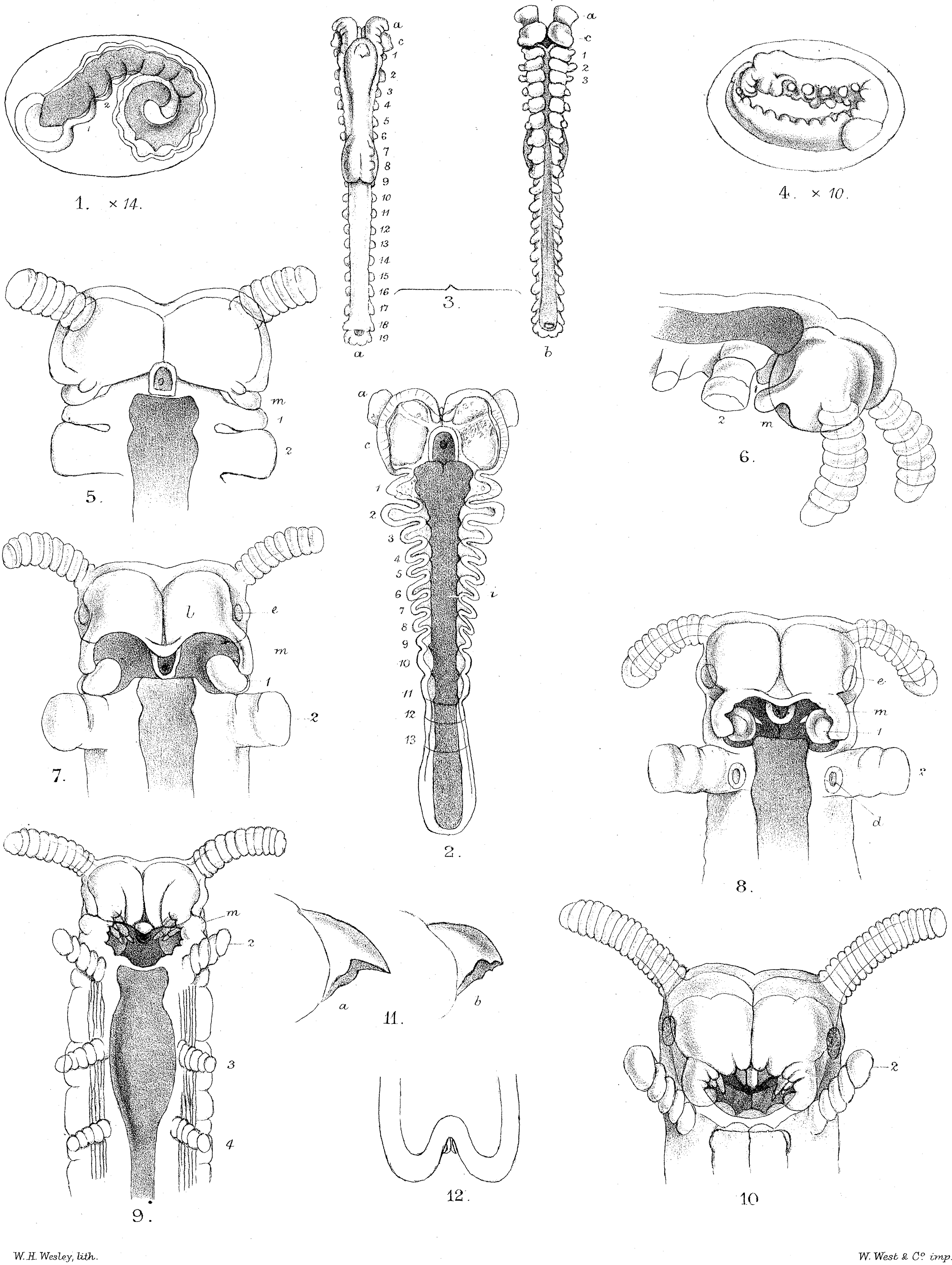

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