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Liverpool Marine Biology Committee.

L.M.B.C. MEMOIRS

ON TYPICAL BRITISH MARINE PLANTS & ANIMALS

EDITED BY W. A. HERDMAN, D.Sc., F.R.S.

VII.

LINEUS

BY

R. C. PUNNETT, B.A.

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(With 4 Plates)

PRICE TWO SHILLINGS.

LONDON
WILLIAMS & NORGATE
APRIL, 1901

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VII.

LINEUS

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,, VI. Lepeophtheirus and Lernæa—published in March, 1901, 62 pp. and five plates, price 2s.
,, VII. Lineus—now ready (April, 1901) 37 pp. and four plates, price 2s.

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APRIL, 1901

EDITOR'S PREFACE.

The Liverpool Marine Biology Committee was constituted in 1885, with the object of investigating the Fauna and Flora of the Irish Sea.

The dredging, trawling, and other collecting expeditions organised by the Committee have been carried on intermittently since that time, and a considerable amount of material, both published and unpublished, has been accumulated. Fourteen Annual Reports of the Committee and five volumes dealing with the "Fauna and Flora" have been issued. At an early stage of the investigations it became evident that a Biological Station or Laboratory on the sea-shore nearer the usual collecting grounds than Liverpool would be a material assistance in the work. Consequently the Committee, in 1887, established the Puffin Island Biological Station on the North Coast of Anglesey, and later on, in 1892, moved to the more commodious and convenient Station at Port Erin in the centre of the rich collecting grounds of the south end of the Isle of Man.

In these thirteen years' experience of a Biological Station (five years at Puffin Island and eight at Port Erin), where College students and young amateurs formed a large proportion of the workers, the want has been constantly felt of a series of detailed descriptions of the structure of certain common typical animals and plants, chosen as representatives of their groups, and dealt with by specialists. The same want has probably been felt in other similar institutions and in many College laboratories.

The objects of the Committee and of the workers at the Biological Station have hitherto been chiefly faunistic and speciographic. The work must necessarily be so at first when opening up a new district. Some of the workers have published papers on morphological points, or on embryology and observations on life-histories and habits; but the majority of the papers in the volumes on the "Fauna and Flora of Liverpool Bay" have been, as was intended from the first, occupied with the names and characteristics and distribution of the many different kinds of marine plants and animals in our district. And this faunistic work will still go on. It is far from finished, and the Committee hope in the future to add greatly to the records of the Fauna and Flora. But the papers in the present series are quite distinct from these previous publications in name, in treatment, and in purpose. They will be called the "L.M.B.C. Memoirs," each will treat of one type, and they will be issued separately as they are ready, and will be obtainable Memoir by Memoir as they appear, or later bound up in convenient volumes. It is hoped that such a series of special studies, written by those who are thoroughly familiar with the forms of which they treat, will be found of value by students of Biology in laboratories and in Marine Stations, and will be welcomed by many others working privately at Marine Natural History.

It is proposed that the forms selected should, as far as possible, be common L.M.B.C. (Irish Sea) animals and plants of which no adequate account already exists in the text-books. Probably most of the specialists who have taken part in the L.M.B.C. work in the past, will prepare accounts of one or more representatives of their groups. The following have already promised their services, and in many cases the Memoir is already far advanced. The first Memoir appeared in October and the second in December, 1899, the third in February, and the fourth in April, 1900, the fifth in January, and the sixth in March, 1901, while this seventh one will be ready early in April; others will follow, it is hoped, in rapid succession.

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GIGARTINA, O. V. Darbishire.
PLAICE, F. J. Cole and J. Johnstone.
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DENDRONOTUS, J. A. Clubb.
PERIDINIANS, G. Murray and F. G. Whitting.
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CALCAREOUS SPONGE, R. Hanitsch.
ARENICOLA, J. H. Ashworth.
ANTEDON, H. C. Chadwick.
PORPOISE, A. M. Paterson.

In addition to these, other Memoirs will be arranged for, on suitable types, such as *Sagitta* (by Mr. Cole), a Cestode and a Turbellarian (by Mr. Shipley), *Carcinus*, an Amphipod, and a Pycnogonid (probably by Dr. A. R. Jackson).

As announced in the preface to Ascidia, a donation from Mr. F. H. Gossage of Woolton met the expense of preparing the plates in illustration of the first few Memoirs, and so enabled the Committee to commence the publication of the series sooner than would otherwise have been possible. A second donation received since from Mr. Gossage, and another recently from Mrs. Holt, are regarded by the Committee as a welcome encouragement, and will be a great help in carrying on the work.

W. A. Herdman.

University College, Liverpool,
April, 1901.

L.M.B.C. MEMOIRS.

No. VII. LINEUS.

BY

R. C. PUNNETT, B.A.

Introduction.

Since the time when it was first noticed by Pallas, in 1766, as "alia Lumbrici species marini tota atra," the Nemertean now known as *Lineus gesserensis* (which we choose as our type) has been the recipient of no less than 10 generic and 13 specific names associated together in various permutations and combinations. Our knowledge of the habits and anatomy of the worm are chiefly due to *M'Intosh, Barrois, Hubrecht, Oudemans, and Montgomery. Varying in size from about 6-20 cm., it is one of the commonest Nemerteans of our shores, occurring abundantly, and frequently in tangled masses, under stones between tidemarks and in the laminarian region.

* M'Intosh, W. C.—British Annelids, The Nemerteans, London, 1873.

Barrois, J.—Embryologie des Némertes, Annales des Sciénces Naturelles, Paris, 1877.

Hubrecht, A. A. W.—Contributions to the Embryology of the Nemertea, Quart. Journ. of Mic. Sc. 1886.

Oudemans, A. C.—The Circulatory and Nephridial apparatus of the Nemertea. Quart. Journ. Mic. Sc. Supplement, 1885.

Montgomery, T. H.—On the Connective Tissues and Body Cavities of the Nemerteans. Zoolog. Jahr. 1897.

,, Studies on the elements of the Central nervous system of the Heteronemertini. Journal of Morphology. 1897.

Its geographical range is extensive, since it occurs on the shores of both sides of the North Atlantic, extending from Greenland in the North to Madeira on the one side and Florida on the other. It also occurs, though not commonly, in the Mediterranean.

Two very distinct colour varieties are to be met with, viz., reddish brown and olive green—the latter being the more common. Specimens intermediate between these two are also frequent. The colour is more pronounced in front, and is darker on the dorsal surface than on the ventral. The snout and mouth are bordered by pale margins. On the head a reddish patch marks the position of the brain, and a bright red colouration is also found in the head slits which is said to be due to the presence of hæmoglobin. On the snout in front of the brain occur the deeply pigmented eyes usually varying from 3 to 6 in number on each side, though more may be present on one side than on the other.

Of the many openings on the body two may be readily seen—the proboscis pore at the tip of the head, and the mouth on the ventral surface just behind the brain. The anus is small and terminal. Of the other openings the lateral nephridial pores in the œsophageal region can only be made out in sections, whilst the numerous generative pores are at certain seasons visible under a lens as a row of white dots on either side in the intestinal region.

For what is known of the habits of the worm we are chiefly indebted to M'Intosh, who kept them in captivity. He states (in the work above cited) that "*Lineus gesserensis* "progresses in an easy, graceful manner, with slight "undulatory motions of the head, its body being marked "by successive contractile waves, which proceed from "before backwards. The specimens frequently herd "together in the water, which they are prone to leave, and "remain attached to the side of the glass a considerable "time. They are very easily kept in confinement for "years; but, as with many of their allies, great diminu-"tion of bulk occurs, from deprivation of the natural "supply of food. When recently captured specimens are "placed in a jar containing injured Annelida, numerous "fæcal masses, consisting of the bristles of *Nereis pelagica*, "and other annelids and digested matter, are found lying "on the bottom of the vessel, showing how greedily they "have fed: a fact, indeed, very easily ascertained by "actual observation. It is also frequently noticed that "specimens confined in vessels along with the deep green "*Eulalia viridis* assume a similar hue, probably from "feeding on the rejected débris of those animals, if not "upon the latter themselves. In their native haunts the "stones under which they lie are often placed on dark, "muddy, and highly odoriferous sand or gravel, and the "water cannot be otherwise than brackish at the estuary "of a river."

BODY WALL AND MUSCULAR SYSTEM.

The outside of the animal is completely covered with cilia, which are borne by long slender cells (Pl. II., fig. 3), widest externally where they carry the cilia, and narrowing to a very fine process which is somewhat branched, and is inserted into the basement membrane. They contain small elongated nuclei in the more external portion. The larger and more rounded nuclei found in the epidermis are for the most part connected with the large greenish unicellular gland cells occurring all over the skin. These last stain vividly with picric acid or with eosin, and it is probably their contents which give the skin its markedly acid reaction. These two forms of cell constitute the main mass of the epithelium, though it is possible that careful histological work may demonstrate the presence of ciliated cells modified to form sense cells somewhat resembling the rods of the vertebrate eye.

The basement membrane is structureless, and is composed of the intercellular substance around connective tissue cells. It takes a deep stain with hæmatoxylin or nigrosin, though it is apparently unaffected by the carmine dyes. Beneath the basement membrane is found a thin layer of fine circular muscle fibrils, and underneath those again a diffuse layer of small glands, each composed of several cells. The secretion of these cutis glands stains deeply with carmine or hæmatoxylin, and by it the minute ducts of the glands may be traced to their external openings. Mixed up with the cutis glands are numbers of connective tissue cells of a peculiar form containing pigment. These will be referred to later among the connective tissues. Around the cutis glands are also found the most external fibres of the external longitudinal muscle layer. The fibres are separated into a number of small bundles by the connective tissue, a structureless investment exhibiting the same staining affinities as the basement membrane, with which it is probably identical as regards composition.

Separating the outer longitudinal and the circular muscle layers (Pl. II., figs. 1 and 2, Pl. III., fig. 8) is a tunic of nervous tissue, consisting of fibrils given off from the lateral nerve cords, which also lie between the same two muscle layers. The circular muscle layer is on the whole not so thick as the outer longitudinal layer, and of about the same thickness as the inner longitudinal layer which it immediately invests. Towards the posterior portion of the body the outer longitudinal muscle layer becomes greatly diminished, whilst the internal longitudinal layer here surpasses the circular layer in thickness.

A thin layer of dorso-ventral muscles (Pl. III., figs. 6 and 8) is found running along each side of an intestinal diverticulum. In some Lineidæ a horizontal muscle layer runs between the proboscis sheath and œsophagus in the mouth region, but this layer does not occur in the present species. The muscle fibres in the head are continuous with the outer longitudinal layer. The inner longitudinal and circular layers of the trunk are not continued anteriorly beyond the brain. In the head, however, are developed an inner layer of longitudinal and an outer layer of circular fibres round the rhynchodæum and cephalic blood lacunæ (Pl. I., fig. 2).

PROBOSCIS AND PROBOSCIS SHEATH.

The remaining portion of the muscular system is that in connection with the proboscis and its sheath. These two structures commence at the anterior level of the brain, and their relations to one another and to the rhynchodæum may best be gathered from a reference to Pl. II., fig. 7. The proboscis sheath consists of a layer of longitudinal muscle fibres, surrounded externally by a layer of circular ones, and internally invested by the flattened epithelium of its contained cavity, the rhynchocœlom. In its retracted state the proboscis lies in the last-named cavity, and its outer surface is covered by the rhynchocœlomic epithelium.

The internal surface of the proboscis (*i.e.*, in the retracted state) is lined by the high glandular proboscidial epithelium, which is of ectodermal origin, and is continuous with the epithelium lining the rhynchodæum. In other words, the cavities of the retracted proboscis and the rhynchodæum are one and the same, whilst that of the rhynchocœlom is entirely closed and separated from the rhynchodæum by the attachment of the proboscis. When, as sometimes happens, the proboscis is violently extruded and broken off at its attachment the rhynchocœlom and rhynchodæum form a continuous cavity until the proboscis is regenerated. The rhynchocœlom contains a colourless corpusculated fluid.

At its commencement between the rhynchocœlom and rhynchodæum the proboscis consists of a layer of longitudinal muscle fibres covered externally by rhynchocœlomic and internally by proboscidial epithelium (Pl. I., fig. 4, *p.*). Just beneath the last layer are the two proboscidial nerves. Further back the proboscis becomes considerably thicker, and a layer of circular muscles makes its appearance between the longitudinal muscles and the proboscidial epithelium. From this circular layer at two opposite poles, as seen in transverse section, fibres pass through the longitudinal layer to the basement membrane just beneath the rhynchocœlomic epithelium, crossing one another in two directions (Pl. II., fig. 6, *mcr.*). In this way are formed the so-called muscle crosses characteristic of the Lineid proboscis. The crossing is more apparent on one side than on the other. In this region also the proboscidial epithelium is thrown up into papillæ, and is highly glandular, whilst just beneath it there is a complete investing nervous layer which has been formed from the two proboscidial nerves. Still further back (Pl. II., fig. 5), the nervous layer and the circular muscles disappear, so that, except for the absence of the two proboscidial nerves, the appearance of a section taken in this region is somewhat similar to that of one taken near the attachment of the organ (*cf.*, Pl. I., fig. 6).

The proboscis is attached by its hinder end to the dorsal wall of the proboscis sheath about one-third of the length of the animal from the anterior end. This is effected by the longitudinal muscles of the proboscis being continued beyond the proboscidial epithelium and its contained cavity, and fusing with the muscles of the proboscis sheath. The muscular slip so formed has been termed the retractor muscle of the proboscis, though it is doubtful whether it exercises the function which its name implies. Not only does it appear too slender to exert the necessary force, but the distance between its point of attachment to the proboscis sheath and the proboscis pore is considerably less than the length of the proboscis. Such considerations, coupled with the fact that in some nearly allied species no retractor muscle is present, would seem to indicate that, whilst expulsion is due to pressure exerted on the rhynchocœlomic fluid by the circular muscles of the proboscis sheath or of the body wall, retraction is probably accomplished by a peristaltic movement of the proboscis itself. Such a form of movement may be observed in the isolated proboscis, and once gave rise to the view that these worms were viviparous—the extruded and broken-off organ being mistaken for a young worm just born.

THE ALIMENTARY CANAL.

The mouth in the living and active animal is an elongated slit on the ventral surface just behind the brain. When widely open under the influence of a narcotic it becomes circular in outline, and surrounded by a prominent and somewhat rugose lip. In life apparently one of its functions is to act as a sucker, since, when the animal is forcibly removed from the surface on which it rests by a current of water from a pipette, the mouth area retains its attachment more vigorously than the rest of the body.

The œsophagus, into which the mouth leads, is thrown into a number of longitudinal furrows, which largely increase its surface (Pl. II., figs. 1 and 2). It has been suggested that this arrangement may subserve the purpose of respiration, and the vascular network which surrounds this region of the alimentary canal (Pl. II., fig. 2, *oesl.*), lends some support to such a view.

Histologically the œsophagus, like the rest of the alimentary tract, is lined by ciliated epithelium. Squeezed in among the ciliated cells (Pl. IV., fig. 3) is a number of large unicellular gland cells, among which two, or possibly three, types may be distinguished. After staining with borax carmine, followed by picro-nigrosin, many of these gland cells (Pl. IV., fig. 3, β) take a yellow stain. They appear to be full of large coarse granules. Others similarly granulated, though much less numerous, shew an intense crimson colouration (Pl. IV., fig. 3, γ). Except for the difference in staining reaction, these two types are indistinguishable. The greater number of the gland cells, however, present a different appearance. Their contents consist of a coarse spongy network, which presents a slaty-purple hue (Pl. IV., fig. 3, a). Whether these various types are in reality distinct, or whether they represent different stages in a single type, is a question which must be left for future histological investigation to decide.

Besides being found between the ciliated cells, these unicellular gland cells also occur massed beneath the ridges of the œsophageal epithelium. It seems feasible that these large glandular œsophageal cells supply the active juices of digestion, whilst the intestinal region is more concerned with absorption. The more granular of them bear a close resemblance to the large unicellular glands of the integument which, as has already been seen, are probably concerned with the markedly acid skin reaction. Such a fact lends some support to the view that the œsophagus is derived from the ectoderm, and, should future investigations prove such to be the case, the Nemerteans would present the interesting feature of possessing an endoderm which probably does not contribute to the digestive juices, but is only concerned with absorption. But in the absence of decisive embryological data, and of the histological appearance of the various parts of the lining of the alimentary canal after injection of various substances, nutritious or otherwise, the question must be left open.

The œsophagus is constricted at its posterior end, and behind this constriction starts the intestine, with its lateral pouches, where the character of the lining of the alimentary canal becomes entirely changed. The intestinal cells are large, though long and narrow (Pl. III., fig. 2). Each contains a somewhat elongated nucleus near its base, whilst between it and the ciliated surface are a number of small round bodies which shew neither nucleus nor any definite structure. These little bodies have been considered to be stored food material absorbed in this region, and in some Nemerteans several types have been distinguished.

The region of the regularly arranged intestinal diverticula (Pl. III., figs. 6, and 7, *i.d.*) continues almost to the anus where the alimentary canal opens to the exterior by a very short rectum. It is worthy of note that traces of food are rarely found in the digestive canal of a Nemertean. Yet various anecdotes illustrating their voracity have been given, among which may be mentioned an observation of *Riches, who, writing about *Micrura purpurea*, states that " A specimen of about 3 or 4 cm. was placed in a dish with

* Riches, T. H. A list of the Nemertines of Plymouth Sound. Journ. Marine Biol. Assoc. Vol. III.

"a *Eunemertes neesi* of quite 20 cm. length. Some little "time after I was astonished to find the *Micrura* busily "engaged in swallowing the *Eunemertes*. The posterior "one-fifth of the latter had already disappeared into the "mouth of the former when I noticed them, and still the "assailant was struggling to gulp down more of its prey. "In the meantime the victim glided round the dish, "apparently not suffering the slightest inconvenience "from the attack upon its posterior extremity. "Ultimately both attacker and attacked became quiescent, "the former having become more than twice its previous "girth. The portion of the *Eunemertes* in the gut of the "*Micrura* still remained in continuity with the rest of "the body, though apparently undergoing digestion." Possibly the food is digested and absorbed and the excreta expelled with a rapidity which precludes its presence within the alimentary canal for any length of time.

THE VASCULAR SYSTEM.

According to the histological structure of the walls, the vascular spaces in *Lineus* are spoken of partly as lacunæ and partly as vessels. The lacunæ are found in the head and in the œsophageal region. They are surrounded by connective tissue, and their only wall consists of a delicate membrane on which occur small oval nuclei at intervals. The vessels, which occur only in the intestinal region, possess a rather more elaborate structure. They are lined by an endothelium (Pl. IV., fig. 2), closely packed with spherical nuclei, and in which cell outlines are not readily to be distinguished. This endothelium rests upon a well-marked structureless basement membrane, but no circular muscle fibres are present. External to the basement membrane is a layer of large parenchyma cells, highly vacuolated and with definite cell outlines.

In the precerebral region the vascular system consists of two lacunæ (Pl. I., fig. 2), which join at the tip of the head over the rhynchodæum. These two cephalic lacunæ, together with the proboscis sheath, are surrounded by the nervous ring. About the level of the ventral commissure of the brain they unite in the mid-ventral line below the proboscis sheath, and from the commissure so formed is given off the median dorsal vessel (or more properly lacuna). Further back the lateral lacunæ form a second ventral communication, whence spring the two small buccal vessels which join the vascular network in the œsophageal region. Soon after this the lateral lacunæ widen out greatly, and surround the hinder portion of the cerebral organs. Just behind the mouth there is a continuous network of œsophageal lacunæ surrounding the ventral surface of the œsophagus (Pl. II., fig. 2), though the lateral lacunæ can still be recognised as the largest and most dorsal of the spaces seen in transverse section. They are in close proximity to the proboscis sheath, and the nephridial tubules come into contact with them (Pl. II., fig. 2, *e.rt.*).

The median dorsal vessel pierces the wall of the proboscis sheath directly after its formation at the level of the brain, and lies in the median ventral line. Directly over it the rhynchocœlomic epithelium, which alone separates the vessel from this cavity, assumes a columnar appearance. The œsophageal lacunar network extends nearly to the end of the œsophageal region. It then terminates, and the lateral lacunæ become much smaller and transformed into the lateral vessels which at first lie just above the level of the lateral nerves, but soon take up a position ventral to the intestine, and not far removed from the mid-ventral line. At about the same level the median dorsal vessel leaves the proboscis sheath, and becoming a true vessel, runs for the rest of its extent between the proboscis sheath and the intestine. In the intestinal region the lateral and median dorsal vessels communicate by a series of commissures (Pl. IV., fig. 1, *cbr*) passing round the diverticula, and which are of lacunar nature, being devoid of the investing layer of parenchymatous cells. As the lateral vessels do not communicate ventrally, the last commissure of the vascular system lies dorsal to the alimentary canal.

The blood is colourless, and contains some corpuscles. In some Nemerteans it is red from the presence of hæmoglobin. As to its course, it has been stated to flow backwards in the median dorsal and forwards in the lateral vessels. It is possible, however, that, in the absence of contractile fibres in the vascular system, there is no definite circulation, but that the blood is intermittently kept in motion by contraction of the muscles of the body wall. To what extent the vascular fluid acts as a respiratory medium is open to question. The vascular network round the œsophagus of many Nemerteans and the occasional presence of hæmoglobin suggest that it may have such a function, but against this must be set the fact that the œsophageal lacunæ are not present in some groups, and also that the presence of hæmoglobin is of rare occurrence. A more likely view is that respiration is mainly, if not entirely, carried out by the integument of the smaller forms; and this may also be the case even in the larger ones, since the body is usually capable of extreme attenuation.

EXCRETORY SYSTEM.

The so-called excretory or nephridial system in *Lineus gesserensis* consists of a number of small tubules lying in close proximity to the lateral lacunæ in the œsophageal region (Pl. II., fig. 2), and communicating with the exterior by a number of fine ducts which pierce the body wall and open laterally above the level of the lateral nerves. The number of ducts varies both in different specimens and on the two sides of the same specimen (Pl. IV., fig. 1, *e.rd.*). There are usually from 6 to 12 on each side. It often happens that some of the ducts are incomplete, the portion which would pierce the circular muscle layer being missing, though whether this is due to such ducts being new formations in course of inward growth from the ectoderm, or whether they are commencing to atrophy is an undecided point.

It has been stated that the number of ducts increases with the growth of the animal, from which it would appear that such incomplete ducts belong to the former of the above categories. On the other hand, the writer's own experience is that a large specimen may have but half as many ducts as one considerably smaller, though in such a case certain of the ducts in the large specimen may possess a very much wider lumen than the rest. Consequently it is quite likely that there is a period in which the number of ducts increases, and then later a period in which certain of the ducts enlarge, with the result that others atrophy through disuse. But the question is one that requires more fully working out.

The excretory tubules commence not far behind the mouth, and extend almost to the end of the œsophageal region (Pl. IV., fig. 1). Directly they cease the lateral blood lacunæ become the lateral vessels and the median dorsal vessel leaves the proboscis sheath. Histologically the tubules consist of what would probably be styled cubical epithelium, were it possible to distinguish the cell outlines. Its protoplasm, which stains readily, is somewhat granular and contains spherical nuclei (Pl. III., fig. 5). It is sparingly provided with long cilia. Near the blind end of a tubule these cilia are often more abundant, and are directed away from the blind end (Pl. III., fig. 5). No flame cells, however, have been detected in this species.

The excretory system lies almost wholly above the level of the lateral nerve cords, never extending into the lacunar network ventrally. Though it is in close contact with the œsophageal lacunæ, there is no communication between the vascular and excretory systems. Although certain observers claim to have demonstrated such a communication for certain of the more primitive forms, such as *Carinella* and *Carinoma*, it is exceedingly doubtful whether it exists. Concerning the nature of the fluid contained in the excretory system no observations have been made.

NERVOUS SYSTEM.

The nervous system consists essentially of two longitudinal cords extending throughout almost the entire length of the body and dilating anteriorly into the brain. Posteriorly they unite by a fine commissure ventral to the rectum. For their whole course they lie immediately outside the circular muscle layer, and are conspicuous objects in a transverse section of the worm (Pl. III., fig. 8, *ss.*). Viewed thus they are seen to be composed of an inner granular-looking portion of a more or less circular outline, surrounded by a layer of ganglion cells. The latter are not present on the side next to the circular muscles, and are very scarce externally. The fibrous core is bounded by a thin connective tissue layer, the inner neurilemma, separating it from the ganglion cells. Outside the ganglion cells is another connective tissue layer, which has been termed the outer neurilemma. The inner neurilemma is broken at intervals by small bundles of axis cylinders from the ganglion cells, which can be traced into the fibrous core. Scattered nuclei are found inside the fibrous core, for the most part just inside the inner neurilemma, though a few may be seen about the centre of it. These are the nuclei of the neuroglial cells, whose branched processes form the supporting groundwork of the nervous system. The fibrous core itself is composed of: —

(1) Fibres of the neuroglial cells, which stain with many reagents (*e.g.*, eosin), and compose the bulk of the core.

(2) Nerve tubules, consisting of homogeneous axis cylinders which are usually unstained by reagents, and probably in life consist of a semi-fluid substance bounded by a fine spongio-plasmic sheath. These tubules are very small, and are for the most part scattered about inside the fibrous core, though near the centre a large space is seen, more or less circular in outline in transverse section, which is found throughout the whole length of the core, and probably represents a bundle of nerve tubules.

(3) Irregular spaces containing fluid.*

Returning now to the general arrangement of the nervous system, it has already been mentioned that the lateral nerve cords dilate anteriorly to form the brain. This structure is composed of a dorsal and a ventral cerebral ganglion on either side. The ventral ganglion is merely the expanded end of the lateral cords, and it is

*It should be mentioned that the above view of the nature of the elements of the nervous core is that advocated by Montgomery (loc. cit. p. 428). Bürger on the other hand (Die Nemertinen, Fauna und Flora des Golfes von Neapel Bd. XIX., 1895) supposes the densely staining elements, considered to be neuroglial processes on the above view, are the nervous fibrils, and that the so-called nerve tubules are clefts filled with fluid.

difficult to say exactly where the one ceases and the other starts. The dorsal ganglia are closely united with the ventral (Pl. I., fig. 5, and Pl. II., fig. 4). The two dorsal ganglia are connected by a dorsal commissure (Pl. I., fig. 4) and the ventral ganglia by a much stouter ventral commissure. The nervous ring thus formed surrounds the proboscis sheath, and not, as in most worms, the alimentary canal. The posterior ends of the dorsal ganglia, now no longer in contact with the ventral ganglia, are continued into the so-called cerebral organ, which will be referred to under the sense organs later.

Histologically the general structure of the brain is similar to that of the lateral cords, with the difference that the ganglion cells are not all alike. In the brain three varieties of ganglion cells may be distinguished:—

(1) Small cells of shortened pyriform shape, the deeply staining nuclei of which almost fill the cell bodies. They occur on the dorsal and ventral aspects of the dorsal ganglia (Pl. II., fig. 4), and also in the cerebral organs, and are probably sensory in function.

(2) Medium sized cells, more or less elongated and pear-shaped. These occur in the ventral brain lobes and in the lateral cords, forming the greater part of the ganglion cell layer of the latter. They vary somewhat in size, but may be distinguished from the next type by the shape of their nucleus, which is oval and not spherical, as in the

(3) Large cells. These are also of elongated pyriform shape, and are found in the dorsal and ventral ganglia, as well as in the lateral cords.

The larger ganglion cells of the last two types are probably motor in function. In some Lineidæ a yet larger type of cell may be present in the ventral ganglia, and sometimes also in the lateral cords. They possess very large axis cylinders, which have been termed neurochords. They are not present in *Lineus gesserensis*.

In addition to the central nervous system, consisting of the brain and lateral cords, various peripheral nerves may be distinguished. These may be classed under five headings:—

(1) Cephalic nerves (Pl. I., fig. 2, *cn.*), given off anteriorly from the dorsal ganglion and innervating the skin of the snout, the frontal organs, and eyes.

(2) The œsophageal nerves (Pl. II., fig. 1, *oesn.*) which come off from the hinder portion of the ventral ganglia, and may be regarded as marking the boundary between the latter and the lateral cords. Immediately after coming off the œsophageal nerves of each side unite by several commissures (Pl. I., fig. 6, *oesc.*). Behind this the nerves may be easily traced for a little way along the œsophagus, where they lie ventrally and somewhat laterally. Just before the excretory region they become broken up, though it is probable that their fine branches extend backwards and innervate the whole of the alimentary canal. By some writers these nerves are spoken of as the vagus nerves.

(3) The nervous sheath (Pl. II., fig 2, *nl.*) which forms a delicate coat lying at the same level as the side stems and completely enveloping the circular muscle layer. In the median dorsal line (Pl. III., fig. 8, *nd*) a thickening of this layer occurs. This is the median dorsal nerve which anteriorly fuses with the dorsal commissure of the brain. From this nervous sheath fine fibrils may be traced to the skin and the muscle layers of the body wall.

(4) The proboscis sheath nerve—an exceedingly fine nerve situated just beneath the circular muscle layer in the median dorsal line. It probably innervates the structure from which it receives its name.

(5) The proboscis nerves which are given off one on each side of the ventral ganglia and pass thence into the proboscis. Inside this structure they soon spread out and fuse to form a nervous sheath investing the proboscidial epithelium in the retracted state of the organ.

On the nerves of the peripheral system are found some nuclei, but these probably belong to neuroglial, not ganglion cells.

SENSE ORGANS.

The ciliated cells of the epidermis doubtless function as sensory cells, though whether the sensory elements can be distinguished apart from the ordinary ciliated cells has not been determined in the case of *Lineus gesserensis*. Some observers, however, have been able to distinguish such cells in other species. Apart from these, three forms of sensory organs are found in the present species.

(1) The cerebral organ. It has already been noticed that on either side of the head there is a groove bounded by mobile lips, reaching from the tip of the head nearly to the mouth region, and deepening as it passes backwards. At the posterior extremity of each of these head slits (Pl. IV., fig. 1, *hs.*) is a small aperture marking the opening of a fine blind canal which, taking first a backward and then a forward course (Pl. III., fig. 3, *cc.*), lies for its whole extent in close proximity to the hinder portion of the dorsal ganglion. Into it open two sets of glands. The first set (Pl. I., fig. 3, and Pl. III., fig. 3, *acg.*) opens into the canal immediately after its commencement, the second set a little further back (Pl. III., fig. 3, *pcg.*). Up to this point the epithelial lining of the canal consists of high thin columnar cells devoid of glands, but behind the opening of the posterior gland the epithelium of the ciliated canal becomes greatly changed.

When viewed in transverse section (Pl. III., fig. 1) the inner half of the canal is seen to be lined by very long cells possessing large nuclei and with an inner hyaline extremity consisting of fused cilia, at the base of which are minute deeply-stained granules. On the outer side of the canal the cells are even more highly specialised, and are five in number (as seen in transverse section), viz., a median one, two smaller ones on either side, and two very large ones again on either side of these. More than one nucleus is present in all of them. The cells of these five rows are separate at their inner ends both from one another and from the cells of the internal half of the canal. Like the latter they possess an inner hyaline portion, consisting of fused cilia projecting into the lumen of the canal. The basal portions of all these cells are without a well-marked limiting membrane, and come into close contact with the fibrous core of the posterior extremity of the dorsal ganglion. Numbers of small sensory ganglion cells of the first type (page 16) are massed round the canal (Pl. I., fig. 6, and Pl. II., fig. 4), and the projection of the fibrous core from the dorsal ganglion.

The function of this elaborate organ is still problematical. By some writers it has been supposed to contribute to the respiration of the brain lobes, though the specialised character of its epithelium and the number of ganglion cells in it would seem to lend more countenance to the view that its function is rather concerned with the elaboration of some special sensory impulses.

(2) The frontal organ consists of three small projecting patches of high columnar glandless epithelium bearing cilia (Pl. IV., fig. 1, *fr.*). The median patch is situated just above the proboscis pore with a lateral patch on either side of it. These patches are retractile, and after

preservation appear in section as small pits (Pl. I., fig. 1). Opening near them are the so-called head glands, which in *Lineus gesserensis* form a small mass of gland cells lying in the anterior portion of the snout just above the rhynchodaeum.

(3) The eyes vary in number, the adult animal usually having a dorso-lateral row of about five on each side. They lie imbedded in the tissue of the snout well below the epidermis and dorsal to the head slits. Each eye consists of a deep layer of cells containing a dark brown pigment, over which is a layer of pyriform cells (Pl. III., fig 4), whose more pointed ends are drawn out into long processes which are inserted into a fine nucleated membrane. On the long processes of these ganglion (?) cells may often be seen minute deeply-staining bodies, whilst between them is a clear fluid kept in by the fine limiting membrane and forming a lens. The eyes are supplied by some of the cephalic nerves which enter them from the pigmented side. Instances may frequently be observed in which two eyes are incompletely separated, whence it may probably be inferred that their number is augmented by division of those already existing. The young *Lineus* when hatched has but a single eye on either side.

THE CONNECTIVE TISSUES.

These have been studied in the present species by Montgomery (loc. cit. p. 1), who distinguishes the following kinds:—

(1) Branched connective tissue cells with inter-cellular substance, composing the basement membrane of the external epithelium, the outer and inner neurilemma, the sheaths around the muscular fibres, the layer immediately surrounding the intestine, the layer outside the endothe-

lium of the blood vessels, and probably also the enveloping membrane of the gonads. The intercellular substance formed by these cells is structureless and of gelatinous appearance, and takes a deep colour with many staining reagents (especially hæmatoxylin or nigrosin).

(2) Pigmented connective tissue without intercellular substance. This occurs in the cutis, and consists of membraneless cells with fine branching fibrils containing greenish yellow pigment granules. It is more plentiful on the dorsal surface where the colour is darkest. The amount and distribution of this pigment probably determines the colour variety (*i.e.*, whether red or green), since a greater amount of pigment usually occurs in the red variety. On this view the red colour must be looked upon as due to the refraction of light rays coming from the greenish pigment.

(3) Mesenchyme tissue composed of bi- or multi-polar cells without intercellular substance. This tissue is much reduced in the present species, being only found in the anterior region of the body between the proboscis sheath and the œsophagus.

(4) Parenchyme tissue consisting of large, much-vacuolated cells with an outer membrane. This occurs round the dorsal and lateral blood vessels in the intestinal region (Pl. IV., fig. 2), though it is not present on the commissural vessels.

BODY CAVITY AND GONADS.

While some observers hold that no body cavity is present in the Nemerteans, others consider that it is represented by spaces sometimes found round the alimentary canal, and in which occur mesenchyme cells. Such spaces are in some species well marked with the mesenchyme cells so arranged as to form a more or less definite lining membrane. It is possible, however, that they may be due to shrinkage in the process of preservation. As has already been seen, the only space of this kind which occurs in *Lineus gesserensis* is a small one between the proboscis sheath and the œsophagus. The space between the intestine and the inner longitudinal muscle layer is small, and is occupied by connective tissue cells and their intercellular substance.

In this space occur sacs alternating with the intestinal diverticula (Pl. III., figs. 6 and 8), and with the intestinal diverticula (Pl. III., figs. 6 and 8), and lined by connective tissue cells. These are the gonads whose cavity, apparent in the young animal, becomes obliterated in the mature worm by the sexual cells which fill it, and which are probably derived from the connective tissue cells which form its lining. Each gonad possesses a duct which opens dorso-laterally (Pl. III., fig. 8, *gd.*), and which is formed partly by a prolongation of the connective tissue lining of the gonad, and partly from an ectodermal depression.

The sexes are separate, and in the breeding season, which lasts from about February till June, the female deposits her ova under stones in a long tubular gelatinous cord. In the walls of this cord are the ova contained in small flask-shaped transparent capsules (Pl. III., fig. 7). One of the gelatinous cords produced by a single female usually contains a hundred or more of these little capsules, and each capsule contains the contents of a gonad, *i.e.*, from one to seven ova, according to the size of the female. The spermatozoa of *Lineus gesserensis* possess a long pointed head (Pl. IV., fig. 4). The gelatinous cord containing the ova is said to be the joint production of the male and the female. Into it the male then proceeds to discharge spermatozoa. Soon afterwards the female deposits her ova, already surrounded by the characteristic capsule, which are then fertilized. The ova are deposited in the capsules, which are probably secreted by the lining of the gonad.

DEVELOPMENT.*

The ova before fertilisation measure about ·3 mm. in diameter, and are opaque owing to the numerous oily yolk granules which they contain. The germinal vesicle is well marked, and in it is a large nucleolus or germinal spot. After fertilisation segmentation is complete and regular, resulting in a blastula. A segmentation cavity is already present in the 8 cell stage. The blastula is covered with cilia by whose action the young embryo is kept in constant rotation. Invagination of the blastula then takes place, and results in the formation of a typical gastrula. The differentiation between ectoderm and endoderm cells is now apparent, the latter being considerably larger. The endodermal invagination is directed somewhat obliquely (Pl. IV., fig. 9), so that the future alimentary canal lies entirely behind the blastopore, enabling one to distinguish already at this stage the anterior and posterior ends of the animal.

The ectoderm of this stage does not directly become the ectoderm of the larva, but the latter is established by a series of remarkable changes. In two small areas on either side the cells of the primary ectoderm of the gastrula divide lengthways forming palisade cells. These areas of secondary ectoderm, the cephalic and ventral

* The development of *Lineus gesserensis* has been studied more especially by Desor, Barrois, M'Intosh, and Hubrecht. The account given by the last-named is the only one based on modern methods, and has been followed in this paper.

plates, are then overgrown by the cells of the primary ectoderm (Pl. IV., fig. 7) surrounding them, so that at these four areas the ectoderm becomes two-layered, viz., a layer of secondary ectoderm covered externally by the layer of primary ectoderm, which has again become continuous (*cf.* Pl. IV., fig. 9). At the anterior end, a fifth area of secondary ectoderm, the proboscidial plate, arises, though it differs from the others in being formed by delamination, and not by sinking in (Pl. IV., fig. 9, *prp.*). The five areas of the secondary ectoderm then spread out and fuse with each other, forming a continuous coat which lies directly beneath, and subsequently becomes entirely separated from the primary ectoderm. This secondary ectoderm eventually forms the ectoderm of the adult. The primary ectoderm is cast off later, degenerates, and is utilised as food material by the embryo.

Before the fusion of the five secondary ectoderm plates, however, two invaginations of the primary ectoderm are formed on either side of the blastopore (Pl. IV., fig. 8, *corg.*). These later sink beneath the secondary ectoderm between the cephalic and ventral plates of the latter, and eventually give rise to the ciliated canals of the cerebral organs. In the process these invaginations lose their communication with the exterior (Pl. IV., fig. 10, *corg.*), but later a secondary opening is formed in each case at the surface of the secondary ectoderm.

At the time when the five plates of secondary ectoderm are commencing to appear the first traces of the future mesoderm are seen as cells budded off from both the primary ectoderm and the endoderm (Pl. IV., figs. 7, 8, 9). After the establishment of the secondary ectoderm as a continuous layer, these mesoderm cells come to be entirely enclosed within it.

Meanwhile changes have been taking place within the endoderm. Whilst the secondary ectoderm is making its appearance the hinder portion of the archenteron becomes shut off from the more anterior part by a coalescence of some of its cells (Pl. IV., fig. 9), resulting in the formation of a posterior intestinal portion with a closed cavity, and an anterior œsophageal portion whose lumen opens to the exterior by the blastopore. The last-named eventually becomes the mouth of the adult. Later the cavities of the œsophagus and intestine become secondarily continuous, but before this occurs a small lateral evagination is formed on either side of the inner portion of the œsophagus. These evaginations eventually lose their connection with the œsophagus, and acquire openings to the exterior through the body wall. In this way are established the nephridia. Thus the œsophagus must be looked upon as endodermal, and consequently the nephridia as diverticula of the archenteron. The anus is formed later at the posterior end of the intestine. During these changes the ectoderm of the proboscidial plate has formed an invagination, which will become the lining of the rhynchodæum and of the proboscis (Pl. IV., fig. 10, *p.*) The embryo now presents the appearance shewn in Pl. IV., fig. 5, and is known as Desor's larva.

The fate of the ectoderm and of the endoderm has now been traced. With the exception of the gonads, the remainder of the body is derived from the mesoderm, whose cells by this time have come together to form a continuous layer round the structures whose formation has already been described. The mesoderm gives rise to the connective tissues, muscles, nervous system, blood vessels, and proboscis sheath. The cavities of the two last are remains of the segmentation cavity. That the nervous system should be of mesodermal origin is a somewhat remarkable fact. Still it has already been seen that the mesoderm is derived in part from the primary ectoderm, and it is possible that these cells are the ones concerned in the formation of the nervous system; on which view its origin would be but ectodermal in disguise. An exception to the mesodermal origin of most of the organs was noticed above. This is the case of the gonads, which are stated to arise at a later stage as ectodermal ingrowths ventral to the level of the lateral nerve cords. The connection with the ectoderm is then lost, and the ducts are developed later above the level of the lateral nerves. The origin of the various organs has now been traced. During the later part of its stay in the egg capsule the larva lengthens considerably, until the little worm, now about 1·5 mm. long, forsakes the protection of its embryonic shelter to become an independent though microscopic unit in the teeming life around its birthplace.

The development through the larva of Desor as sketched above is not the only form which occurs in the family of the Lineidæ. In some other species of Nemerteans a free swimming pelagic larva, known as the Pilidium, is formed, and a slight knowledge of its developmental history throws some light upon the peculiar formation of the ectoderm in Desor's larva. A typical gastrula is formed, which then acquires a dorsal tuft of long, fused cilia and two lappets produced by ectodermal folds hanging down laterally on either side of the mouth. From its fancied resemblance to a helmet at this stage the larva derives its name.

The young worm is then developed inside the Pilidium, in whose ectoderm five invaginations now make their appearance round the mouth, viz., two paired and one anterior median unpaired. These invaginations lose their connection with the outer ectoderm of the Pilidium, and grow together to surround the endoderm of the larva. When this process is complete the body wall of the animal, exclusive of the mesoderm, now consists of four layers. Externally is the ciliated ectoderm of the larva, and internally the endoderm, whilst between these are two layers of ectoderm formed by the fused invaginations. Of these two layers the inner becomes the ectoderm of the adult worm, and corresponds to the secondary ectoderm of Desor's larva. The young Nemertean continues to develop, and, when full grown, parts company with the remains of the Pilidium, which then consist of the original outer ectoderm and the outer layer of the fused ectodermal invaginations. Hence the discarded layer of primary ectoderm in Desor's larva corresponds to the ectodermal shell of the Pilidium which is cast off when the young Nemertean escapes.*

In several important respects the process of development by Pilidium is said to differ from that by the larva of Desor. Among these may be more especially mentioned the origin of the nervous system and of the nephridia. The former is said to arise directly from the secondary ectoderm as local thickenings of this layer, whilst in the larva of Desor it has already been seen to take its origin from the mesoderm. Again in Pilidium development there is said to be an ectodermal œsophageal invagination when the nephridia arise, and these are consequently not of endodermal origin as in Desor's larva.

There are also other differences, but the above are sufficient to show that Hubrecht's account (which has been followed above), though in its original form full and

* An excellent account of Pilidium development, illustrated by numerous coloured diagrams, is given by L. Joubin in Les Nemertiens, Traité de Zoologie de R. Blanchard, fascicule XI. Paris, 1897.

circumstantial, should be accepted with caution until confirmation has been received from other sources.

REGENERATION.

Though observations on the regeneration of lost parts do not exist in the case of *Lineus gesserensis*, yet in a closely allied species, *Lineus sanguineus*, interesting facts in this connection were brought to light by M'Intosh. When kept in captivity, examples of this species shew a tendency to rupture into many pieces. Each of these fragments may develop into a complete worm, both anterior and posterior ends being formed anew.

PARASITES.

Like most Nemerteans, *Lineus gesserensis* is frequently infested with Sporozoan parasites. These occur chiefly in the intestinal region attached to the epithelium of the alimentary canal and hanging freely into its lumen. A curious large Mesozoan parasite has also been recorded in this species (*Rhopalura*). It is found burrowing in the body wall, and its presence may be recognised, according to M'Intosh, "by the perforated and honey-"combed appearance of the dorsum of the affected animal, "whose textures seem to be the seat of the workings of a "microscopic *Tomicus typographicus*."

SYSTEMATIC POSITION.

The Nemerteans are divided by Bürger into four orders based mainly upon the number of muscle layers in the body wall, and the position of the lateral nerve cords with respect to these layers. Briefly these orders, with the British families and genera belonging to each, are as follows:—

I. PROTONEMERTINI.

Two muscle layers in body wall, *i.e.*, external circular and internal longitudinal. The lateral nerve cords lie outside the circular layer. Proboscis without stylets. Mouth behind brain.

Fam. CARINELLIDÆ.

Genus. *Carinella.*

II. MESONEMERTINI.

Two muscle layers in body wall, *i.e.*, external circular and internal longitudinal. The lateral nerve cords lie in the midst of the longitudinal layer. Mouth behind brain. Proboscis without stylets.

Fam. CEPHALOTHRICIDÆ.

Genera. *Cephalothrix*
Carinoma.

III. METANEMERTINI.

Two muscle layers in body wall, *i.e.*, external circular and internal longitudinal. The lateral nerve cords lie beneath the longitudinal layer. Mouth in front of brain. Proboscis armed with stylets.

A. PRORHYNCHOCŒLOMIA.

Body long and thin. Proboscis and proboscis sheath much shorter than body.

Fam. EUNEMERTIDÆ.

Eyes present. No otocysts.

Genus. *Eunemertes.*

Fam. OTOTYPHLONEMERTIDÆ.

No eyes, but one or more pairs of otocysts ventral to brain.

Genus. *Ototyphlonemertes.*

B. Holorhynchocoelomia.

Body usually short. Proboscis at least as long as body. Proboscis sheath reaches into hinder third of body.

Fam. Tetrastemmidæ.

Four eyes. Cerebral organs in front of brain. Dioecious or hermaphrodite.

Genera. *Prosorochmus.*
Tetrastemma.

Fam. Amphiporidæ.

Numerous eyes. Cerebral organs generally behind brain. As a rule members of this family are considerably larger than those of the preceding.

Genera. *Amphiporus.*
Drepanophorus.

Fam. Malacobdellidæ.

Parasitic in Lamellibranchs. Sucker at posterior end.

Genus. *Malacobdella.*

IV. HETERONEMERTINI.

Three muscle layers in body wall, *i.e.*, outer longitudinal, middle circular, and internal longitudinal. Proboscis without stylets. Mouth behind brain.

Fam. Eupolidæ.

Without head slits.

Genera. *Eupolia*
Valencinia.
Oxypolia.

Fam. LINEIDÆ.

With head slits.

Genera. *Lineus.*

Euborlasia.

Micrura.

Cerebratulus.

Micrella.

The genera of the Lineidæ set down above are exceedingly difficult to define. The three genera *Micrura*, *Cerebratulus* and *Micrella* (together with the exotic genus *Langia*) agree with one another in the possession of a slender tail filament at the posterior end of the body. For this reason they have been grouped together as Micruræ in opposition to the rest of the family, which are known as the Amicruræ. It is very doubtful, however, whether this caudal appendage is homologous in all the instances in which it is found, for in some cases the anus opens at its tip, whilst in others it opens at its base either just above or just below it. It also presents other anatomical differences in different species.

The body form is regarded by some as affording a character upon which to base generic distinctions. Especially is such the case in *Cerebratulus*, of which genus the species are often characterised by their breadth, due chiefly to the sides of the animals being flattened out to form a kind of fin known as the side folds. Gradations between such a state and a more or less circular outline in section are found, so that the absence of well-marked side folds does not necessarily preclude a species from being relegated to this genus. *Cerebratulus* is also supposed to be characterised by a fine layer of diagonal muscles just outside the circular layer. This, however, is often absent. In fact at present the three genera, *Lineus*, *Cerebratulus* and *Micrura* are exceedingly illdefined. Many anatomical differences are found in the family, amongst which may more particularly be mentioned the following:—

(*a*) A diagonal muscle layer, neurochord cells, eyes, and frontal organ may be either present or absent.

(*b*) A well-marked cephalic vascular head loop may be present, or the cephalic vessels may form an anastomosing network.

(*c*) The excretory system shews great variations in its backward extent; the position of the tubules may be dorsal or ventral, or both; they may reach forward to the cerebral organ, or may commence some way behind it. Also some species possess a number of ducts whilst only one pair is present in others.

In the majority of the Lineidæ, and indeed in many British forms, we are as yet in ignorance with regard to many of these points, and until they have been determined it is useless to attempt to place the classification of the family upon a more satisfactory basis.

Explanation of Plates.

Reference Letters.

acg. anterior gland of cerebral organ.
bc. buccal vascular commissure.
cbv. commissural vessel between *dv* and *lbv.*
cc. ciliated canal of cerebral organ.
cmc. circular cephalic muscles.
cml. longitudinal cephalic muscles.
cn. cephalic nerve.
corg. cerebral organ.
cugl. glandular cutis.
cvl. cephalic vascular loop.
dc. dorsal commissure of brain.
dg. dorsal ganglion.
dv. median dorsal blood vessel.
ep. epithelium.
exd. excretory duct.
ext. excretory tubules.
fr. frontal organ.
gc. ganglion cells.
gd. gonidial duct.
hs. head slit.
id. intestinal diverticulum.
iep. intestinal epithelium.
lbl. lateral blood lacuna.
lbv. lateral blood vessel.
m. mouth.
mc. circular muscle layer.
mcp. circular muscles of proboscis.
mcr. muscle cross.
mdv. dorso-ventral muscles.
mli. internal longitudinal muscle layer.
mlo. external ditto.
mlp. longitudinal muscles of proboscis.
n. nerve to eye.
nd. median dorsal nerve.
nl. nervous layer.
nlp. nervous layer of proboscis.
nuc. nuclei.
ocg. ganglion cell (?) layer of eye.
oes. oesophagus.
oesc. oesophageal nerve commissure.
oesl. oesophageal vascular lacunae.
oesn. oesophageal nerve.
oep. oesophageal epithelium.
ogl. gland cells round oesophagus.
ov. ovary
p. proboscis.
par. parenchymatous cells.
pcg. posterior gland of cerebral organ.

pep. proboscis epithelium.
pg. pigment layer of eye.
pn. proboscis nerve.
ps. proboscis sheath.
rd. rhynchodaeum.
rhc. rhynchocœlom.
rhce. rhynchocœlomic epithelium.
sdg. superior lobe of dorsal ganglion.
ss. lateral nerve.
vc. ventral commissure.
vep. epithelium of blood vessel
vg. ventral ganglion.

Plate I.

Fig. 1. Transverse section through the tip of the head. × 60.

Fig. 2. Transverse section taken between brain and tip of snout. × 45.

Fig. 3. Transverse section through hinder part of brain, where the anterior gland of the cerebral organ opens near the end of the head slits. × 60.

Fig. 4. Transverse section through dorsal commissure before the two limbs of the cephalic vascular loops have fused ventral to the proboscis sheath. × 45.

Fig. 5. Transverse section through brain at a level between 4 and 3. × 45.

Fig. 6. Transverse section through level of cerebral organ, buccal vascular commissure and œsophageal nervous commissure.

Plate II.

Fig. 1. Transverse section through mouth region. The œsophageal vascular lacunæ are just commencing. × 45.

Fig. 2. Transverse section through about the middle of the œsophageal region. × 45.

Fig. 3. Transverse section of epithelium from anterior intestinal region. × 300.

Fig. 4. Longitudinal vertical section through brain taken rather to one side of the median line. × 45.

Fig. 5. Transverse section through hinder region of proboscis. The circular muscles and nervous layer have both disappeared. × 120.

Fig. 6. Transverse section through proboscis at its widest—about the middle. × 80.

Fig. 7. Longitudinal median section through anterior end, shewing the relations of the proboscis to the rhynchodæum and rhynchocœlom when retracted. × 45. Somewhat schematic.

Plate III.

Fig. 1. Transverse section through so-called ciliated canal of cerebral organ, shewing the seven large external cells and the internal homogeneous cell layer all with crystalline ends formed from fused cilia projecting into the lumen. × 300.

Fig. 2. Portion of intestinal epithelium, shewing the circular refractive bodies enclosed in the elongated ciliated cells. × 168.

Fig. 3. Schematic longitudinal horizontal section through the cerebral organ of a Heteronemertean. (After Bürger).

Fig. 4. Section through eye just anterior to the entry of the nerve into the pigmentary layer. × 240.

Fig. 5. Section through blind end of an excretory tubule (left portion), shewing elongated cilia. × 300.

Fig. 6. Longitudinal horizontal section through intestinal region, shewing the intestinal diverticula alternating with the gonads. × 45.

Fig. 7. Flask-shaped egg capsule, containing a single embryo in the morula stage. (After M'Intosh.) × 25.

Fig. 8. Transverse section through intestinal region passing between two diverticula. × 45.

Plate IV.

Fig. 1. Schematic figure, shewing the relations of the various systems in the anterior end of the animal as viewed from above. The proboscis and its sheath, the œsophageal nerves and the buccal vessels have been omitted.

Fig. 2. Transverse section through lateral blood vessel. On the side of the alimentary canal the parenchyma cells are smaller and complete. On the outer side no cell wall is to be distinguished away from the vessel. × 168.

Fig. 3. Portion of œsophageal epithelium from a transverse section. Three kinds of gland cells are seen among the ciliated epithelium and below it:—(*a*). (*β*), and (*γ*). (for explanation vide text). × 168.

Fig. 4. Two spermatozoa (after M'Intosh). × 700.

Fig. 5. Larva of Desor as seen from the ventral surface. The outer ciliated coat is not yet shed. (After Barrois).

Fig. 6. Young Lineus just hatched. × 40. (After M'Intosh).

Figs. 7-11. Diagrammatic sections through larvæ of Lineus at different stages. (After Hubrecht).

Fig. 7. Transverse section, shewing the secondary epiblast of the cephalic plates (*cp.*) gradually overgrown by the primary (*prep.*). The proboscidial plate (*prp.*) arises antero-dorsally by delamination.

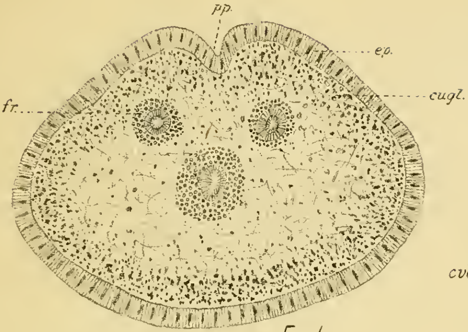
Fig. 8. Transverse section of slightly later stage, shewing the two invaginations from the primary epiblast on either side of the blastopore, which will eventually give rise to the cerebral organs (*corg.*).

Fig. 9. Longitudinal section through a stage slightly younger than 7. The archenteron is subdivided into intestine (*int.*) and œsophagus, which do not communicate.

Fig. 10. Horizontal section of older embryo. Proboscis now invaginated and mesoblast accumulating. The secondary epiblast, consisting of proboscis, cephalic (*cp.*) and ventral plates (*vp.*), now forms the external surface of the worm, having sunk in, and become separated from the primary epiblast (*prep.*). The section corresponds to the stage shewn in figure 5.

Fig. 11. Median longitudinal section through somewhat later stage. The hinder portion of the proboscidian mesoblast is now attached. The œsophagus and intestine communicate. Rhynchocœlom now apparent (*rhc.*).

C. Tinling & Co., Printers, 53, Victoria Street, Liverpool.



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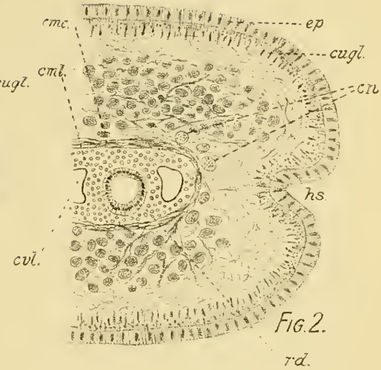

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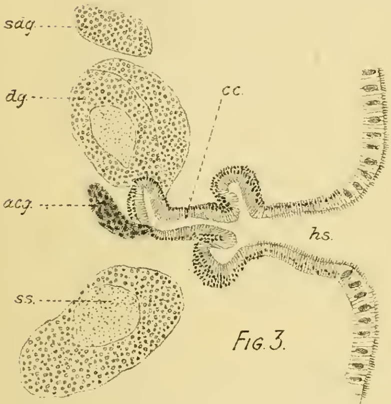

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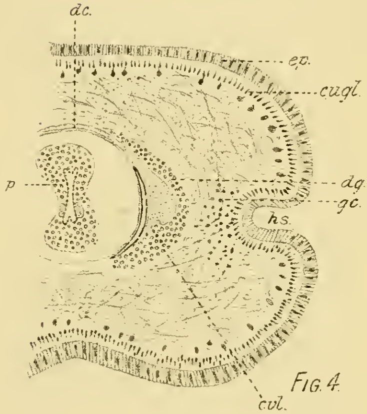

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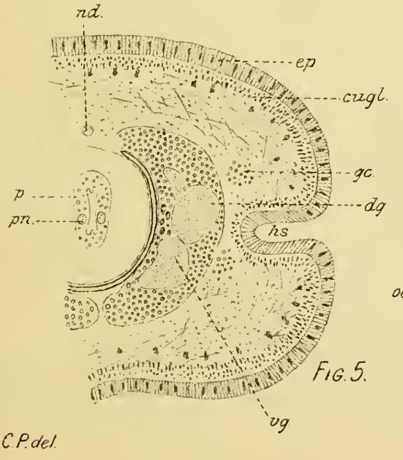

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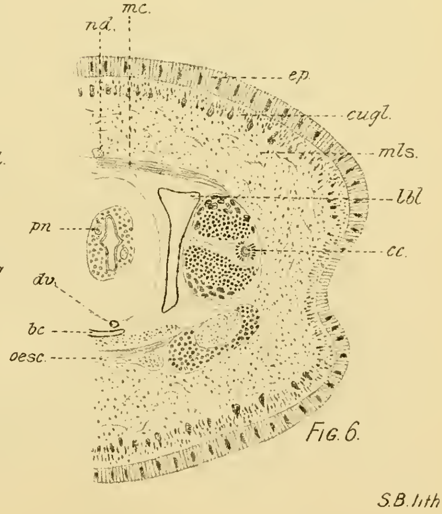

Fig. 6.

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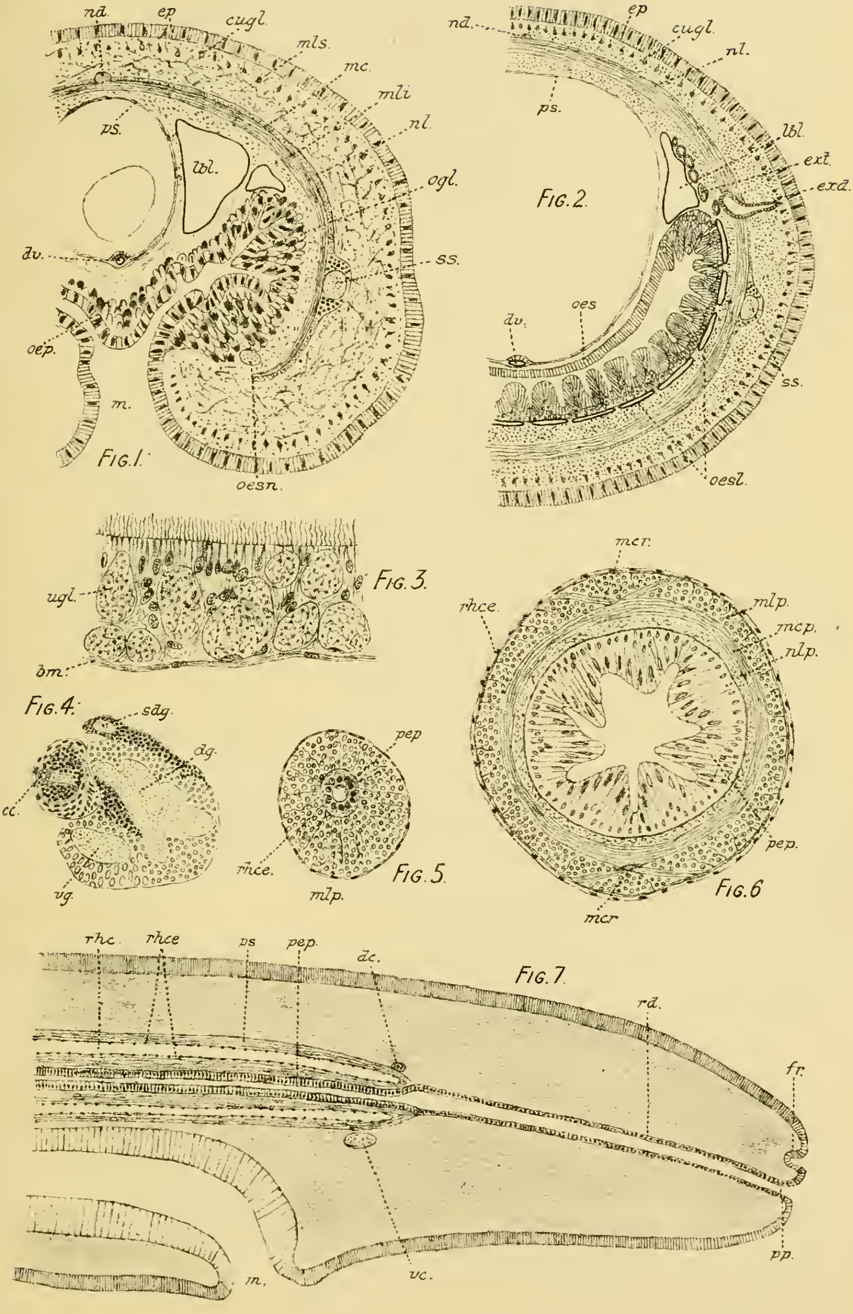

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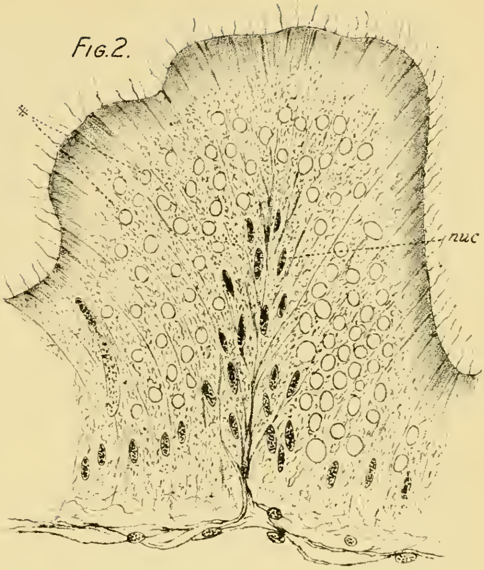
Fig. 1

Fig. 2



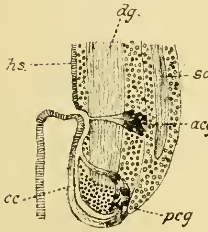
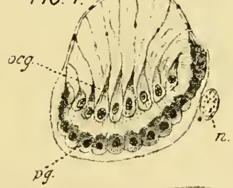


Fig. 3.

Fig. 4.



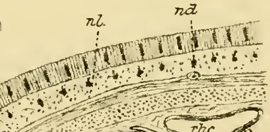
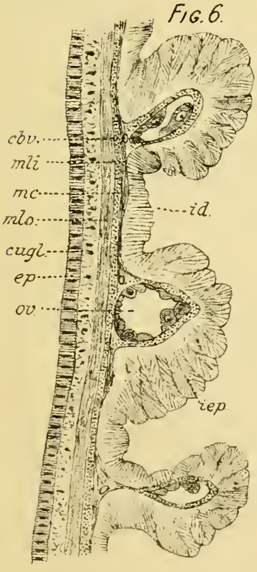


Fig. 5.

Fig. 6.



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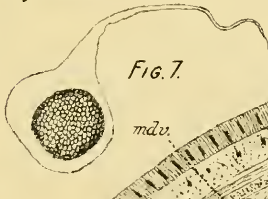

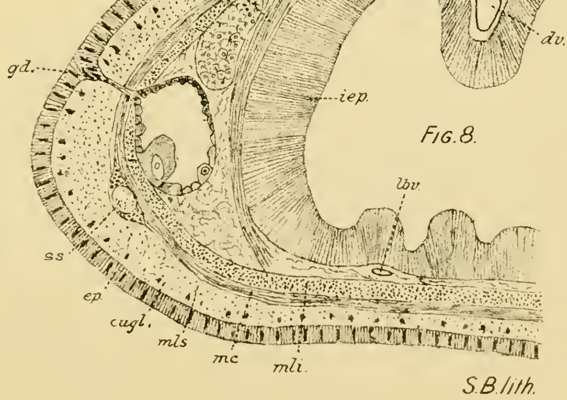

Fig. 8.

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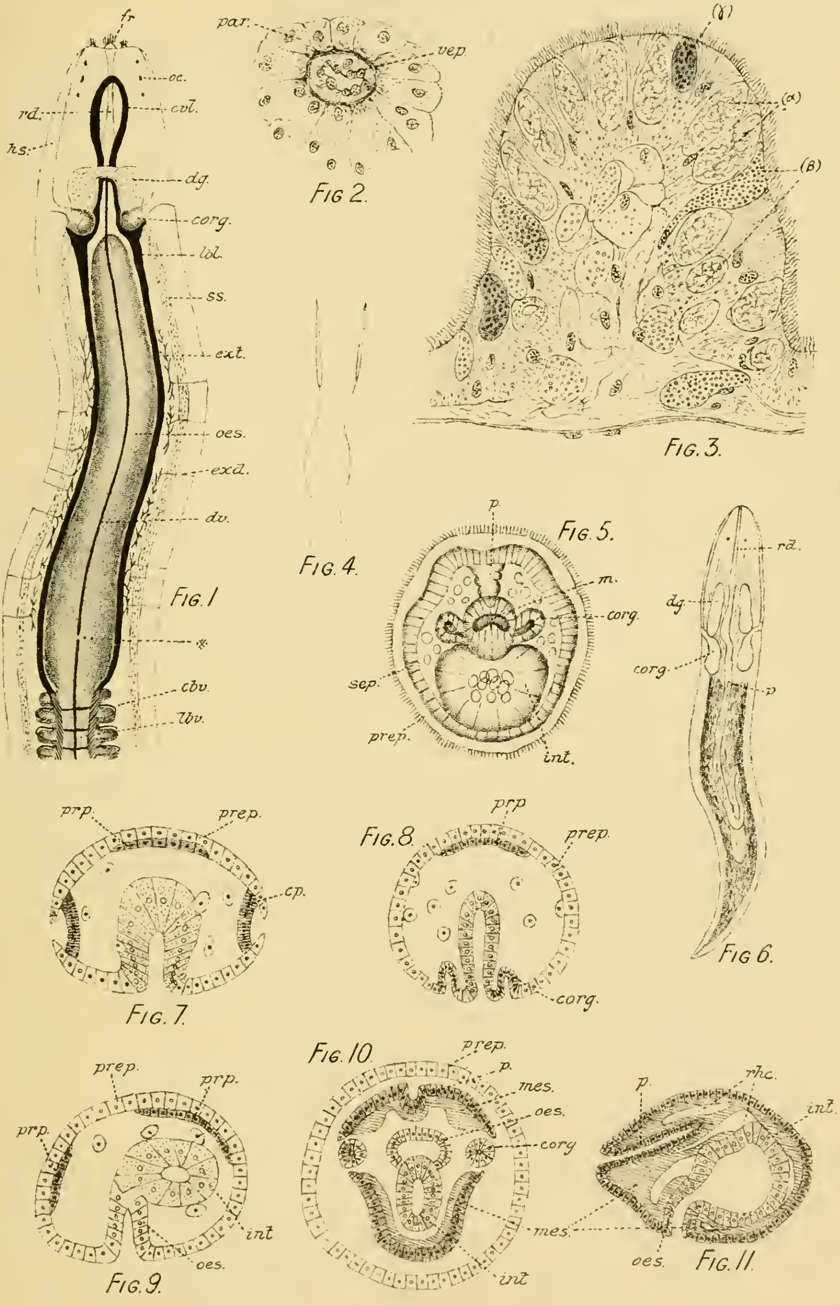

R.C.P. del.

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