THE ANNALS

AND

MAGAZINE OF NATURAL HISTORY.

[NINTH SERIES.]

" .... per litora spargite muscum,
Naiades, et circùm vitreos considite fontes:
Pollice virgineo teneros hìc carpite flores:
Floribus et pictum, divæ, replete canistrum.
At vos, o Nymphæ Craterides, ite sub undas;
Ite, rècurvato variata corallia trunco
Vellite muscosis e rupibus, et mihi conchas
Ferte, Deæ pelagi, et pingui conchylia succo."
N. Parthenii Giannettasi, Ecl. 1.

No. 7. JULY 1918.

I.—*Notes from the Gatty Marine Laboratory, St. Andrews.*—No. XLI. By Prof. M'Intosh, M.D., LL.D., D.Sc., F.R.S., &c.

[Plates I.-VI.]

1. On some Points in the Structure of the *Sabellidæ*, chiefly of *Bispira volutacornis*, Montagu.
2. On some Points in the Structure of the *Serpulidæ*, chiefly of *Pomatoceros triqueter*, L.

1. *On some Points in the Structure of the* Sabellidæ, *chiefly of* Bispira volutacornis, Montagu.

Many authors have alluded to the structure of the Sabellids since Cuvier noted that they rarely form a calcareous tube, whilst they had the fan-like gills and the thoracic membrane of the Serpulids. In alluding to the branchiæ of the Sabellids he mentions " un filament charnu," and, further, that in this group the two " filets charnus " (fleshy filaments —probably the tentacles) adherent to the branchiæ do not form an operculum. Most text-books, like those of Huxley, Gegenbaur, and Hayek, contain references to the " cartilaginous " skeleton in Sabellids and Serpulids.

Amongst others, R. Wagener* (1832) describes the alimentary canal in *Sabella ventilabrum* (*S. penicillus*, L.) as having two sacs in front, such apparently, from his figure, representing the anterior nephridia. He pointed out the commissures connecting the great nerve-cords.

Milne-Edwards (1838) considered the circulation in the Sabellids to be akin to that of *Nephthys* and the Nereidæ, a dorsal and a ventral trunk being present, and the inner aspect of the integument is supplied with a multitude of vascular filaments for the secretory organs, and, with the bases of the feet, present also a capillary *rete* which probably aids in respiration, though the main respiratory organs are the cephalic fans. He did not allude to the special vascular sinus around the gut.

Grube (1838) gave a general account of the structure of *Sabella unispira* (*Spirographis spallanzani*), especially of the alimentary and circulatory systems. He pointed out that Leuckart was wrong in attributing two vascular trunks to each branchial filament. He thought that the anterior (thoracic) nephridia were connected with reproduction.

Kölliker †, in his researches (1856), describes the "cartilage" of several annelids, such as *Sabella unispira* (*Spirographis spallanzani*), but he was uncertain as to the distinctions between the blood-vessels and the nerves of the filaments, and his figures indicate that his "Knorpelfaden" structurally differs from that described here. He noted the specially thickened hypoderm (his epithelial layer).

De Quatrefages (1850) thought that in the branchiæ of the Sabellidæ and Serpulidæ are venous and arterial twigs, which mingle in a system of vessels the walls of which cannot be distinguished from the surrounding tissues, and in which respiration is carried on through the thin covering tissues and their cilia. He describes in these branchiæ what he terms a cartilaginous skeleton, composed of cells surrounded by a tough fibrous investment like a periosteum. According to this author, the cephalic ganglia in *Sabella flabellata*, Savigny, form two pairs connected by a large commissure, and from these branches go to the branchiæ and the eyes. The œsophageal connectives are very short. The visceral system seems to arise from these ganglia as a small twig on each side furnished with two ganglia. The great ventral nerve-cords are separate throughout, though nearer each other posteriorly, and the first ganglia are close to the cephalic,

* 'Isis,' 1832, p. 655, Taf. x.

† 'Untersuchungen z. vergl. Gewebelehre augestelt in Nizza im Herbste' (1 Sitzung. 13 Dec.).

the others following segmentally, each being joined to its neighbour by fine connectives and giving branches to the muscles and various organs.

Dr. Thos. Williams* (1858) stated that the segmental organs both in Sabellids and Serpulids were absent from the anterior or thoracic region and were present only in the abdominal portion in the form of looped tubes, but he could not distinguish the part of the tube to which the ova were attached. He thought the ova did not escape into the cœlom, but were confined in a membranous bag. He found a similar structure in the Amphictenidæ, Spionidæ, and other forms.

In *Spirographis spallanzani* Claparède (1873) describes the giant fibres of the nerve-cords as separate in the inter-ganglionic spaces from the trunk, and figures them (his pl. v. fig. 5) surrounded by connective tissue. Internally is a medullary substance. These fibres run throughout the abdomen without apparent anatomical connection. In the thorax they are repeatedly joined by anastomoses. Throughout the rest of the body the nervous chain is united in each segment by two transverse commissures. On entering the thorax the two tubular fibres divide into two branches, which pass forward reduced in diameter, and ultimately penetrate the cerebral ganglia, where they branch and are lost. Various branches are given off from the tubular fibres along the commissures, but he could not trace them along the ventral nerves of the thorax. The branchial nerves are greatly developed in the Sabellids and in *Myxicola.* He found in *Spirographis* that circular muscular fibres penetrate the ventral shields and that the fibres generally show nuclei surrounded by granular matter. Further, that in transverse section of the setigerous processes the bristles are arranged in a spiral, just as Pruvot and Racovitza showed subsequently. No dorsal vessel exists anteriorly, only a plexus of anastomosing trunks from which the large branchial vessel arises on each side. A periintestinal sinus surrounds the stomach †. There is a well-developed rete in the collar, and the purified blood afterwards enters the ventral trunk.

He considered that in the Sabellids the connective tissue of the anterior region is of importance and aids in filling up the cœlomic cavity, which is almost suppressed, except the spaces for the branchial vessels. The two segmental tubes

* Philos. Trans. 1858, p. 123, pl. vii. fig. 13.

† De Quatrefages first described this plexus around the gut (his lacunar system).

in front are curved on themselves, and are highly vascular. He thought they secreted mucus.

He describes and figures the "cartilage" of the branchial apparatus of *Spirographis*, with its "perichondrium," as if this was a separate tissue, and the same tissues occur in *Myxicola* and *Protula*. In his figure this structure is shown as a rod with a single transverse series of septa in the filaments, and his description of the general structure corresponds with that in *Bispira*. His figures of the various parts in the sections of *Spirographis*, though small, are generally true to nature, for the author had equal facility with pen and pencil.

Löwe * (1878–9) distinguishes in the branchiæ of the Serpulids an ectothelium and an endothelium, the former coating the outer surface of the bifid region in a section of the filament, the latter the inner surface. He seems to agree with Kowalewsky in regard to the homologies of the nervous system of worms and vertebrates, and concludes with a comparison of the Sabellid skeleton with that of the embryo dog's skull in horizontal section (his fig. 8).

Cosmovici (1880) considered that, as in *Myxicola*, the organ of Bojanus in the Sabellids was situated at the anterior end, each organ, from a pouch which is longer than in *Myxicola*, opening by a pore, the cilia of the interior causing currents in this direction. The segmental organs are found, he states, in each segment from the middle of the body to the tail, and consist of a ciliated funnel behind the diaphragm and a tube which opens below the setigerous process of the foot. These organs transmit the reproductive elements, which are developed in glands attached to the inferior lateral vessel and extending to the superior lateral vessel. He thus considered the thoracic glands the organs of Bojanus.

A careful account of the thoracic glands and other segmental organs is given by Prof. Haswell † (1884), who, in contrast with the views of some later authors, could find no internal opening of the former. His sections of the thoracic region of *Eupomatus*, a Serpulid, agree on the whole with those of *Pomatocerus*. He points out that the true segmental organs are found in pairs in all the segments of the posterior or abdominal region. He figures the appendix to the thoracic glands in *Eupomatus*, but does not allude to it. The position of the nerve-cords in relation to the ventral longitudinal

* Zeitsch. f. w. Zool. Bd. xxxii. p. 158, Taf. ix.
† Proc. Linn. Soc. N.S.W. vol. ix. pp. 7–12 (sep. copy).

muscles needs revision, but the general structure is in accordance with nature. His account of the circulation in both Sabellids and Serpulids is excellent.

Viallanes * (1885) thought the skeletogenous tissue of the Sabellids (e. g., *Sabella flabellata*) approached that of the vertebrates, though Krukenberg found that chemically it differed. In the tentacles (his antennæ) the skeleton ("tige cartilagineuse") forms a central arc enveloped in thick perichondrium continued from the branchial lamina, and it seems to be absolutely homogeneous and transparent, though composed of a single row of cells. The perichondrium he compares to horn, and it and the "cartilage" have no ground- or fundamental substance. This skeleton is in contact with a blood-vessel which passes to the tip and is surrounded by a lymphatic space, and he thought that the lymph, and not the blood, respired directly.

Pruvot † (1885), like many others, alluded to the branchial "cartilage" of the Sabellids, and described the union of the dorsal and ventral longitudinal muscles to form two large cylindrical muscles which go to the branchiæ, a fasciculus passing to each filament. The anterior thoracic glands are coiled or tangled ("enchevêtrés"), and open dorsally behind the branchiæ in the median line. He did not place the same weight as Claparède did on the distinctions of this organ in the Sabellids and Serpulids respectively, and they are soldered in the middle line in *Sabella penicillus*. The tentacles (his antennæ) vary from the normal two to ten or twelve (*Sabella terebelloides, S. analis*, &c.). In *Apomatus ampulliferus*, Phil., there are three pairs, and they resemble the branchial barbules, whilst in *Potamilla reniformis* two pairs occur, the first being well differentiated, but the second represents an intermediate structure with the branchial barbules.

Andrews ‡ (1891) described the structure of the compound eyes of annelids, his *Potamilla reniformis* having seven or eight eyes on each branchial filament instead of the three given by Malmgren; and *Sabella microphthalma*, Verrill, has them on the outer side of each branchial stem, which likewise has transverse bars of pigment. In *Dasychone conspersa*, Ehlers, the eyes also occur along the outer bases of

* Ann. Sc. Nat. 6 sér. t. xx. pp. 1–20, 1 pl.
† Archiv. Zool. Expér. 2 sér. t. iii. p. 335.
‡ Journ. Morphol. pp. 271-399, pl. xxi.

the filaments (pl. xxi. figs. 20–22); and, lastly, he gives an account of *Sabella melanostigma* (pl. xxi. figs. 17–19).

A large memoir on the structure of the Tubicolar Polychæts (chiefly Sabellids and Serpulids) was published by Soulier * (1891). It deals particularly with such forms as *Spirographis spallanzani*, Viviani, *Branchiomma vesiculosum*, Montagu, *Sabella viola*, Grube, *Myxicola infundibulum*, Montagu, and *M. æsthetica*, Claparède; whilst amongst Serpulids *Protula milhaci*, Marion, *Serpula infundibulum*, D. Chiaje, and *Hydroides pectinata*, Müller, were specially studied. Interesting accounts are given of some of these in captivity, including the formation and structure of their tubes and other features. His interpretation of the structure of the anterior "nephridia" (periœsophageal glands) for the most part agrees with that of Ed. Meyer. The histology of the skin and other organs is described with great detail in this paper.

A memoir by Ed. Meyer † on the Sabellidæ and Serpulidæ (his Serpuliden) was published in Russian in 1893. A careful account of the nephridia in *Eupomatus* and *Psygmobranchus* and the structure of the body-wall is given, along with the structure of the nephridia in *Sabellaria alveolata*. Late stages in the development of *Psygmobranchus protensus* further elucidate the subject. Like Soulier, he describes and figures a ciliated funnel opening into the perivisceral cavity at the cephalic end of the anterior segmental organs or thoracic glands. Since the work of Claparède no investigator except Eisig has more fully dealt with the structure of the Polychæts, more especially of the Sabellids and Serpulids, and his memoirs in the Naples 'Mittheilungen' ‡ are models of patient research, skilful draughtsmanship, and general accuracy.

Otocysts were early described in the Sabellids by De Quatrefages (1844) in an *Amphicora*, and, amongst others, Claparède, Langerhans, Meyer, Brunotte, De St. Joseph, Caullery and Mesnil, Soulier, and Fauvel have studied their occurrence in this group. The most comprehensive account is given by Fauvel § (1909), who describes them in *Branchiomma vesiculosum*, in the first bristled segment, in two species of *Potamilla*, viz. *Potamilla reni-*

* Thése, 'Etud. sur l'Anat. des Annél. Tubic. de la Cette, Secret. du Tube, &c.,' Montpellier, 1891.

† 'Die Organisation de Serpuliden u. Hermelliden,' Kasan, 1893, 3 pls.

‡ *E. g.*, Bd. vii. and Bd. viii.

§ Ann. Sc. Nat. 9 sér. t. vi. pp. 1–144, pls. i.–iii.

formis and *P. forelli*, in *Amphiglena mediterranea*, three species of *Jasmineira*, viz. *J. caudata*, *J. oculata*, and *J. elegans*, in *Myxicola infundibulum* and three other species of *Myxicola*, in three species of *Chone*, viz. *C. duneri*, *C. arenicola*, and *C. collaris*, in *Euchone rosea*, *Dialychone acustica*, in *Oria armandi*, and *Orcopsis metchnikowii*. In this family they occupy the first bristled segment and they are innervated from the œsophageal collar. As in other annelids, Fauvel considers that these organs perform the function of statocysts, for perceiving vibrations, and are, perhaps, also organs of orientation.

Numerous instances of the regeneration of both extremities have been recorded in the Sabellids. Thus, Dalyell * observed the reproduction of both ends in *Sabella pavonia* (his *Amphitrite ventilabrum*). Grube and De St. Joseph subsequently found a similar condition in the same species. C. Vaney and A. Conte † described regeneration after experiments in *Spirographis spallanzani*. Ivanow ‡ and Orlandi § respectively studied the same species in regeneration. Grube || found renewal of the anterior region in *Potamilla reniformis* and De St. Joseph ¶ in *P. forelli*, with regeneration of the branchiæ in *Myxicola dinardensis* and in *Dasychone bombyx*. Soulier **, again, describes regeneration of the branchiæ in *Branchiomma vesiculosum*.

One of the most complete accounts of the regeneration of the anterior and posterior ends of a sedentary annelid is that of P. Ivanow ‡ (1908) in *Spirographis spallanzani*. Both text and figures are full of interest—especially as regards the nervous system and segmental organs. Many authors, however, describe bifid posterior ends of other species.

The Sabellidæ, like the Terebellidæ, are stated by Dr. Goodrich †† to possess nephridia which open internally, and that the genital funnel becomes connected with the nephrostome and loses its primitive opening to the exterior.

An account of the "cartilaginous" substance in the branchiæ of *Spirographis spallanzani*, *Branchiomma köllikeri*, *Sabella reniformis*, and *Sabella infundibulum* is given by

* 'Powers of the Creator,' vol. ii. p. 225 (1853).
† Bull. Mus. Hist. Nat. t. xiv. (1908).
‡ Zeitsch. f. w. Zool. Bd. xci. p. 511, Taf. xx.-xxii.
§ Archiv. Zool. Napoli, vol. iii. 2 fig. (1906).
|| 'Ein Ausflug-Triest u. Quarnero,' 1861.
¶ "Annél. Dinard," Ann. Sc. Nat. 7 sér.
** Trans. Instit. Zool. Montpelier, 1891.
†† Quart. Journ. Micros. Sc. vol. xliii. n. s. p. 740.

Nowikoff * (1912), illustrated by representations of stained sections, which indicate the position of muscles, nerves, and blood-vessels as well as the skeletogenous elements. He regards the supporting substance as homologous with that in Mollusca and Vertebrates, presenting, moreover, less polygonal or somewhat rounded cells, with ground-substance of a chondro-mucoid character, with nuclei and protoplasmic contents, and having externally a layer, which he terms perichondrium, upon which the cuticle and its nuclei rest. The author does not go into the distribution of the skeleton in the foregoing forms, but confines his attention chiefly to the histology of the tissue, the so-called "cartilage"-cells being filled with fluid, and almost resemble plant-cells from their distinctness. They possess one, rarely two, nuclei. The perichondrium is granular and has an alveolar (basement-) layer between it and the hypoderm.

The structure of the body-wall in *Sabella penicillus*, L., is typical, though there are special developments of the surface. Thus, on each side of the mid-ventral line a thick glandular layer outside the circular muscular coat occurs. This appears to be a special development beneath the hypoderm, which is readily traced over it and along each side of the mid-ventral fissure. The circular muscular coat is well developed and is continuous or nearly so. The dorsal longitudinal muscles are in section thick externally, but taper to the mid-dorsal line, where a hiatus for the suspensory mesentery of the alimentary canal occurs. These muscles are comparatively narrow and do not reach the lateral edge. In the same way the ventral longitudinal muscles are compact or almond-shaped in section, slightly thinned internally, and each is separated by a wide gap from the muscle of the opposite side. Both dorsal and ventral longitudinal muscles have a translucent sarcolemma on the free surface and both show bands of sarcolemma here and there cutting the mass into various fasciculi. Under the inner edge of each lies the nerve-trunk surrounded by neurilemma and with comparatively little neuroglia. On the upper and inner edge of each is a large neural canal, which in many sections is larger than the nerve-trunk and is occupied by a coagulable material. It appears to be unnecessary to call such a tube a giant nerve-fibre, and, indeed, the term neural canal was adopted in 1877 †, and may as well comprehend the finer

* Zeitsch. f. w. Zool. Bd. ciii. p. 686, Taf. xvi.

† "On the Arrangement and Relations of the Great Nerve-cords in the Marine Annelids," Proceed. Roy. Soc. Edin. Session 1876–77.

canals, which can be traced into nerve-cells. An intricate series of fibres in transverse section occurs in the middle line between the nerve-cords and surrounds a small granular area above and another below. In each segment (probably at the junction) a very complex series of fibres—chiefly transverse and oblique—commingle over the nerve-area, whilst in the intermediate regions the ventral vessel and the muscular fibres and mesentery attached to the lower edge of the alimentary canal are more distinct. The alimentary canal itself is normal in section, and it has large blood-sinuses and vessels on its wall, besides the dorsal trunk (in its region). The thoracic glands occur in front, and the segmental organ lies to the exterior of the ventral longitudinal muscle.

Toward the posterior end, whilst little change takes place in the hypoderm and the ventral subhypodermic belt, or in the circular muscular coat, the dorsal longitudinal muscles are considerably extended laterally, whereas the ventral longitudinal muscles are diminished in transverse diameter and have the bristles close to their outer edge. The nerve-cords occupy the same position at the inner edge of the muscles and next the circular coat, the neural canal having about the same proportional size as in front. The complex crossing of fibres above the area occurs at intervals as in front. The gut in this region is filled with dark sandy mud.

Branchial Apparatus.—One of the most interesting featur s in the structure of the Sabellids, such as *Bispira volutacornis*, Montagu, is the chordoid skeleton which supports the branchial apparatus, and which commences behind the brain as a small lateral area (Pl. III. fig. 15, *ch.*), which soon develops into an arc on each side (Pl. I. fig. 1, *ch.*). About the region of the brain the lateral arcs fuse in the mid-dorsal line (Pl. I. fig. 2, *ch.*) and thus form a continuous curved belt from side to side, not, however, of uniform breadth in a given section, but with indentations, as at the large cœlomic area dorsad of the brain or at the enlargements laterally. This chordoid tissue is finely reticulated in the adult, more distinctly cellular in the young, the connecting walls staining slightly, and nuclei are very evident, especially in young examples. It is bounded externally by the firm investment or "perichondrium," the basement-tissue and muscular layers, hypodermic and articular, whilst internally it is bounded by the same homogeneous border of "perichondrium" to which muscles are attached. This "perichondrial" boundary (Pl. II. fig. 10, *pr.*) is not a separate layer, but processes from its inner edge all round pass as bridles to the reticulations and cells composing the interior, so that the two are modifications of the same tissue, the whole organically connected as a stout supporting layer externally and a central region of complex reticulations. There is thus a considerable divergence from the bone-forming periosteum or the perichondrium of vertebrate cartilage, though the structureless matrix of the latter with its enclosed cells comes nearest: The great mass of this chordoid skeleton is dorsal, as are also the ganglia, whilst the great nerve-cords rapidly seek a ventral position, the former being above the alimentary canal, the latter beneath it. The muscular fibres on the inner curve of the chordoid skeleton about the level of the open vestibule—that is, before the closure to form the œsophagus—are not longitudinal, but oblique or vertical, stretching from the lower part of the inner concavity to the upper part of the arch, so that they would shorten the curve. Moreover, the "perichondrial" border shows large reticulations on its inner edge, a feature of importance in the elasticity of the parts during the varied movements (Pl. II. fig. 10). The inner border of this tissue widens at the level of the full development of the apparatus, and at its broad lateral part the sides of the curve projecting outward are laced together by muscular fibres, so that the curve—acute as it is—can be shortened. At this level also the chordoid central area is strengthened by special processes of the marginal tissue ("perichondrial" of authors). At the origin, again, of the chordoid skeleton (Pl. III. fig. 15, *ch.*) transverse muscles connect the two sides, and mesenterial fibres pass from their lower edge to the œsophagus, whilst the common duct of the thoracic glands is clasped by the strands. It forms a protective shield and support to the two great vascular trunks, the cœlomic spaces, and to the cephalic ganglia, whilst stiffening the attachments of the muscles of the region ; indeed, in extent, it exceeds the cephalic skeleton of the cuttlefishes, and yet it has a certain degree of elasticity in the varied and graceful movements associated with the display of the branchiæ. Passing forward the lateral regions of this chordoid skeleton enlarge and begin to present intruding pillars, cutting the outer edge into regular spaces with convex margins externally, the first indication of the bases of the branchial filaments. Then the chordoid tissue arranges itself in long lobes connected with a narrow and rapidly diminishing inner belt of the same tissue, and this is soon followed by the disappearance of the inner belt and the inner portion of each lobe, leaving only a rounded or ovoid chordoid area marking the origin of each filament (Pl. II. fig. 12). The space occupied by the chordoid arch is now the seat of a series of radially arranged muscular bands, two for each filament, a connective-tissue septum from each chordoid oval passing in transverse section between them. The cuticle and hypoderm externally become crenate and then notched, whilst spaces or slits appear between the chordoid ovals, by-and-by pass to the surface, and thus truncated fillets representing the separate filaments are formed all round the edge of the branchial base. The outer edge of each has a thick coat of hypoderm under the cuticle, but this diminishes internally on the sides, becoming thinner in its progress inward, the whole area resembling a narrow wedge with the broad end outside (Pl. II. fig. 12). Within the broad end is the basement-membrane and a "perichondrial" area surrounding the chordoid oval from which the median strand passes inward to support the blood-vessel. In this region the bases of the filaments and their axes are joined by a long band of the "perichondrial" substance, the appearance after partial maceration resembling a chain of *Perophora listeri* or similar series of tunicate stolons.

The two bands of muscle then show signs of diminution. Just before the filaments separate, small clear spaces occur at somewhat regular intervals in the interfilamentar tissue, but they are not visible after separation. At this level the sections of the bases of the filaments have their longest diameter radial (Pl. II. fig. 12), but this by-and-by shortens, and their inner border separates from the internal lining at the base, and each forms an independent filament, the muscular fibres, meanwhile, gradually diminishing. The chordoid cells in these form a double row (Pl. II. fig. 12), sometimes with two nuclei, but generally with a single nucleus in each, and the number of cells diminishes in the distal parts of the filament (Pl. I. fig. 4). When a pinna is cut longitudinally, a double row of cells is present in the sections (Pl. I. figs. 5 & 6), besides the external investment, or, as the knife slants superficially, the closer lines indicating the cells of the hypoderm intrude, as at the lower part of the drawing (fig. 6). The nerve occupies an area near the ciliated groove at the inner border. The double character of the slits is still preserved, for one-half of the inner joins that of its neighbour to the right, and the other that to the left. Then the diameter of each filament, now free, still further diminishes, and the blood-vessel is separated from the chordoid skeleton only by a narrow belt of connective tissue. Moreover, a double row of pinnæ springs from the inner and narrower edge, the outer having its thicker belt of hypoderm and its more massive connective-tissue layer and nerve internally. A single row of chordoid cells passes from the chordoid oval into each pinna as its skeletogenous rod, and thus the whole system is continuous from its massive base to the threads in the delicate pinnæ, which have a thick coat of hypoderm and a ciliated cuticle. In the young *Bispira* the chordoid cells are especially large and distinct.

The branchial skeleton thus springing from a firm base spreads forward (or, as usually described, "upward") as a vase- or funnel-shaped sheet, binding together the bases of the filaments and, finally, dividing into the isolated rods for the filaments and pinnules. At the origin of the filaments the skeletogenous tissue forms a broad belt, continuous externally as a narrow rim, and having within this a small group of the chordoid reticulations, then a series of skeletogenous areas (in section) sometimes with marginal muscles, indicating the rudiments of the filaments. The chordoid reticulations then become more numerous, the "perichondrial" area diminishes, the soft parts increase, and by-and-by the separate filament is evolved. The chordoid rods to the pinnules appear to pierce—if such an expression can be used in connection with this continuous tissue—the "perichondrial" investment of each filament, and come into contact with the reticulations at the outer part of each. The whole chordoid skeleton is, however, a continuous structure, and it is only the continuity of the areolæ of the pinnules with those of the filaments which makes the use of the term "piercing the perichondrium" intelligible. A comparison of the adult and young specimens of the annelid show that the nuclei are remarkably distinct in the latter, whilst the smaller number and proportional larger size of the cells are features of moment. Many previous authors having used, in connection with this skeletogenous tissue, terms which would imply separate tissues, it has been necessary to insist on the unity of the structure as a whole.

Another feature of the chordoid skeleton is its connection with the shedding of the whole branchial apparatus in the Sabellids, for all the chordoid tissue appears to be thrown off with the branchial fans and the tentacles, the funnel-shaped anterior or distal portion consisting largely of this tissue covered by the integuments. The vessels on the proximal side would thus be more readily constricted, and an active surface for the reproduction of the apparatus uncovered. Whether this shedding of the branchial fans occurs frequently in nature is an open question, but the annelids in confinement sometimes do so.

The branchial fans double inward at their ventral base as a thin lamina with miniature filaments, each with its chordoid axis, and along the inner border of each the nerve-strands occur.

The tentacles (Pl. I. fig. 3, *t.*) belong to the branchial system, and separate in such a form as this and probably in all or many Sabellids, along with the branchiæ, which in their normal line of separation show a notch between the symmetrically curved chordoid basal support, which unites the halves above the gap by a firm bar of similar tissue. A little beyond the outer edge of this bar on each side springs a tentacle, the spout-shaped external basal fold of which is deeply pigmented with brown in *Bispira.* The inner basal web of each runs forward on the first dorsal branchia, whilst the outer web forms a free flap, the important furrow from the base of the branchial fan lying between them, and it is this groove which is pigmented. The tentacle itself is continuous with the inner flap or base, and presents a somewhat thicker median rib supported by the chordoid skeleton, the whole tapering to a delicate tip. Its nerve is of considerable size, and the organ is probably of great importance in regard to the nature and contents of the currents swept through the groove. Claparède * applied the term "tentacle" to the inner lateral fold of the mouth in his sections, but such is a wholly different structure from the tentacle as here described, and performs a different function.

In transverse section the tentacle, when fairly formed, presents a rounded axial region and two flaps or lamellæ arranged in opposite curves (Pl. I. fig. 7). The curves of the lateral flaps or wings are diagnostic, and indicate special functions, one flap curving to the left of the central region and the other more or less to the right in transverse section. Over the whole is the cuticle, then a layer of short nucleated epithelium resting on a basement-tissue, and within it a consistent connective tissue and probably muscular fibres, though these are indistinct on the wings. The central region is more or less rounded in section, with a tough cuticle and thinner hypoderm, but it is supported by a transparent skeletogenous axis containing a homogeneous substance surrounded by granules, whilst on one side (that furthest from the curved flaps) is a band of muscular fibres and on the other a nerve. The fact that this homogeneous substance does not stain would point to its solidity or coagulability. It is noteworthy that in the marginal line of filaments connected by the "perichondrial" strand, similar appearances, without the granules, in section are found, so that the tinted centre may be of the same "perichondrial"

* Annél. Sédent. pl. i. fig. 1, *tt.*

substance. The curve of the larger flap, which appears to be normal, would seem to show that the connective tissue in its middle is more or less elastic. Viewed in section the central rib presents cuticular and hypodermic coverings, then the transparent skeletogenous layer, which shows no evidence of cameration, and in the centre the tinted coagulable substance surrounded by the granules. In all probability this is a blood-vessel, and a trunk is seen in other forms, such as *Spirographis*, running up the centre of the skeletogenous sheath which ends in a delicate tip; and in the basal region of the tentacle numerous fine twigs ramify in the tissues. In sections from the tip downward the longer curved flap lies within the outer branchial row, between it and the tip of the inner row, and it has a blood-vessel at its edge.

Nervous System.—The cephalic ganglia in section (Pl. I. fig. 1, *cg.*) form two ovoid masses, connected by a broad commissure, and situated about the commencement of the chordoid skeleton of the region. The outer and more cellular part of each ganglion stains slightly, whilst the inner region and the commissure are pale. Moreover, at the outer edge of each mass is a pale area in section surrounded by brown pigment apparently representing an eye (Pl. III. fig. 14, *oc.*), and thus akin to the deep-seated eye of the ammocete stage of the lamprey, though it does not reach the surface in adult life. The capsule is consistent and stains, the centre being pale as if functioning as a lens, whilst the brown pigment seems to be chiefly massed on the inner border. Between the dorsal mass of muscle and the ganglia is a large vascular trunk on each side—the branchial—besides a closely reticulated tissue, the same tissue occurring laterally where the lower ends of the muscles cease; whilst the œsophagusis in the middle line below the commissure, and its sheath of muscle and connective tissue abuts inferiorly on a broad glandular hypodermic area ventrally, the apex of which is joined to the œsophageal sheath by the same reticulated connective tissue mentioned previously. In front of the ganglia a large cœlomic space and a vascular trunk lie at the base of the branchial apparatus before separation into branches for the filaments.

The sections, at the separation of the great nerve-cords from the cephalic ganglia were somewhat imperfect, but these trunks appeared to follow a similar course to those of *Spirographis,* as described and figured by Meyer * and others.

* Mitt. Zool. Stat. Neapel, Bd. vii. Taf. xxiii. fig., and Bd. viii. pp. 537–569.

The great cords after the disappearance of the eyes pass downward with their cellular sheath to the sides of the œsophagus (Pl. III. fig. 15), having beneath them only the dense mass of the ventral glandular hypoderm, the œsophagus being surrounded by the tissues of the region before this takes place, and, as those around the organ are chiefly muscular, firm constriction of this part can readily occur, the distinction between this region, imbedded as the gullet is in firm contractile tissues (Pl. II. figs. 8 & 9), and that which follows—in which the canal is more or less free—is therefore marked. Proceeding backward the œsophagus is fixed by a median mesentery ventrally and by various strands dorsally to a transverse sheet above it and the nerve-cords, a space, divided into two by a median muscle, occurring above—that is, below the dorsal longitudinal muscles (Pl. II. fig. 8). The nerve-cords with their investment then pass below the level of the alimentary canal and lie at some distance from each other at the inner border of the ventral longitudinal muscles, the ventral blood-vessel being between them and the massive ventral hypoderm externally. A small neural canal is now visible at their upper and inner border, no trace of this having been observed previously, as the great cords lay at the sides of the gullet. Passing gradually downward the cords are enclosed by fibres from the circular coat crossing above and below them (Pl. II. fig. 8), the small neural canal, sometimes two, being visible—for instance, at the ganglia in the nerve-sheath at the upper and inner angle of each. The nerve-cells are confined for the most part to the exterior investment of the ganglia and the trunks, though some are in the substance of both. The transverse (circular) fibres above the cords increase in strength, and are further stiffened by the fusion of strong muscular fibres from the sheath of the alimentary canal in the middle line. Other fibres pass outside the cords, and even between them in the intervals between the ganglia, so that in this region they are well supported and they are nearer each other than in front. The transverse (circular) fibres above the cords remain after the muscular band from the gut disappears and a median mesentery takes its place, whilst the small neural canal shows little change. Proceeding backward, the ventral blood-vessel is surrounded by a thick ring of muscular and connective-tissue fibres fixed ventrally between the neural canals and beyond them. The neural canals are now considerably larger, and the gut and the ventral vessel are connected with the slender transverse fibres by a thin mesentery; but this only lasts for a short distance, when the thick investment of the trunk again appears in the progress backward, so that an intermittent arrangement is present, a feature probably due to the intervals between the thicker mesenterial bands from the gut, these bands being composed of fibres studded with nuclei ; and the fibres cross each other on their way to those beneath the cords in the interganglionic areas. The neural canal is sometimes double on one side, single on the other. At the thickened perivascular areas the gut touches or is sessile on the coat of the vessel. In the intermediate regions, where the vessel hangs in a thin mesentery, it has a pigmented coat of clavate chloragogen-cells (Pl. III. fig. 17, *chl.*), the broad end being external, so that they form an arc on each side. The secretion of these, no doubt, is of some importance in connection with the vascular trunk and the cœlom *. Anteriorly, when the thickened coat occurs, the pigmented cells are placed to the exterior of the arch on the cœlomic surface, but, by-and-by, in the progress backward they are grouped inside the channel of the tube on the blood-vessel, and this continues till it again is free. The great cords are now more rounded in section, with the neural canals at their upper border or at their outer and upper border, and on the right side in one case two are present, the larger almost extra-neural and pressing into the border of the ventral muscle. Comparatively few cells occur in the interganglionic areas, the general surface of the cords in section being finely granular and somewhat reticulated so as to form rounded areas. The cells increase at the ganglionic regions, and appear chiefly in the neuroglia, only a few occurring in the commissural band. Posteriorly, the cords in section at a commissure are placed close together with the neural canals between them, the nuclei of the neuroglia scattered thinly in their area in section and more thickly exteriorly.

A short distance behind the foregoing the body-wall assumes its normal arrangement, the ventral longitudinal muscles lying within the hypoderm, basement-tissue, and circular coat, whilst the nerve-cords and the intermediate ventral blood-vessel occupy the space between their inner ends. Each cord has the circular muscular coat, the basement-tissue, and the glandular mass of the shield externally, with its fibrous area inferiorly, and above it is the now large neural canal, which has a firm wall and usually a coagulum

* In a large example a peculiar and symmetrical appearance was caused anteriorly by the intrusion of the massive ventral coat ef hypoderm on each side of the cords and their ganglia, so as to form an arborescent mass above and on each side over the inner ends of the ventral longitudinal muscles. Such probably was due to pressure in preparation.

in its lumen, the edge of which stains deeply. A reticulated investment (neurilemma) separates it from the ventral blood-vessel, and a firm layer of the same tissue roofs in the entire area, the fibres of which closely link it on to the alimentary canal immediately above. The neural canal soon becomes as large as the section of the nerve, and, as mentioned, it seems unnecessary to term it a "giant fibre."

Cunningham * (1888) is inclined to regard the neural canals as supporting structures, which prevent the nerve-cords being bent at a sharp angle, and where they are highly developed the cords are not separated from the epidermis. He states they have a position similar to that of the notochord in relation to the neurochord and aorta. He failed to trace a connection between these canals and any ganglion-cell, whilst admitting their homology with those of the Errant annelids.

In a section of a young *Bispira* stained with Ehrlich's hæmatoxylin, the cephalic ganglia are rather widely separated, for they occupy the upper and outer border of the vestibule leading to the mouth, and which has the outline dorsally of the letter M. To the exterior is a pale belt free from cells, then a band of muscular fibres inside the chordoid layer with its investment, whilst the cuticle and hypoderm form the superficial coverings. The chordoid cells are large, distinct, and transparent, each with its nucleus, and sometimes with two, and they form at the level of the brain a horseshoe guard on the dorso-lateral region, the ventral aspect of the ganglia abutting to a large extent on the mucous membrane of the vestibule, the isthmus between them following the descending bars of the M in its progress from side to side. Moreover, in contact with the isthmus dorsally are the basement-membrane and the hypoderm of the cephalic *cul-de-sac* in free communication with the sea water. The organ thus is in a favourable position for receiving impressions from the exterior as well as by its nerve-trunks, whilst the elastic chordoid skeleton gives sufficient protection. In the transverse sections the entire ganglion on each side is dotted with deeply stained nerve-cells, which perhaps are most numerous toward the surface, and they extend into the nerve-trunks, leaving the organ, as well as being distributed on the isthmus from side to side. In some cases they are grouped in arcs with the pale neuroglia between, as if pertaining to a lobule, but, as a rule, there is little definition in this respect. Immediately behind, the

* Quart. Journ. Micros. Sc. n. s. vol. xxviii. p. 275.

nerve-mass bulges ventrally at the sides of the vestibule, and the trend of the intervening commissure is more or less straight—from the change in the roof of the vestibule, the central lines of the M being more or less obliterated.

The eyes (Pl. III. fig. 14) do not appear in the sections until the protective chordoid tissue has diminished to a small arc above the posterior region of the cephalic ganglia, and when a mere chink above the gullet indicates the external pit in communication with the sea-water. The œsophagus itself is now enclosed in connective tissue and circular muscular fibres. The eyes rest on the ganglia, and the great trunks arise near, and show a pale faintly granular central area and a thick investment of neuroglial cells. The eyes have dense brown pigment-cells apparently radially arranged round a pale region, which probably represents a lens, a thinner layer of the pigment occurring on one side of the elliptical organ according to the level of the section. In some sections a pale spot appears in the centre of the pale brownish median region, the dark pigment forming a belt exteriorly. These eyes appear to be similar to those Meyer * found in *Psygmobranchus protensus* (= *Protula tubularia*, Mont.) and *Amphiglena mediterranea*.

In *Serpula contortuplicata* (= *Hydroides norvegica*) De Quatrefages describes the cephalic ganglia as large and only separated by a constriction in the middle line, and giving off from each side a large branch to the branchiæ. The œsophageal connectives are longer than in *Sabella*, and from the first widely separated pair of ganglia a considerable trunk passes to the "voile palléal" (the thoracic membrane). The ventral cords remain separate, and ganglia connected by a slender commissure occur in every segment. The trunks are wider apart anteriorly than posteriorly.

Muscular System and Body-wall.—About the level of the brain muscular fibres are fixed to the inner wall of the chordoid skeleton (Pl. II. fig. 10, *m.*), which here attains great development, and their general trend shows that they draw the horseshoe bend of the skeleton close. Proceeding backward, a strong longitudinal muscle (Pl. I. fig. 1, *m.*) appears at the ventral end of the diminished chordoid area, and a smaller muscle above the skeleton, and the disappearance of the skeleton permits this muscle to form a continuous curved sheet, widest below, in the area formerly occupied by the skeleton, and it soon approaches its fellow of the opposite side, separated only by a series of transverse

* Mitt. Zool. Stat. Neapel, Bd. vii. Taf. xxiv. fig. 14.

fibres which connected the inner ends of the vanishing skeleton. Externally are circular fibres, which pass downward to a firm connective-tissue area at each side of the massive ventral hypoderm. This great muscular sheet is most massive below, where it supports the origins of the great nerve-trunks. At first no differentiation of the sheet is observable ; then pale connective-tissue fibres appear in its middle opposite the upper end of the nerve-masses, and in this an aperture appears, its cavity being surrounded by stained granules, and now it is seen that there are two longitudinal muscles, an upper and somewhat smaller rounded muscle, which projects dorsally on each side of the median groove, and a larger ovoid muscle at the outer side of the nerve-trunk, the two being separated on each side by an increasing cœlomic area. The two dorsal muscles are separated by a space, crossed by the circular fibres of the body-wall, and others passing from the inner edge of the muscle and from the six or more vertical bands from the alimentary canal. The hypoderm covering the prominence of these muscles dorsally is specially thickened. The second or ventral pair of muscles are still lateral in position, have the circular fibres, basement-tissue, and hypoderm externally, the nerve-cords and neuroglia internally, and connective-tissue bands and the hypoderm below. The dorsal muscles remain more or less rounded in section (Pl. II. figs. 8 & 9, *dm.*), but the ventral muscles become somewhat longer, more oblique in position, and the nerve-cords now lie below their inner edge inferiorly. Their elongation and obliquity increase in the following sections, for they assume a spindle-like outline, their limiting fibres fusing across the middle line with each other and with those from the vertical bands and those surrounding the gut, whilst the nerve-cords now lie below this fibrous isthmus, with a small neural canal in the neuroglia of their upper and inner border. The dorsal muscles are still rounded or ovoid, separated by a considerable interval in the middle line and wholly dorsal in position, but they by-and-by become pear-shaped in section, pointed mid-dorsally, and thicker externally; moreover, they slope a little downward and laterally. The ventral muscles stretch upward almost to the dorsal bristle-tuft, and are thus longer than the former (Pl. II. fig. 8, *vm.*)—indeed, their mass exceeds that of the dorsal, a condition so different from that in *Pomatocerus*. The dorsal muscles do not meet in the middle line, though thinned like the ventral in expansion of the body-cavity, and they are still less in bulk than the ventral. The oblique are long and slender, and are fixed over the outer part of the nerve-trunks.

Passing backward, in the anterior region, the dorsal muscles increase in bulk and pass further downward, the dorsal arch of the body being better developed, and the feet having taken a lateral position somewhat below the middle line. A median hiatus still occurs dorsally, and the muscles increase in thickness from this downward until reaching the blunt cone inferiorly. The ventral longitudinal muscles are sausage-shaped in section and now not half the bulk of the dorsal.

In the middle of the body of *Bispira* the walls have assumed the normal arrangement, the hypoderm being thin dorsally, thickened laterally, especially on the processes, and considerably diminished (from that in the front) in the mid-ventral line, the ventral area in section being that of a gracefully curved spindle, massive in the middle below the nerves, tapering off at each side, and again having thickened glandular areas in the lateral region with its processes. The dorsal longitudinal muscles are larger, somewhat thinned toward the dorsal middle line, where there is no distinct hiatus at the attachment of the mesentery, and the curve on each side increases in breadth to the lateral processes, where it bends slightly inward, and in some a slight median projection or keel occurs to which the median mesentery is attached. These muscles are lined by the cœlomic cells with nuclei. The fasciculi in section are fibrillar, and they abut externally on the somewhat thin circular coat and internally on the cœlomic surface. The ventral longitudinal muscles are less in bulk and more compact, but have similar fasciculi, each having a blunt point in section sloped upward and inward at the nerve-cord, slightly tapered and rounded at the external edge. In the interganglionic areas the nerve-cords have the support of the muscle on each side, the inner end often rising above them, and a deep hollow, in which the blood-vessel and its mesentery lie, between them. The neural canals are slightly larger than in front, an additional smaller canal in one case being within the larger on the right, and the investment of each is firm, with a few nuclei, and the usual coagulable contents. They occupy the upper and inner region of each trunk, though a small one occasionally is seen toward the lower border of the cord at the ganglia. The alternation of the slender ventral mesentery with its pigmented cells free in the cœlom, and the massive tunnel of crossed fibres with the vessel and its cells inside, and others along the cœlomic wall adjoining still continues. The gut in the middle of the body is capable of great dilatation, and there is a slight separation of the dorsal longitudinal fibres in the mid-dorsal line, but the fasciculi are similar to those in front, and the muscles are broader—that is, stretch further downward. On the other hand, the ventral muscles are more compact, and the hypoderm in the mid-ventral arc has diminished and shows a furrow ("copragogue") in the centre, and the sides project a little. The area of the nerve-cords in section is smaller, and the neural canals are proportionally larger. The same alternation of the muscular arches and tunnels with the free mesentery and its vessel occurs, but the ventral longitudinal muscles are thicker, their transverse diameter less, and their inner ends rise much above the nerve-cords, though these ends are thinner than the outer in section. The dorsal longitudinal muscles have attained great preponderance in bulk. In this region muscular fibres pass downward by the side of the gut and from the inner border of the lower mass of the dorsal longitudinal muscles, and cause, by passing through the fasciculi of the ventral sheet, a differentiation into an inner and outer belt at intervals.

Posteriorly the chief changes are the diminution and flattening of the body-wall, the great lateral expansion of the dorsal longitudinal muscles, so that each has a clavate outline in section, and a median hiatus, to which the mesentery goes, is present. The ventral muscles have proportionally increased in bulk and each is also clavate in section, the broad end being exterior, but they do not project above the great nerve-cords as in the middle region of the body. One of the most evident changes is the appearance of vertical bands of muscles which connect the dorsal with the ventral longitudinal muscles on each side of the alimentary canal, and they penetrate the fasciculi in both to the basement-membrane. The nerves and the neural canals are likewise diminished. Toward the tip of the tail an increase in the hypoderm takes place all round, the shrunken muscles rendering this more conspicuous, the dorsal longitudinal thinning off in the middle line much more than the ventral, so that the gut occupies the dorsal arch, whilst a thick mass of hypoderm occurs ventrally.

The muscles of the spines and bristles follow the same plan throughout, forming a fan-like or radiating series in each case.

Bristles.—When the setigerous process in the middle of the body is cut at right angles to its long axis two groups of bristles are found, a more compact series arranged in a somewhat spiral manner, and an outer series forming a single curve, the larger bristles in this case being above and the smaller at the ventral end.

Circulation.—In transverse sections from the tip of the branchial fan backward it is found that a clear space, it may be with a translucent coagulum in the centre, appears on the inner curve of each fan dorsally and soon is surrounded by a well-defined nucleated wall. Passing backward the trunk has a curved lamina attached to it about the level of the fused branchial filaments, and then it occupies a larger internal lamella, with the curved membrane distally. Before the chordoid skeleton appears the two trunks are imbedded in the folds, which by-and-by lead to the mouth, being situated on each side of the median fissure (Pl. I. fig. 2, *bv.*), when only slight crenations mark the incipient filaments with their chordoid skeleton, the central chordoid mass having disappeared. These trunks would seem to arise from the division of the dorsal vessel anteriorly, but the sections of the region did not afford absolute proof. Moreover, it has to be noted that, if these are vessels, their contents are devoid of the minute corpuscles present in the trunks elsewhere. Anteriorly the dorsal blood-vessel splits into two great trunks for the branchial fan, and each of these at the level of the chordoid skeleton divides into a series for the filaments, the whole in section having the aspect of a rosette (Pl. I. fig. 2, *bv.*). In the middle of the body the dorsal vessel has disappeared, and a plexus or blood-sinus surrounds the gut, whilst the ventral vessel remains as before; and this conditions remains to the posterior end.

In a series of sections of a large example in which the thoracic glands were unusually spacious, but which (preparation) had been overheated and damaged, deeply stained granular masses occurred inside the membranous sheath around the gullet, such probably representing the blood in the large sinus, though it might be mistaken for masses of sperms.

At the level of the brain in transverse section the ventral attachment of the collar occurs on each side of the central glandular area, the cuticle and hypoderm of the body-wall bending outward and ensheathing the collar, that part of it, however, covering the central glandular area being much more cellular and granular as well as slightly thicker than the rest. Between the two layers of hypoderm the collar has connective-tissue fibres, cells, and probably muscular fibres, though the latter were not differentiated. The flaps on the sides of the dorsal furrows have the same structure and all are modifications of the wall of the body.

Alimentary Canal.—The aperture of the mouth, fed by the grooves from the branchial fan, besides those elsewhere described, and with its dorsal transverse fissure and the two lateral folds or lappets on each side below, soon assumes in section the form of a transverse slit, the dorsal epithelial wall of which is boldly scalloped or crenate, with two projections in the middle line, whilst the ventral is two-lobed—two prominent lobes or projections occurring on each side of the central fissure. Then, passing backward, the canal forms a long transverse or slightly fusiform slit, its epithelial surface becoming at the same time less dense, whilst various mesenterial strands are attached to its outer wall; but soon the epithelial lining diminishes in depth and the canal becomes more capacious—shorter in transverse and longer in vertical diameter; its walls increasing in thickness, and its muscular and mesenterial strands more numerous. Thereafter its inner lining is thrown into narrow longitudinal ridges, and strong muscular fibres are attached to its outer surface. The great increase of the mucous lining and the diminution of the diameter of the canal cause the organ in section to be ovoid or even rounded, the entire area being occupied by the folds of the inner lining and the basement-tissue—circular and radiating fibres externally giving firmness to the rounded canal (Pl. I. fig. 1, *d.*). Then the mucous folds change their character, and the inner lining is thrown into slightly arborescent ridges in transverse section, somewhat after the fashion of the gizzard of certain Orthoptera, but it is not chitinous. Behind this, though still in the anterior or "thoracic" region, the canal retains the bold longitudinal ridges of the mucous surface, though they are less arborescent; the suspensory mesentery from the mid-dorsal arch is short and strong, and the walls of the gut are massive, since, besides the coats formerly mentioned, a reticulated connective-tissue layer with vascular spaces, as well as a chlorogogenous coat, surround it. Besides, it is further clasped by powerful vertical bands passing on each side from the dorsal longitudinal muscles to the area of the nerve-cords (Pl. II. fig. 8). The ventral blood-vessel lies in the thick investment immediately beneath it, and a complicated plexus of muscular and connective-tissue fibres takes place beneath the canal and above the ventral vessel in various sections at intervals. Posteriorly, the canal considerably diminishes and its internal surface is marked by complex folds. Dorsally and externally is the median mesentery, whilst inferiorly is the ventral mesentery enclosing the blood-vessel, and at intervals the plexus of muscular fibres from the oblique muscles and the gut itself, making the arch over the ventral vessel.

Thoracic Glands.—The thoracic glands, or anterior segmental organs of some, have been the subject of various interpretations. Thus Ehrenberg * in *Amphicora sabella* and Grube in *Spirographis spallanzani* thought them reproductive organs. Oscar Schmidt † more or less followed this interpretation, though he associated them also with an excretory function. He describes them as two short sacs opposite the first bristle-bundle in *Amphicora mediterranea*, each with a duct leading obliquely forward to join its fellow and to open in the mid-dorsal line behind the branchiæ. Williams, again, did not allude to these organs, but located the segmental organs of Sabellids and Serpulids in every abdominal segment, each with an external and an internal opening. Leydig and Huxley (the latter in *Filograna*) added little more than a notice of them. De Quatrefages considered them in the Serpulids as blind hepatic sacs connected with the stomach. Claparède (1870) thought them modified segmental organs which in the Serpulids secreted mucus, the ordinary segmental organs occurring in all the abdominal segments of such as *Psygmobranchus.* Cosmovici interpreted them as excretory organs or "Organs of Bojanus"; whilst the segmental organs in the posterior region transmitted the ova and sperms. Langerhans termed them head-glands in *Sabella* (*Potamilla*) *stichophthalmus* and *Euchone rosea*, and that they opened dorsally. A. G. Bourne ‡ (1883) considered these organs in *Haplobranchus* tubiparous glands or modified nephridia, and he mentions no ducts.

In his account of the segmental organs of *Branchiomma* Brunotte § describes, after Claparède, the thoracic glands as thoracic segmental organs, and situated in the first and second segments, thus being less developed than in *Spirographis spallanzani,* and even than in *Chætozone* and *Myxicola,* the former species having them in all the thoracic segments, the latter in more than two segments. The author interprets their structure as glands formed by the volutions of two tubes, and in his figures (pl. i. fig. 31, and pl. ii. fig. 40) shows the cœlom as filled by the coils of these, yet in pl. ii.

* Mitth. Verh. Ges. Nat. Freunde, Berlin, 1836.
† Neue Beiträge Naturges. der Würmer-Reise nach Faror, 1848, Jena.
‡ Quart. Journ. Micros. Soc. vol. xxiii. p. 168.
§ Recherches Anat. Branchiomma, p. 59 (1888).

fig. 38 only the section of a single tube on each side is indicated. This interpretation shows certain differences from the arrangement in *Bispira.* Brunotte's view that the walls of these tubes (individual folds) are specially arranged holds only good in *Bispira,* so far as it refers to folds of the appendicular duct posteriorly (Pl. II. fig. 11, *tg.*). The author is inclined to think that these thoracic segmental organs represent the series found in other forms, and are probably homologous with the longitudinal canal in *Lanice.*

The thoracic glands (anterior nephridia) in *Bispira* and other Sabellids follow a different arrangement from those in the Serpulids, *e. g. Pomatocerus,* which have their widest part anteriorly and diminish in their progress backward to a blind end. In longitudinal section these glands fill the cœlomic spaces of the first two segments in *Bispira,* which thus agrees with *Branchiomma* as described by Brunotte, though their convolutions would appear to be larger, such depending to a certain extent on the degree of contraction or expansion. In the serial (transverse) sections from the front the first trace observed is a small tube with pigmented walls situated about the level of the upper arch of the gullet, between the approximated dorsal and ventral longitudinal muscles, and it is imbedded in muscular fibres stretching from the gullet to the body-wall. Such represents the anterior duct of each side, thus corresponding to the arrangement in the Serpulids. The thoracic gland increases gradually in size and passes downward to the exterior of the œsophagus, resting on a plate of muscle passing outward to the wall and cutting off a cœlomic space above it on each side. Here the small tube has fixed to it a loop of vesicular and cellulo-granular tissue which seems akin to the chloragogenous investment of the gut, the cells and vesicles hanging on a thin mesenterial tissue in groups (Pl. II. fig. 11, *chl.*). The structure of the gland in section is similar to that in the Serpulids, but the walls are, perhaps, less massive than in *Pomatocerus,* though of considerable thickness, the tough external layer having muscular fibres within it and the epithelial layer being largely developed. With the increase of the cœlomic space the gland on each side moves downward and the cellular loop (really a tube) enlarges, and the sections of the gland lie within the ring of this tissue. Then sections of two glandular tubes appear, as if the organ had become bifid, both connected with the granular- cellular tissue, the vesicles and cells projecting into the ring from the limiting membrane externally, and they form a thicker and more definite layer.

Moreover, that part of the wall of the vesicular tunnel adjoining the gut-wall applies itself to it, whilst the outer part of the cellular structure forms loops in connection with the thoracic glands, which when the sides are flattened present in section the aspect of a tube, as shown by Brunotte (his pl. i. fig. 21). Masses of cells with brown pigment occur on various parts of this cellular membrane, and the transparent cells themselves are often grouped near the oblique muscles as they pass to their insertion above and to the exterior border of the great nerve-trunks. A conspicuous feature at this level is the occurrence of a comparatively large aperture through the body-wall just below the bristle-tuft, the finished nature of which shows that it is a permanent structure, but whether in connection with the thoracic glands or otherwise the imperfection of the sections does not enable a decision to be made. The area of the thoracic glands is much larger than in front, the reverse of the condition in the Serpulids, and they form complex structures by folding or division. The complexity of these glands is best shown in longitudinal sections, and they fill up the cœlomic space in the first two segments. Brunotte describes them as double. Further, toward the posterior part of the glands one tube is found in section to the outer side of the fibres of the oblique muscle and has considerably diminished. Transverse sections of the smaller tubes present an investing membrane lined by nucleated cells probably with internal cilia, all the parts, including the thoracic gland proper, being more delicate and transparent than in *Pomatocerus*. Then the gland increases in area and shows various folds or pouches, and the vesicular and cellular strands become abundant, the main gland, to which these are attached, often presenting septa dividing it into two chambers. Finally, the gland and its tubular appendages disappear, only the translucent botryoidal tissue being left in strands connected with the mid-ventral region, and passing up to the dorsal longitudinal muscles. Besides the vesicles and cells attached to the membrane a small tube is seen in section, and, moreover, it is clear that this tissue is identical in structure with that attached to the wall of the gut, and nucleated strands pass beneath the canal to be attached to it above the ventral blood-vessel, probably separated from the gut-wall during preparation. Further backward the wall of the alimentary canal is free from this tissue, only a slight development of it taking place posteriorly.

Segmental Organs.—In the middle of the body a folded tube with transparent nucleated cells lies in the space above the outer ends of the ventral longitudinal muscle. The nuclei along the sides of the tube stain deeply, thus outlining the canal which curves downward and outward and opens below the bristle-tuft external to the outer edge of the ventral muscle (Pl. II. fig. 13, *so.*). Nothing was seen of its internal connections except an occasional wider section. Separate masses of the deeply stained cells were noticed here and there, as if from folding or lobulation of the main tube, which in some cases appeared to form loops, and the vascular supply is abundant. Occasionally masses of minute cells were present toward the middle, attached by mesenteries to the other parts of the organs, and in section such were sometimes circular. The ducts seem to be smaller and longer posteriorly, and in some cases did not appear to be functional, especially toward the tip of the tail. Further investigations in this region are, however, necessary. When the nephridial tubes are cut longitudinally the nuclei ranged along each wall are conspicuous.

In *Amphiglena mediterranea* the chordoid arch supporting the branchiæ is narrow and composed of but two large cells from side to side of the middle of the bar, which is boldly curved ventrally at each end, whilst the central bar is concave dorsally beneath the dorsal groove—the whole having the form of certain bows, especially as a blunt conical projection occurs at each end of the transverse bar where the cells also are increased. The mouth in section in this region forms a vertical slit, bifid dorsally—that is, leaving a median pointed cone dorsally. The cephalic ganglia occupy a similar position to that of the typical forms. The pharynx soon forms a thick-walled tube rounded in section, and filled with granules and spicules, the mesentery holding the dorsal vessel above and the ventral inferiorly, the latter being close to the two nerve-cords which lie on the inner surface of the massive and continuous hypodermic glandular area of the region and at some distance from each other, the comparatively massive ventral longitudinal muscles being as yet to their outer border and wide apart, whilst the ventral blood-vessel is placed between them. No neural canals are present. Proceeding backward the ventral longitudinal muscles, which are now extended and comparatively thin, send their inner edges into the median groove formed in the centre of the ventral hypodermic mass, the nerve-cords, which were very indistinct in the preparations, apparently lying at the sides of the fissure, in the middle of which is the mesentery from the alimentary canal fixed to the distal end of the fissure. About the level of the nerve-cords is the ventral blood-vessel which has remarkably thick walls, so that at first sight the mass resembles the halves of a narrow elliptical ganglion or flattened cord, after the character of that in *Arenicola,* since the actual cords are difficult to recognize. The thickness of the walls of the vascular trunk would indicate special contractility in this region. The hypoderm is thus divided into lateral lobes with a slight median ventral ridge, the whole being glandular.

The body-wall in *Dasychone dalyelli* (*argus*) has externally the cuticle and a thick hypoderm, and there is a glandular ventral belt of great depth as in *Sabella,* with a median notch. The circular muscular coat appears to be comparatively thin, though continuous. The dorsal longitudinal muscles are in section rather broad and thin, the thickest end being external, and a hiatus occurs in the mid-dorsal line. A considerable gap exists between the ventral longitudinal muscles, which are about the thickness of the dorsal, though narrower, and without curvature, apparently from the feebleness of the oblique muscles. At intervals somewhat powerful muscular bands slope downward and inward, to be attached to the complex area above the nerve-cords, but the system is less marked than in *Sabella.* The alimentary canal has its median dorsal and median ventral mesenteries. The nerve-trunks lie more distinctly under the inner edge of each ventral longitudinal muscle, and no neural canal is present. The fibres of the circular and oblique appear to cross between them, and from the trunks fibres radiate into the glandular coat outside. The ventral longitudinal muscular layer is often broken up into several fasciculi.

The structure of the body-wall in *Chone infundibuliformis,* Kröyer, introduces a new type into the series, were it only for the remarkably coiled arrangement of the muscular fasciculi of the longitudinal muscles in transverse section. The cuticle covers a hypoderm well developed and highly glandular throughout, the long cylindrical cells being characteristic, especially when slight softening of this coat occurs. In the mid-dorsal line is a deep groove, and its bottom and sides show a somewhat finer granular structure, so that it may be a more sensitive area than the general surface. A decided thickening of the hypoderm takes place in the mid-ventral line, and it tapers to the normal thickness in the ventro-lateral region. The circular muscular coat is well developed and continuous, modifications occurring at each foot. The dorsal longitudinal muscles are largely developed, and, like the ventral in section, are in two concentrically arranged bands, the outer layer, however, extending over the dorsum of both. The median band is somewhat triangular with the pointed end internally, the outer is ovoid, and in the hiatus between the muscles of opposite sides the alimentary canal is suspended, and so closely that no mesentery is apparent—indeed, it would seem that the muscular fibres which pass from the circular coat into its walls form the suspensory apparatus. Ventrally the longitudinal muscles likewise form in transverse section two areas, in this case somewhat heart-shaped, the base of each being central, the apex external, and the outer (ventral) fillet of the muscle likewise extends over both areas. The inner edge of each muscle is separated by a considerable gap, in which lie the nerve-trunks which rest in a granular neuroglia, with the neurilemma and the circular muscular coat externally, whilst to their upper edge are attached strands from the alimentary canal. The two cords are surrounded by a sheath or neurilemma, and at the upper and inner angle is a small neural canal. At the ganglia the neurilemma is confined to the outer surface. In the mid-ventral line beneath them is a granular mass (in section) of neuroglia, and a trace also appears at each side, whilst in the region of the separate cords this inferior granular structure is thicker in the centre and tapers off laterally. On each side of the strands from the alimentary canal is a foliate granular mass (male elements ?), whilst between the strands is the ventral blood-vessel. Large vascular trunks or sinuses occur along the wall of the alimentary canal. The fan-like arrangement of the long hooks is well shown in such sections.

Somewhat behind the foregoing the mid-dorsal groove becomes only a slight depression, though the hypoderm retains the same character as in front and the cuticular surface appears to be ciliated. The hypoderm now forms a coat of nearly equal depth all over, though there is still a slight thickening in the mid-ventral line due apparently to increase in the basement-substance as well as in the hypoderm proper. The circular coat has increased in strength, the suspensory fibres for the alimentary canal are longer, and the canal itself shows both circular and longitudinal fibres, whilst the folds of the mucous surface are sometimes so arranged in the empty organ as to interlock. Strong fibres at intervals pass from the dorsal to the ventral region—grasping the alimentary canal at each side, and being attached to the fibres, including those of the oblique muscles, which form a complex around the ventral blood-vessel and over the nerve-cords. The latter have now, at their upper part, a larger neural canal which in some sections exceeds in bulk the main mass of each nerve, as in Allen's *Pœcilochætus* *. The neuroglia external to the trunks has increased. The condition of the dorsal and ventral longitudinal muscles is the same as in front, the coiled arrangement of the fasciculi being conspicuous in section.

In a section about half an inch from the tip of the tail, no evident dorsal notch occurs in the hypoderm, but a deep groove exists between the thickened hypoderm on each side of the mid-ventral line. The circular muscular coat is still conspicuous. Each moiety of the dorsal longitudinal muscle is now separate, the outer coil dorsally leading externally to several folds wedged between the moieties, the inner being rounded and smaller than the outer moiety. A strong series of muscular fibres leaves the dorsum, joins the oblique, and passes to the ventral border on the outer side of the nerve-trunks. The arrangement of the coils in the ventral longitudinal muscles in section is as in front, viz., the outer or ventral band envelops both moieties which are irregularly rounded and the inner is the smaller. The alimentary canal is small, firm, and rounded, highly vascular, and fixed by the mesenteries as in front, its circular muscular coat being conspicuous. The nerve-cords have a considerable mass of neuroglia externally—that is, between them and the circular muscular coat. A small neural canal occurs at the upper and inner border of each, the nerve-tissue completely surrounding it.

In the *Dialychone acustica* of Claparède †, the two statocysts (otocysts) in the first segment are well developed, but the chief interest, in connection with the present remarks, is the characteristically coiled condition of both dorsal and ventral longitudinal muscles (on section) from the anterior end backward. The large size of the skeletogenous reticulations and their numerous nuclei are also features of note. In a female large ova occurred in the anterior thoracic region.

The body-wall in *Othonia* conforms to the general type of the family. In those having the body-cavity distended with comparatively large ova the muscular layers are somewhat thinner, and the alimentary canal forms an ellipse held by the dorsal and ventral mesenteries, the minute nerve-cords apparently having no neural canals.

In *Euchone analis* (about $\frac{1}{6}$ of an inch) from the front the

* Journ. M. B. A. vol. xlviii. p. 105.
† Annal. Chét. Neap. p. 432, pl. xxx. fig. 3.

hypoderm is greatly developed on the ventral surface, thinning off in the lateral regions, and with a slight groove mid-dorsally. The circular muscular coat is fairly developed all round. The dorsal longitudinal muscles form a continuous loop in transverse section, the broader end of each being external, and the short mesenterial attachment of the alimentary canal separates each muscle in the mid-dorsal line. The folds of the ventral longitudinal muscles are also apparently continuous in section, both these and the dorsal being somewhat lappet-shaped, the inner end being pointed, the internal fold of the muscles terminating before reaching the point in each case. The oblique muscles seem to be feeble and indistinct, each appearing as a thread-like process along the inner border of the ventral longitudinal muscle, and being attached over each nerve-cord. The alimentary canal (gullet) is large in this region, and has a firm exterior with circular and longitudinal muscular fibres, and a thick mucous coat, the nerve-cords are comparatively small and lie in the intervals between the ganglia in the middle line below the attachment of the mesentery from the gut. Externally are a mass of neuroglia, the circular muscular coat, and the much thickened hypoderm of the ventral surface, which shows no median groove in this region. The nerve-area is considerably larger when a ganglion is severed. The canal is ensheathed by a firm mesentery fixed on each side over the nerve-cords. A small canal occurs in the median line above the nerve-cords, and the gonads are at each side. The sheath of the alimentary canal is close to the vessel, thus differing from the usual condition of a free space between loose mesenteries.

A little ($\frac{1}{6}$ in.) behind the foregoing the ventral surface is marked by a deep groove, so that the thick hypoderm forms a crescentic mass on each side. The alimentary canal is much enlarged, and its lumen filled with folds of mucous membrane. The dorsal and ventral longitudinal muscles have the same structure in section.

Toward the posterior region of the body, whilst at first the ventral muscles indicate no change, the dorsal loop presents a hiatus at the ventral edge on each side of the middle line, from which apparently the homologues of the oblique muscles pass, the outer fold being enlarged next the fissure; such is the condition at $\frac{1}{5}$ of an inch from the tip of the tail. The whole aspect of each muscle, however, alters at about $\frac{1}{8}$ of an inch from the tip of the tail. Each dorsal muscle forms in section a continuous thick arch superiorly, the inner end bending downward and forming a coil of a turn and a half, whilst the outer and thicker end does the same. Each ventral muscle, on the other hand, makes a single coil of one turn and a half from its outer end, and thus forms a contrast with the double coil in each dorsal. The small gut lies in the centre, fixed by the ordinary mesenteries. The ventral groove is now open and the ventral hypoderm is considerably thinner.

Euchone would thus appear to show a more primitive type than *Chone*, since anteriorly the dorsal and ventral longitudinal muscles have a simple loop, after the manner of *Nereis*, whereas posteriorly the coiled type of muscle has made its appearance. It is also in contrast with *Dialychone* of Claparède, in which the coiled muscles begin at the anterior end.

2. *On some Points in the Structure of the* Serpulidæ, *chiefly of* Pomatocerus triqueter, *L.*

Less was accomplished in the minute structure of the Serpulids than in the Sabellids until Claparède took up the subject in his 'Recherches sur la structure des Annélides Sédentaires' *. He dealt in this group for the most part with *Protula intestinum*, in which he found the hypoderm greatly developed on the ventral surface and richly vascular. In *P. infundibulum* he noted the pennate arrangement of the longitudinal muscles in section, and pointed out that the intestinal sinus is lodged between the epithelial coat and the circular muscular fibres, and that giant fibres occur in its great nerve-cord and œsophageal commissures. He thought that in *Psygmobranchus protensus* the distant halves of the ganglionic cord denoted inferiority, especially as in larval annelids this condition is more marked than in the adult. Three pairs of ganglia occur in the thoracic region, the largest being the second, and they are united by transverse commissures. He stated that in the Serpulids only a single pair of segmental organs occured, viz., in the thorax, and that they gave exit to the reproductive elements. In his description and figures the voluminous folds of the organ are indicated, and he considered that, by filling up the body-cavity, they conduced to the solidity of the region.

Schenk † (1874) gave a brief account of the structure of the body-wall in *Serpula uncinata*. In his transverse sections he appears to have overlooked the great nerve-trunks, though traces of these occur in his figures.

* Posthumously published in 1873.

† Sitzb. K. Akad. Wiss. Wien, Bd. lxx. pp. 1, 2, pl. i.

Eugen Lee * (1912) describes the blood-vessels and sinuses in *Protula*, *Vermilia*, and other Serpulids:—The main channels, he states, are determined by the metamerization and differentiation of mesodermic bands which arise from pole-cells. The gaps between the splanchnopleure and intestinal epithelium, or between the neural and hæmal mesenteries and septa, give rise to channels for the nutrient fluid diffusing through the epithelium of the gut. The channels at first have no proper walls. The walls of the visceral sinus and dorsal and ventral vessels are due to muscular differentiation of the splanchnopleure The lumen of other blood-channels is interseptal and closed off by peritoneal walls from the cœlom.

As indicated in the remarks on *Bispira*, E. Meyer has devoted much attention to the structure of the Serpulids, which he contrasted chiefly with the Hermellidæ. He also followed the development of the thoracic nephridia in *Psygmobranchus protensus*, and went minutely into the processes and collar of the anterior region. His observations on the various organs, though somewhat diffuse, are of much interest. The Sabellids were included with the Eriographididæ and Serpulidæ under his Serpulidæ.

A prominent feature in the anterior body-wall of *Protula tubularia*, Mont., is the great size of the dorsal longitudinal muscles, thus agreeing with *Pomatocerus*. The cuticle and hypoderm are well developed throughout, whilst on the ventral region anteriorly is a thick glandular investment with numerous small blood-vessels at its inner edge, a condition probably associated with a special secretion. In order to follow the arrangement of the muscle it is necessary to examine the extreme anterior end, where the dorsal surface has a deep groove in the middle line, the rounded parts on each side indicating the projecting dorsal muscles, which already are large. The lateral regions are formed by extensions of the body-wall, and bear the bristles in each segment. A thin circular coat lies under the hypoderm external to the dorsal longitudinal muscles, and it extends into the lateral regions. Sections of the posterior end of the ganglia lie below the great muscles, and in the mid-ventral line is an elongated area between them. The alimentary canal is clasped by strong circular muscular fibres, the circular muscular coat of the body-wall being external to it. In the middle line numerous vertical fibres pass

* Jen. Zeitsch. Natur. xlviii. pp. 432–78, with 6 plates.

from the alimentary canal to the mid-dorsal groove, and they by-and-by separate the nervous masses on each side. A projecting process, probably glandular, occurs on each side of the middle line ventrally, and the hypoderm is specially thickened toward its exterior. At the outer edge of the space lying below and external to the great dorsal muscle on each side is a muscular band, but such is distinct from the ventral longitudinal muscles which in section appear as small rounded areas on each side of the middle line, and with the nerve-trunks and the great neural canals at their inner borders. Proceeding backward the ventral longitudinal muscles gradually separate from each other and become flattened in section, thus carrying the nerve-trunks further from the middle line, the ventral blood-vessel lying in the centre with the alimentary canal above it grasped between the massive dorsal longitudinal muscles. In the long space between the ventral muscles and the nerve-cords are several small fascicules of longitudinal muscular fibres, and large processes of the alimentary canal appear above the inner edges of the ventral longitudinal muscles. The vascularity of the inner region of the hypoderm is noteworthy. Further backward the œsophageal region diminishes, whilst a process of the gut appears above it, and the two processes beneath the œsophageal chamber have moved inward toward the ventral blood-vessel, whilst the dorsal longitudinal muscles are somewhat further apart. The ventral longitudinal muscles are larger and are elongate-ovoid in transverse section with the nerve-cords at their inner edges. They are separated by the processes of the gut and the ventral blood-vessel.

In the posterior region a change has taken place in the structure of the body-wall. The dorsal longitudinal muscles have now spread out into thick plates on each side of the middle line, and in the lateral region end in a massive rounded area of folded muscular fasciculi, which in section show a pennate or feathered aspect. A large alimentary canal occupies the centre. The ventral longitudinal muscles are still proportionally small, forming, in section, elongated plates somewhat thicker externally, and with the nerve-cords and their large neural canals at the inner edge. They are separated from each other by the ventral blood-vessel, which is in contact with the gut superiorly. The inner edges of the ventral muscles have thus moved nearer the middle line. The ventral hypoderm now presents the same structure as the dorsal.

The hypoderm in *Serpula vermicularis* is firmer than in

Protula, and anteriorly the ventral hypoderm is non-vascular. Within is the circular coat which extends all round, and presents special developments at the foot. The dorsal longitudinal muscles form massive kidney-shaped lobes in transverse section, separated in the mid-dorsal line by the alimentary canal and its short mesentery and by a vessel at each side. These muscles extend from the dorsal almost to the ventral edge, and are proportionally larger than in *Protula*. On the other hand, the ventral longitudinal are smaller, and in section are short spindle-shaped bands widely separated from each other, and with the nerve-cord and its large neural canal at the inner edge. Between the latter stretches a thin but continuous layer of longitudinal fibres, having the circular muscular coat externally and the ventral blood-vessel internally, with the muscular aponeurosis on each side, as well as certain fibres from the slender oblique, which passes the cord and is attached over the thin muscular layer. The alimentary canal has a thick investment of circular muscular fibres with groups of inner longitudinal and a richly folded mucous lining. It stretches from the dorsal surface to the ventral blood-vessel. The dorsal fold arising from the foot is hollow distally.

An interesting feature is the presence of a peri-intestinal sinus in the outer wall of the alimentary canal and extending from the posterior region forward to the œsophagus, and which takes the place of the dorsal vessel of other forms, and the same arrangement occurs in the Ariciidæ, Chætopteridæ, Ammocharidæ, Sabellidæ *, and other families.

The peri-intestinal sinus surrounds the canal throughout the greater part of its extent, and in *Eupomatus elegans* Prof. Haswell states that the sinus ends in front of the œsophageal region in a short wide dorsal sinus or cardiac sac, from which a pair of vessels pass to each branchial base, "where it (each) unites with a smaller branch from the ventral vessel to form the common branchial vessel," which makes a curve—giving off a branch to each branchia and the operculum and pseudo-operculum. "The ventral vessel is a distinct wide trunk, which is continued along the body, and in front communicates with the branches from the dorsal sinus. The capillaries of the collar and flaps receive blood from the ventral vessel, and, as in the branchiæ, the circulation is to-and-fro." The blood which enters the peri-intestinal sinus by the segmental vessels is carried forward

* Haswell, Proc. Linn. Soc. N.S.W. vol. ix. pp. 1–27 (sep. copy).

by peristaltic contractions to the cardiac sac, whence it is driven at intervals forward to the common branchial vessels and by the separate trunks to the tips of the branchiæ. It returns by the same course and enters the lateral ventral trunks, and passes to the ventral vessel, by which it is distributed to the collar and the body generally" (*Haswell*). In *Pomatocerus* the abdominal region possesses the peri-intestinal vessel and a minute ventral trunk. Anteriorly the former splits into a large dorsal vessel or cardiac sac and about 16 smaller vessels, which run on the wall of the alimentary canal. Further forward the peri-intestinal vessels join the dorsal trunk, thus making two main trunks, a large dorsal and a small ventral. Then the dorsal bifurcates into the two branchial, and so does the ventral, but Prof. Haswell was uncertain whether the latter communicated with the former as in *Eupomatus*. All the vessels possess a muscular wall, and the blood in the majority is of a light green colour, and contains certain clear oval bodies probably derived from the epithelial lining of the vessels.

A pair of thoracic glands exist in this group as in the Sabellidæ. In *Eupomatus* and *Serpula* each has the form of a brown body with its long axis directed longitudinally, the posterior part with thinner clearer walls and an anterior dark brown folded part. No opening into the cœlom was made out by Prof. Haswell. In front the gland is continued into the ciliated duct, which passes almost directly inward to meet its fellow in the middle line, the common duct going straight forward to open ventrally (dorsally) between the bases of the branchiæ. The gland is lined by large, granular, nucleated cells, each furnished with a flagellum at its apex. Haswell found the "true" segmental organs in all the abdominal segments, viz., delicate pyriform sacs ciliated internally, and opening externally on the sides of the segments by slit-like apertures having active cilia. No internal aperture could be made out. In *Eupomatus* each in the female contained a group of ova at various stages up to the fully developed egg. These segmental organs alternated with the ovaries. In the males these sacs were always empty.

No feature is more distinctive of the Serpulids in contrast with the Sabellids than the extreme transparency, thinness, and minute serrations of the hooks. As a rule, they approach in shape those of the Ampharetidæ rather than those of the Sabellidæ. The hard, smooth, calcareous nature of the tube probably necessitates a special adaptation of a mobile torus with flexible hooks, the free edge of which is beset with a multitude of minute processes—probably of great use in fixation. Another structural characteristic is that of the first or collar bristles, which, for example, in the Spirorbids are of specific importance. The absence of tentacles (two of which are present in the Sabellids) and the presence of a calcareous operculum in the Serpulids are distinctive, just as the long branchiæ of the Sabellids are in contrast with the shorter organs in the Serpulids.

The secretion of the tube, as indicated under *Pomatocerus triqueter*, takes place with considerable rapidity—for instance, on the carapace of the shore-crab, on porcelain or stone-vessels and bottles thrown into the sea, and is further proved by observations in confinement. Mr. Arnold Watson thinks it is secreted by the outer side of the collar, since, as soon as the anterior part of the annelid emerges, the collar is folded over the edge of its tube, its two lobes meeting over the mucro. He adds, however, that the formation of a diaphragm in a broken tube shows that other parts may likewise secrete the calcareous matter. As detailed in the structure of the hypoderm, the collar and the free surfaces of the thoracic jacket contain much glandular tissue, as likewise do the lamellæ or elevations for the tori uncinigeri.

Hypoderm.—In the anterior sections of the body-wall of *Pomatocerus triqueter* the dorsal is distinguished from the ventral hypoderm by the intensity of the stain (Ehrlich's Hæmatoxylin and Eosin) * in the latter, viz., from the slight projection below the enlarged base of the dorsal flap or process to that of the opposite side, the glandular tissue, like that of the œsophageal wall, readily absorbing this stain, so much so as to become opaque. The dorsal hypoderm, on the other hand, has only the nuclei tinted near its outer edge, and the inner part of the enlarged base of the dorsal flap shows likewise glandular tissue. The thoracic collar anteriorly (Pl. IV. fig. 21) is somewhat complex in *Pomatocerus triqueter*, having dorsally a large fan-shaped lamella on each side, then a gap between it and the continuous ventral portion of the collar, whilst a small lamella with processes on the edge occurs at the gap, its base having a closer connection with the ventral than the dorsal moiety. This condition of the ventral hypoderm continues backward to the end of the thoracic glands, the lateral processes bearing the hooks being especially glandular. Then the glandular

* I am indebted to Miss Lamont, of the Zoological Department of Edinburgh University, for aid in section-making, my own trained men being on service.

tissue forms a patch on each side of the middle line ventrally, as well as on the edges of the ventro-lateral processes, and thus these form a contrast with the dorsal (branchial) processes. Thereafter (proceeding backward) the glandular tissue is almost absent from the median ventral region, but is highly developed on the ventro-lateral processes ; soon, however, it again appears in the ventral plate or fillet, which has glands along its lower edge, a few remaining in the hypoderm of the ventral surface of the body-wall.

So long as the free flap of the thoracic jacket or collar occurs, the glandular tissue in the hypoderm of the ventral edge of the flap is dotted at intervals with glands, and they are also distributed along the ventral hypoderm of the body-wall, but in moderate numbers. As the flap diminishes the ventral median groove of the body-wall becomes deeper, but its hypoderm is thinner than that at the sides (beneath the ventral longitudinal muscles), the glands, however, being continued in it. When the jacket ends, the hypoderm generally is somewhat thinner, the ventral groove rather more shallow, and the glands are but slightly developed, the most conspicuous aggregations being in the lateral thickenings bearing the hooks, so that the region is in marked contrast with the anterior. This description applies to the body-wall as far backward as the valvular region of the alimentary canal.

In the posterior division of the body the glands still occur in the lateral region and on the lamellæ for the hooks, as well as a few along the ventral border, especially on each side of the ventral groove. Very few occur dorsally—indeed, in most sections they are absent form the dorsal arch, only nuclei occurring there.

The hypoderm at the level of the origin of the opercular stalk (Pl. IV. fig. 20) often presents a fan-like arrangement of its long cells, as at *hpe.*, a condition probably due to slight folds in the sections, but such recalls the aspect of some simple sense-organs, *e. g.* eyes, though no pigment is present, only the stout basement-tissue on which the cells rest. That this modified hypoderm in the anterior region performs special functions is evident by contrasting the outer and inner surfaces of the thoracic collar or jacket, also by the massive thickness of some parts, the thinness of others, and the blanks in the layer only invested by cuticle (*hb.*) in the same figure. The almost perfect regularity of the nuclei and the fibroid aspect of the long cells are other features of moment. The blanks (*hb.*) in the hypodermic coating consist of a reticulum of nucleated cells supported internally by strands of basement-tissue, whilst externally is the cuticle and within it a very thin extension of the hypoderm from each side, only of sufficient depth to contain the abbreviated nuclei continued in close array along it. The general aspect of the reticulum agrees with that found in the central area of the differentiating opercular stalk, and is in contrast with the modified hypoderm above-mentioned.

Thoracic Glands.—In the fresh example two brownish bands lie on each side in front, pointed behind, and increasing in diameter as they go forward. A wide duct from each passes inward, apparently with a slight forward obliquity, to meet its fellow of the opposite side, and then by a common median duct to open dorsally between the bases of the branchiæ. The lateral ducts show large brownish granular glands similar to those lining the interior of the glands proper, but they do not pass forward from the point of junction of those of opposite sides.

The glands in the anterior region of *Pomatocerus triqueter* are first noticeable in transverse sections from the front as somewhat irregular spaces due to folds, for this is their widest region, shortly after the ventral cords leave the brain, and in the lateral region to the upper and outer side of the nerve-trunks. The early stages do not present so definite a cellular lining as subsequently forms, though the cells are present, with processes, apparently of cilia, extending inward from their free edges. Surrounding the cellular lining is a layer of connective tissue with numerous nuclei. The spaces soon unite (proceeding backward) into a large cavity lined with cubical cells, and stretching from the nerve-cord obliquely upward and outward to the bristle-tuft (Pl. V. fig. 26, *tg.*), the processes still projecting from the inner surface of the cellular lining (the flagella mentioned by Prof. Haswell). Externally is a compact cellular mass, *cm.*, with distinct nuclei, and this, from the contraction of the lumen of the organ and its passage toward the ventral aspect, gets above the cavity—touching the basement-membrane of the body-wall. The latter in this region has the comparatively small dorsal muscles separated by a gap, in the middle of which is the mesentery holding the dorsal blood-vessel and the alimentary canal below it. A considerable band of longitudinal muscle (Pl. V. fig. 26, *m.*[1]) lies dorsad of the two masses of the dorsal longitudinal, and separated from them by septa. A thin band of longitudinal muscular fibres stretches on each side a short distance to the inner side of the nerve-cord. As the thoracic gland diminishes, its cubical cells and their large nuclei become clearer, the processes still project from their inner edges, and the duct lies to the ventral or inner edge of the tori and the bristles. When the tube has about 18 cells in its wall (and is therefore small) the glandular or dorso-lateral appendix, *cm.*, is fully twice its diameter, and soon the tube vanishes, leaving only the thin glandular belt within the body-wall. This dorso-lateral appendix appears to be somewhat akin to the multinucleated cœlomic bodies described by Prof. Caullery * in *Eunice harassii*, Aud. & Ed. As already mentioned, the ducts from the anterior end show flask-shaped brown granular glands, but the single duct formed by their union is quite pale.

Toward the termination of the thoracic glands, and behind them, the cœlomic cavity contains vessels and chloragogenous tissue covered with opaque granular masses, often enveloped in the chloragogenous sheaths. These continue for some distance backward and by-and-by disappear.

Whilst the thoracic glands are still of moderate size—that is, toward their posterior third,—it is noticeable that they are bounded externally by a firm layer of the body-wall ending inferiorly in a free process, which in transverse section is clavate (Pl. V. fig. 28, *p.*). This layer, *ab.*, has rather regularly arranged fibres at right angles to the axis of the body, which stain like the muscles in their neighbourhood, and do not resemble the hypodermic nucleated cells. It has externally the pad or process bearing the hooks, and it terminates ventrally, rather past the middle of the section of the thoracic gland with its appendix, in the free process, the ventral end being pale. The narrow bar, however, proceeding forward, soon enlarges into a thicker layer of prism-like cells with the nuclei at their free surface, thus giving the aspect of a series of punctures at the enlarged outer ends, for the cells, *ce.*, are clavate and minutely granular (Pl. V. fig. 29). This peculiar cellular layer runs upward on the external border of the branchial stalk, the inner layer, continuous with the dorsal hypoderm, presenting quite a different structure, and the nuclei are within their superficial ends (Pl. V. fig. 29). The function of this special cellular development would seem to be in connection with the well-developed hook-pads of the region rather than with the thoracic glands, probably acting as an elastic cushion. The muscular fibres seen in Pl. V. fig. 28, *m.*, are those which move the hook-pad, whilst that structure itself is largely composed of the modified hypodermic cells just described. Hence the appearances of the parts vary

* Compt. rend. Soc. Biol. t. lxxviii. p. 593 (1915)

according to the line of section. Thereafter, the tissue gradually merges into the hook-pad with its superficially arranged glands, and so on throughout the region, the inner or secondary ridge appearing and disappearing in each segment.

The supporting tissue in the anterior region of *Pomatocerus triqueter* differs from that in the Sabellids. Just as the nerve-cords leave the cephalic ganglia, and whilst still connected by a long and strong commissure, no special supporting tissue is visible. The long, narrow, hypodermic cells of the dorsal wall (Pl. IV. fig. 20, *hpe.*) are indeed of great depth, especially in the middle line, so that when torn they resemble fibres, whilst within the basement-membrane are only the thin circular muscular fibres and the dorsal longitudinal muscles—as yet little developed. As the opercular stalk leaves the body-wall of the region (Pl. IV. fig. 20, *op.*) its central areolar mass joins the other tissues and may stiffen the parts, for as yet the fibres of the dorsal longitudinal muscles are few. Through this mass a bifid nerve-trunk from the cephalic ganglia passes. The remarkable thickness and the appearances of the hypoderm of the region in this species would suggest the view that it may more or less be connected with the function of the special chordoid skeleton of other forms. In this respect the dorsal differs essentially from the ventral hypoderm of the region, which is richly glandular. The muscular tissue at the base of the stalk is reticulated in longitudinal section, as if the sarcolemma formed a network ; indeed, reticulation of the muscular fibres themselves would appear to occur, though the trend of most at the base of the stalk is longitudinal.

The projection of the opercular stalk causes asymmetry of the body-wall and of the incipient dorsal longitudinal muscles, for the muscle of the same side considerably increases in size, probably in relation to the movements of the stalk. The body-wall remains asymmetrical after the stalk separates, that side being less than the opposite one, in which, moreover, the slits separating the branchiæ first appear. This asymmetry subsequently disappears in front when the filaments approach separation, but it is a marked feature. Connective-tissue cells fill up the lateral space within the body-wall beyond the region of the cephalic ganglia, but these do not show special chordoid structure. Deeply stained nerve-cells surround the cords and the transverse fibres between them. The enlarged base of each ventral flap of the thoracic jacket has connective-tissue cells similar to those in the lateral region of the body, the flap being joined to the body-wall by a firm isthmus in the middle line, its two surfaces beyond being structurally differentiated, the inner (that is, next the body-wall) being coated by a thick layer of the long hypodermic cells with the nuclei near the surface, whilst the outer has much shorter cells, the inner ends of which seem to run into the reticulated connective-tissue of the central region. Masses of gland-cells, moreover, occur along the convex margin of the jacket. In the area of the cephalic ganglia the modified hypoderm is thickened in the mid-dorsal line and also laterally so as to form a protection to the organs. Then on the side (generally the left) from which the opercular stalk springs this modified hypoderm bulges out and envelops it (Pl. IV. fig. 20). Further, the glandular nature of the ventral wall diminishes, and a split separating the jacket or collar appears and joins the folded lateral and dorsal flaps, both the inner surface of the collar and the outer of the body-wall being invested by layers of the hypoderm. As soon as the collar becomes free (in section) the entire body-wall, with the exception of a narrow lateral belt on each side, is invested by this modified hypoderm, the thickest parts being the dorso-lateral and mid-dorsal regions; and the origin of the opercular stalk has the same investment, special support being afforded by the adjoining mid-dorsal and lateral enlargements of this modified hypoderm. Proceeding forward the ventro-lateral regions of this coat are considerably thickened, and a deep furrow now cuts off the opercular stalk (Pl. IV. fig. 22). The diminished area of the anterior region is specially stiffened, for in section the greater part of its surface is composed of this modified hypoderm, the only gaps being those of the mouth, the branchial trunks, and a cœlomic space. The shape in section is that of a curved dumb-bell (Pl. IV. fig. 23), the narrow median region with the oval slit corresponding to the handle and the enlarged lateral regions to the bells. Instead of the dorsal region having the thick layer of modified hypoderm, it is now the ventral surface, and the band is dilated at each side, after which is a connective-tissue belt, then a band of the modified hypoderm round the bulbous ends, in which by-and-by appear the slits indicating the separation of the branchial filaments. These slits have a regularly arranged cellular investment with distinct nuclei, and they increase in size and number from behind forward. The intermediate region, between the dilated ends of the dumb-bell, has only a thin coating of ordinary hypoderm, and is thus in contrast with the lateral regions. Advancing forward a slit appears on each side of the vestibule, and thus the enlarged ends of the dumb-bell are more distinctly differentiated from the curved median region with its widening vestibule (Pl. IV. fig. 23). At this level there are four intermediate branchial slits, and the inner on each side is the more elongated, whilst the conical ventral edge of the lateral enlargement is stiffened by a cap of the modified hypodermic tissue. The ventral collar (jacket) has now much diminished in size, but the dorsal edge of the organ still shows a coating of the modified hypoderm. Further forward the collar forms but a small U, the thick layer of its hypoderm being, as formerly, dorsal; the median lamella containing the vestibule is longer, whilst the dilated ends are somewhat crescentic and show six intermediate slits. The ventral edge still has the thickest cap of modified hypoderm. The vestibule has now expanded laterally into a wide space at the base of the branchiæ, and there are seven intermediate slits, the largest being dorsal and the smallest ventral in position. Advancing forward, or distally, the slits increase to nine, and the outer margin of the dilated ends becomes frilled as the filaments differentiate, the dorsal, where the largest slits are, soon presenting filaments connected only as their outer border, the free inner edge being deeply grooved (bifid in section) (Pl. II. fig. 12). The outer border of each filament has the tough cuticle with the hypoderm beneath, in which is a nerve, and joining in the centre a connective-tissue area which runs inward to the free grooved edge, whilst the sides are strengthened by the modified hypoderm, especially externally, for it tapers internally. Each of the laminæ forming the groove has a blood-vessel in its centre (Pl. III. figs. 18 & 19), and branches by-and-by enter the pinnules. Proceeding still further distally, the curve in each fan is larger, and the dorsal filaments, which have become rounder and their hypoderm more glandular, show longer connecting bands, and finally separate, the isolated ones having slightly shallower grooves than the fixed, whilst their radial diameter diminishes and their transverse increases proportionally.

The filaments gradually taper distally, the edges of the groove break into pinnæ (Pl. IV. fig. 25), and the modified hypoderm forms three distinct external divisions, whilst in the centre is the connective-tissue area with its blood-vessel, a vessel occurring also in each pinna. Besides the central blood-vessel there are two conspicuous channels slightly to the exterior on each side, and these probably communicate with the cœlom. In longitudinal sections of the filaments the centre shows a distinctly chordoid structure not always easily observed, and this is apparently due to the cells of the hypoderm or to a supporting tissue within it, the former interpretation being the more likely, as no differentiation is observed in transverse section.

Diverse views have been held with regard to the structure of the filaments and pinnules; thus Meyer described a diverticulum of the cœlom in each filament and pinnule, whilst Orley insisted that only connective tissue occupied the centre. It is by no means easy to decide, since in the case of sections the parts are considerably altered even in good preparations. A cœlomic space occurs on both sides at the level of the dumbbell-shaped region in front of the brain (Pl. IV. figs. 20 & 21, *cœ.*), and their walls are defined by connective-tissue, and probably muscular, fibres, the area surrounding them consisting of nucleated connective-tissue cells. About this level the thoracic jacket or collar has just become free or is only connected by a narrow isthmus. As a rule, also, the two sides are asymmetrical in section, the opercular half having no slits, but a considerable cœlomic space, whilst the other side has only small apertures, so that the area within (that is, ventral to) the slits is reticulated, these reticulations in the succeeding sections becoming less and less until only the branchial vessel is evident. The epithelium surrounding the slits becomes regularly arranged and forms the hypoderm and cuticle of the filaments, each side being attached to a separate filament. The elongated centre of each filament in formation is almost wholly occupied by nucleated connective tissue with the blood-vessel in the centre, but two splits, one on each side of the mesentery, are often seen at the distal end of the central area, occasional strands of tissue crossing the spaces in some sections. The definite median mesentery with its central blood-vessel and the definite cœlomic spaces at each side, and from end to end in transverse section of a pinnule, as shown by Soulier in *Protula milhaci*, have not been observed either in filament or pinnule. In longitudinal sections of a filament, the sides are formed of cylindrical nucleated epithelium, whilst the centre is almost filled with nucleated connective-tissue cells, a narrow split at one or other side being present, and even this has a few strands with nuclei. The pinnules of this form (*Pomatocerus*) show only a central cavity in which the blood-vessel is (Pl. IV. fig. 24), but the cœlomic fluid could readily rush to and fro in the space around it, whether a special mesentery fixes it or not. On the whole, therefore, the view that the cœlomic spaces—carried forward to the splits for the commencing branchial filaments—do not blindly end there, but communicate with the filaments and pinnules, would seem to correspond with the appearances. The branchial apparatus of such forms would thus in their movements appear to have not only muscular aid, but the important influence of the cœlomic fluid, so that the ciliary action of the pinnules and filaments would materially aid respiration as well as conduce to alimentation.

Opercular Stalk.—The opercular stalk arises as a process of the basal region of the branchial apparatus immediately in front of the brain, the tissues of one side gradually projecting (Pl. IV. fig. 20), then being nipped off as an independent process surrounded by the cuticle, the modified hypoderm as a considerable coat all round, and a central area more or less muscular at first, with numerous nuclei. The base of the organ occupies at first more than half the dorsal outline, but, as it separates and the median fissure deepens, the other side increases in bulk. The external fold of the cuticle bends inward, the hypodermic cells curving round the central area (Pl. IV. fig. 22) and soon the stalk is free. Its outline in section is somewhat rhomboidal, and much smaller than it is distally. At this level the thoracic jacket or collar is fixed by a broad isthmus to the region below the gullet. Then the stalk becomes conical in section, and the blood-vessel in the centre of the muscular tissue more distinct, whilst the modified hypoderm, which is almost fibroid in section, maintains nearly an equal thickness all round. The base of the cone—that is, the dorsal edge—by-and-by lengthens by a transverse projection at each side, so that it resembles a cocked hat in section (Pl. VI. fig. 32), the projecting edges having the thickest hypoderm from the approximation of the two layers separated by a line, the central pseudo-chordoid and muscular areas with the vessel remaining as before. The opercular stalk at this level is flattened externally or dorsally, convex ventrally, and its cuticle is dense. A differentiation of the central region now takes place, for the outer or dorsal edge of the hypoderm becomes thinner, and an elongate-ovoid and apparently muscular area stretches from lateral projection to lateral projection, a groove in which the blood vessel lies (Pl. V. fig. 30) occurring ventrally. The muscular fibres seem to pass to the calcareous region of the operculum—namely, to the tip of the stalk. They are well developed in the region of the lateral ridges. The appearance of the parts seems to vary considerably in sections of different examples, a feature due perhaps to recently reproduced organs (*cf.* Pl. VI. figs. 32 & 33) and to obliquity in section, for in some cases (Pl. VI. fig. 33) muscle and pseudo-chordoid tissue are both present. The reticulations of the next (more distal) area are larger and better defined than the pseudo-chordoid tissue which occupies the convex region ventrally (Pl. VI. fig. 33). The chordoid axis soon increases in bulk, and fills the stalk except the thin hypodermic region and a stripe of pseudo-chordoid tissue, still with its blood-vessel ventrally, the cuticle enveloping all. The basement-tissue is slightly developed in the ventral arch, but forms a well-marked layer dorsally, fusing with the tough issue in the middle of the stalk, but being better differentiated at the base of each external ridge, a thin line of it running almost to the tip of the latter. The section of a nerve (Pl. VI. fig. 32, *n.*) occurs at each outer angle and in the middle of the dorsal arch, the former being outside the basement-tissue, the latter within it. In the basal (proximal) or incipient condition of the stalk this basement-tissue is less developed than distally, and the relationships of the nerve therefore undergo changes. The groove for the larger blood-vessel in some preparations sinks more deeply into the chordoid tissue. The projecting ends of the ovoid area of the opercular stalk assume a clavate outline and then disappear—that is to say, the ridge on each side of the stalk ceases after the lateral filaments of the stalk have separated. With the disappearance of the lateral ridges the chordoid tissue occupies in section the entire area of the ovoid stalk, only a thin, barely visible, belt of hypoderm occurring under the cuticle. In some of the sections the strands of the chordoid tissue are arranged in a somewhat radiate manner with the nuclei and cut ends of fibres at the circumference, so that, when the hypoderm and the cuticle are shed, such might be mistaken for the modified hypoderm. Further, the blood-vessel is now enveloped by the chordoid tissue. Soon a differentiation in the midst of this area appears as a smooth central region from which lines radiate to the external margin. This central region gradually increases distally, and the differentiation of the radiating cells with the nuclei externally gives it, in some preparations, the appearance of a hypoderm within a hypoderm as just mentioned; and, moreover, a ridge or papilla appears on one side of the actual cuticle or hypoderm. The blood-channel is enclosed in the inner area, and is large. The ventral hypoderm and cuticle diminish and disappear, leaving what was the chordoid area and its central region, with the addition of a small patch, isolated in cuticle, to represent the former envelope of the stalk, and that soon vanishes. Thus the enlarged opercular stalk now consists of the tough cuticle, the modified coating of the chordoid area representing the hypoderm, with its nuclei externally and a large pale area, probably chordoid, with a well-defined ovoid outline, in the centre of which is the blood-vessel. Muscular fibres would thus act on the base and up the stalk of the operculum, whilst its rigid tissues distally are fitted to perform the part of a plug to the calcareous tube. Beyond the lateral subulate processes the distal region of the decalcified operculum presents externally a tough cuticular investment, then a layer of long hypodermic cells with the nuclei near the external border, the central area being occupied by a tough nucleated plasma with small spaces near the external margin, where a thin basement-tissue bounds the hypoderm.

In vertical section the decalcified operculum has on its convex side the thick cuticle very dense at the rim, then a deep layer of long narrow granular cells, a thin connective-tissue or chordoid centre, and on the concave surface (anterior) a narrow belt of reticulated tissue, and externally a cuticular coat about twice the thickness of that on the convex side. When viewed externally the distal (calcareous) region of the operculum presents a minutely reticulated condition all over (after decalcification).

It has generally been held that the operculum is developed on a modified branchial filament, and hence the occasional occurrence of one on each side, or the facility with which a new organ is produced on the right when the other is lost. Without calling this view in question, the foregoing account shows that about half the area of the body-wall behind the branchial base is concerned in the production of the operculum with its special differentiation of tissues, and that the development of the branchial filaments occurs in front under different conditions, and rather in association with the vestibule and mouth than with the protective, or it may be in certain cases the reproductive, functions of the operculum. The appearance of the inter-filamentar slits after the formation and separation of the opercular stalk point to a wide divergence both of structure and function, though it may be argued that these radical differences may have been evolved slowly in the history of the race. Yet eye-specks or more complex visual organs are never found on the opercula, while they are not infrequent on the branchial filaments; just as calcareous or other hard structures belong to the opercula, for the soft cellular thickenings of the tips of the branchial filaments, which characterize certain varieties of *Filograna,* and which some have supposed to perform opercular functions, can scarcely be placed in this category. Moreover, in some groups the opercula are very variable, and may be present or absent, as in *Filograna*, with perplexing indifference, whilst in other forms their stability and characteristic shape have made them of specific importance. It is interesting in connection with the branchial view of the opercular stalk that transverse bars of bluish pigment are occasionally seen on it.

Muscular System.—Immediately behind the brain muscular bands pass from the sides of the ventral to the dorsal wall (or *vice versâ*), some of the same side being attached to the base of the opercular stalk dorsally—indeed, they seem to be strongest and best developed at first on that side. Ventrally they are inserted on each side of the nerve-cord, and by-and-by they bound the thoracic glandular organ on its inner border.

Behind the ganglia and the opercular stalk the body-wall assumes a more symmetrical outline, and the dorsal longitudinal muscles become more distinct and quite separate from each other, but the ventral longitudinal muscles are indistinguishable. In the median ventral region, however, a special thin longitudinal muscular band occurs on each side, and continues backward a short distance—disappearing as the actual ventral longitudinal muscles become distinct. These ventral longitudinal muscles are formed by fibres on the lateral region of the body-wall outside the anterior glandular organ and its appendix, and not in contact with the nerve-cords, which are separated from them by a considerable interval. Their outline in transverse section is elliptical, and, as the glandular organ in its progress backward diminishes, the fibres seem to pass externally; then, as the glandular tube disappears they form a thin stratum to the outer side of the nerve-trunks and in contact with them, the anterior median ventral fibres being still visible between the nerve-trunks. By-and-by the median, or pseudo-ventral, or anterior ventral, fibres (Pl. V. fig. 26, $m.^2$) disappear from the middle line, and the ventral longitudinal form a spindle-shaped layer in section, separated by an interval from the dorsal, which bend inward at their lower ends, whereas the ventral pass outward below and beyond them. The dorsal and the ventral longitudinal muscles, however, by-and-by fall into line and the body-wall becomes more compact, the dorsal muscles retaining the great preponderance in bulk, and closely approximated to the ventral, only a slight incurvation of the inner surface and traces of the oblique muscle indicating the line of separation; yet the distinctly pennate arrangement of the fasciculi of the dorsal is characteristic. The nerve-cords are more closely approximated than in front, but are still separated by a considerable interval. The body behind the foregoing region of the thorax becomes rounded in transverse section, a large area being occupied by the dorsal longitudinal muscles, which cover nearly two-thirds of the circumference (Pl. V. fig. 27), and form a broad belt in section, only slightly narrowed as it approaches the mid-dorsal line, where no distinct hiatus occurs, the whole forming a hoof-shaped belt. The ventral longitudinal muscles, on the other hand, form two spindle-shaped areas, now also with pennate fasciculi, separated by the median space containing the ventral blood-vessel. This disproportion of the dorsal longitudinal muscles continues to the posterior end, though in relation to the diminished area of the body-wall both sets of muscles are more bulky; whilst the thinning of the dorsal muscles toward the middle line is scarcely evident.

The dorsal longitudinal muscles, though comparatively small, are formed in front of the cephalic ganglia, and at the ganglia they show two lateral enlargements connected by a median band of fibres to which the dorsal vessel is attached. Behind the ganglia the connecting band of fibres is shorter (in transverse section), whilst the lateral enlargements are gradually increasing. These muscles do not at this part reach the lateral regions of the body, but lie in a special cavity invested by membrane on each side of the median dorsal vessel, the direction of the lateral masses being nearly vertical, since to their exterior is the dilated anterior end of the thoracic glands. Proceeding backward, the first change noticeable is an increase of the nucleated connective tissue in the median belt and its continuation between it and the enlarged lateral regions until each of the latter is separated, so that it lies in a membranous chamber of its own, the spindle-shaped median belt being characterized by its numerous connective-tissue nuclei. Moreover, the direction of the muscular fibres of this median band seem to differ, since they are obliquely cut in the sections. Each dorsal longitudinal lies in its sheath in this region, with the vertical bands of muscle and the dilated cavity of the thoracic gland to its exterior, the long diameter of the mass being still nearly vertical. Then, instead of being spindle-shaped, the median band of muscle is divided into two by a central dimple to which the mesentery from the dorsal vessel is attached. This separation of the two halves increases until there is a clear space between them, the median mesentery now being fixed to the basement-tissue inside the hypoderm, the separated portions of the muscles lying closely over the larger masses beneath them, and they soon fuse with them, meanwhile this wide space dorsally intervening. The diminution of the cavity of the thoracic gland on each side permits the muscles to assume a more oblique position, so that their axis in section is directed downward and outward. On the disappearance of the thoracic glands (in the progress backward) the muscles more closely approach each other in the mid-dorsal line, the upper as well as the lower ends being pointed in section. Then a tendency for the lower ends to bend inward is noticeable, the investing mesentery being still visible externally, whilst the muscles have likewise considerably increased in bulk. This divided condition of the dorsal longitudinal muscles characterizes the anterior region of the body, for toward the middle there is complete union of the halves (Pl. V. fig. 27), and the entire muscle has greatly increased in size, forming a broad crescent which reaches by its expanded inferior edges almost to the ventral surface. No distinct trace of a mid-dorsal fissure is seen, the median mesentery being attached to a slight muscular ridge at its inner surface.

Alimentary Canal.—The various ciliated grooves from the branchial apparatus to the mouth converge to the double isthmus connecting the two fans, and which in the sections is usually V-shaped, the apex being directed ventrally (Pl. IV. fig. 23), the upper layer being pierced by a blood-vessel at each end. Then, proceeding backward, the V expands into a curve, the ventral isthmus receives a coating of hypoderm, both isthmuses becoming shorter and thicker, with a slit at either end opening by-and-by to the dorsal surface. Further, the cellular walls of the central chamber of the isthmus (the vestibule) have a more finely granular structure than the hypoderm covering the ventral surface, and the dorsal border is soon modified, by a median furrow, into two thick ridges—about the level of the origin of the stalk of the operculum. The dorsal wall of the vestibule or mouth increases in thickness, and the opercular stalk sends out a process which fuses with the opposite side, so that two apertures now exist, viz., the mouth and that dorsad of the groove and ridges and formed by the external pit. Processes fuse with the point of junction, and others from the dorsal region of the now irregularly quadrangular part soon fill up the extended area (Pl. IV. fig. 21), leaving a small space dorsad of the mouth with its ventral edge marked by the groove before-mentioned, and showing a slight differentiation of its hypodermic wall. The vestibule, on the other hand, has glandular walls which stain deeply all round. This dorsal pit, still retaining the dorsal groove with modified cells on each side, then disappears, but it comes near the central nervous system, and perhaps performs a sensory function. Immediately thereafter the central nervous system occupies the region above the gullet—separated therefrom by strands of connective tissue with several apertures. The gullet has an internal lining of columnar nucleated cells which stain deeply, surrounded by a circular muscular coat and an external investment of reticulated tissue and nucleated cells. It is slung by several bands to the cœlomic wall around it, and instead of its cavity, now diminished, having its long axis transversely placed, it is vertical. Below it is the commissure between the œsophageal ganglia, above it is a large transverse space in which the dorsal vessel by-and-by appears, and the common duct of the thoracic glands occurs below the hypoderm above it, and blood-vessels lie internally. The investing cells and tissue increase in bulk, and the cut ends of numerous vessels are intermingled, whilst median furrows give a cruciform aspect to the central cavity in section, and longitudinal muscular fibres are more distinct within the circular coat. Below it is the ventral blood-vessel in the median line. The nuclei of the cœlomic cells are distinct and correspond with those investing the alimentary canal. In this region (thoracic) the dorsal and ventral blood-vessels are of large size, and the rete around the alimentary canal well developed as a ring of longitudinal vessels in section (Pl. VI. fig. 35). The alimentary canal now increases in size, and, in the preparations, shows a tendency to split into layers, the entire lumen being filled up by the various coats. Instead of the firm circular coat with a few longitudinal fibres between it and the columnar epithelial layer characteristic of the smaller œsophagus, the area in section enlarges, the circular coat becomes thinner, the longitudinal investment within it thickens, as also does the cellular mucous layer, and there is a tendency to separation of these coats in the sections—indeed, it is clear that a change is taking place in the structure of the walls of the gut, probably representing a differentiated stomach, the central part in the sections representing the invaginated gullet and the larger separated external region the stomachal wall. The latter consists internally of a closely arranged, almost fibroid, cylindrical epithelium of uniform thickness, then of the longitudinal fibres, followed by the thin circular coat. The foregoing coats are invested by the cellular and a vascular coat, which presents two variations, for the smaller region in front shows the cut ends

4*

of numerous longitudinal blood-vessels and a large dorsal vessel, whereas the larger stomachal area, with its firm and thick walls and its central vertical slit, has externally a blood-sinus all round, and no separate dorsal vessel is now apparent. The narrower anterior region, therefore, with its numerous longitudinal vessels, may differ in function from the wider posterior region surrounded by a blood-sinus.

The enlarged region, with its thick walls, continues beyond the posterior termination of the thoracic glands—that is, after the formation of the ventral longitudinal muscles—and behind this where the body-wall is wider and more flattened. Food is more frequently present in the anterior part than in the wider posterior region. In the narrower part of the body, behind the foregoing, where the muscles become proportionally massive, the walls of the intestine are much folded and the area is large, but the structure of the wall is the same, though little cellular tissue surrounds the vascular sinus externally. Still further back the gut dilates into a wide chamber without folds and having the vascular sinus externally. Then it thickens laterally, apparently from a septum-like fold with a vertical V-shaped slit in the centre, the upper and lower arches being thin. Thereafter the firm and rather thick-walled canal shows a median pair of plates in section, as if from a fold or valve (Pl. V. fig. 31), and then, proceeding backward, enlarges so as to form the two halves of a pear which fill up the entire central area, a slit soon appearing in the middle of each half, and finally broadening out into a T-shaped fold, which runs from the transverse dorsal folds by a long median one to the ventral wall (Pl. V. fig. 27, *d.*). Such appears to be a valvular structure, and it is interesting that the lateral walls are thin, the ventral arch thick, and the dorsal somewhat thin in the median line, whilst the double stalk of the T is thick. The double stalk of the T, indeed, widens, has the structure of the gut, even to the vessels, on its walls, and gradually takes the place of the wall in front, for it is apparently a valvular invagination. If the serial sections can be relied on, it would seem that in this region the sinus breaks up into longitudinal vessels, the ventral remaining as before. The gut is of various shades of brown or reddish brown, the glands of its walls usually being brown by transmitted light.

Toward the tail (Pl. VI. fig. 34) the chief feature is the diminution of the canal and the larger size of the cells of the cylindrical epithelium, which is richly ciliated, lining it. The wall of the gut is sometimes folded, but no distinct evidence of a typhlosole in this region occurs. Moreover, whilst the ventral vessel remains in position, the vascular branches on the walls are inconspicuous, though they seem to form a reticulate series. This part of the gut is often loaded with sandy débris, surrounded by the dilated but tough investment of the gut-wall, which appears to contain inner longitudinal and circular muscular fibres, though these are only visible in some sections, the tough investment in dilatation being apparently homogeneous, as observed in cases where the cylindrical epithelium has disappeared by maceration.

Nervous System.—The cephalic ganglia occur behind the bases of the branchiæ, their anterior border appearing about the level of the base of the opercular stalk as it begins to project from the somewhat quadrangular outline of the body in section. They form a fused mass above the œsophagus, supported in front by a dense group of nucleated cells with slight differentiations at each side, probably indicating the issue of nerves. Then a somewhat narrow band appears, chiefly of transverse fibres with two large nerves passing off at each end, one entering the base of the operculum on the left and the other entering the lateral tissues, whilst those on the right go to corresponding parts. The central part of the ganglia behind increases in bulk, the organ forming a broad band with an enlargement at each end, the whole surrounded by a coating of the nucleated cells, and many transverse commissural nerve-fibres appearing in the centre. The outer enlargement then bends downward and elongates ventrally, the transverse commissural fibres still persisting between the sides, but finally these are gradually replaced by the nucleated cells, and the great nerve-cords, widely separated, lie on each side of the œsophagus. Before this occurs, however, long commissural fibres pass between the trunks over the œsophagus. There is thus a variation from the ordinary arrangement in typical forms, in which these cords slant below the œsophagus and meet more or less closely in the first ganglion of the chain. The nerve-cords are wide apart in the region of the muciparous glands, and it is just after these have been passed in the backward progress that a small neural canal is observed at the inner end of each trunk—still at a considerable distance from its fellow, and with the fibres of the special interneural bands of longitudinal muscular fibres still present. The nerve-trunks lie at the inner edge of each ventral longitudinal muscle, which forms a comparatively thin plate on each side. In the middle of the body the nerve-cords are still separated by a considerable interval, the median mesentery with the ventral vessel being attached to the basement-tissue between them, and each has a large neural canal filled with coagulable substance superiorly—occupying fully half the area. Instead of the more or less complete fusion of the ganglia at intervals, all that occurs in this type is a slight increase of the nerve-cells in the separate trunks and the passage of commissural fibres between them, with an increase of the neuroglia and its nuclei, the large neural canals undergoing no change. The interganglionic regions are recognized by the absence of the transverse or commissural fibres and of the increased neuroglia, and by the conspicuous condition of the median ventral mesentery with its blood-vessel, the strands of the mesentery passing directly to the basement-tissue.

Posteriorly the great nerve-cords are nearer each other, yet separated by a considerable interval. In section they have the same granular and streaked appearance, with a small neural canal at the upper and outer border, which lies against the inner margin of the ventral muscle. Numerous neuroglial nuclei occur at the commissural regions, which occur as in front. In longitudinal sections of the tail the nerve-cords follow every fold of the body-wall, dipping with a sharp angle into each pit, so that the neural canals have no noteworthy influence in this connection. The main direction of the nerve-fibres is longitudinal, and lateral branches leave at each dissepiment even to the tip of the tail.

Various authors have dealt with the general topography of the nervous system of the Serpulids : the earlier, such as De Quatrefages, described a smaller and a larger pair of cephalic ganglia which lie over the œsophagus, with the various nerves which proceed from them. Pruvot also held that there were two pairs of ganglia. E. Meyer, again, found that in *Psygmobranchus protensus* and *Eupomatus lunuliferus*, Clap., there were, in addition to the smaller central and the larger lateral lobes from which the great trunks to the branchial system arise, two accessory lobes to the latter ; and his minute account of the branches from the cephalic ganglia and of those from the great nerve-cords (termed by him "spinal nerves") is excellent and his figures carefully drawn.

Reproduction.—In the ripe female, longitudinal sections of the tip of the tail show that the larger ova in the cœlomic spaces do not, as a rule, extend quite to the tip, about eight segments presenting only small ova. As the sections pass downward from the dorsum toward the ventral aspect a process appears at the posterior edge of the rounded projection formed by each segment. This is the first indication of the segmental organ, and, in accordance with the structure of the parts, it appears earliest in the terminal segments, the process surrounding the cavity of the segmental organ. These processes, as well as the hypoderm of the segment, are outside the basement-membrane, which, with the circular fibres, separates them from the longitudinal muscles in the preparations. In transverse sections of the caudal region it is seen that these segmental cavities pass inward and downward, to open by a wide aperture on the ventral surface (Pl. VI. fig. 34, *ao.*) on each side of the ventral groove, and the ripe ova can be followed from their inner (cœlomic) aperture to the wide external one. These wide tubes might aptly be called, after Dr. Goodrich, cœlomoducts, since they transmit only the reproductive elements, which enter at the space above and to the exterior of the outer ends of the ventral longitudinal muscles. Besides the conspicuous larger ripe ova, smaller ova occasionally occurred in the canal. These segmental organs seem to be simple wide passages for transmitting the ova to the exterior without the complexity of structure observed in other forms. The inner opening is above and to the outside of the ventral longitudinal muscles, the canal curving round the latter to open on the ventral surface below it. The ovaries are situated over the ventral longitudinal muscles, the products being shed into the cœlom, in which further growth takes place. The females, from November onward for some months, have a bright pinkish coloration posteriorly, so that the breeding-season is prolonged.

In passing from behind forward the size of the body-wall and its muscles increases, but the general arrangement of the segmental organs and of the ovarian tufts is the same, the external apertures being outside the shallow ventral groove of the region and of the nerve-cord on each side.

So far as could be observed, no atrophy in the wall of the alimentary canal takes place in the ripe forms, and the muscles of the body-wall likewise are normal.

The Serpulids proper, in the separation of the sexes, are in contrast with such as *Spirorbis* and *Amphicora* (a Sabellid), in which Meyer observes that the anterior abdominal segments are female, the posterior male; whereas in *Salmacina* Giard held that this condition is reversed.

EXPLANATION OF THE PLATES *.

Plate I.

Fig. 1. Transverse section through the region of the cephalic ganglia, *cg.*, of a large *Bispira volutacornis*, Montagu. The chordoid skeleton, *ch.*, is at this level divided into lateral halves, whereas a little in front it forms a continuous arch from side to side. *cm.*, ganglionic commissure; *d.*, œsophagus; *cd.*, dorsal processes; *ct.*, thoracic collar or jacket; *m.*, anterior single mass of longitudinal muscles; *tgo.*, median or common duct of thoracic glands. Enlarged.

Fig. 2. Similar section anterior to the former, the chordoid arch being now complete. *bv.*, branchial blood-vessel, which is dividing into branches; *ch.*, chordoid skeleton; *vc.*, ventral region of the collar; *n.*, nerve. Enlarged.

Fig. 3. Transverse section of the cephalic region of a young example (partly macerated) at the origin of the branchial filaments indicating the tentacles, *t.* From its macerated condition the margins and posterior region are only diagrammatic. Slightly reduced from Zeiss oc. 4, obj. A.

Fig. 4. Transverse section of the distal region of a macerated branchial filament. × oc. 4, obj. A.

Fig. 5. Longitudinal section of a branchial filament in a similar condition, to show the arrangement of the chordoid skeleton. × oc. 2, obj. D.

Fig. 6. Longitudinal section of another filament, indicating the appearance of the cellular hypoderm covering the chordoid skeleton. Young example. × oc. 4, obj. D, with 2 inches of draw-tube.

Fig. 7. Transverse section of a tentacle, with its peculiarly curved lamellæ and its central skeleton and vessel.

Plate II.

Fig. 8. Transverse section of the anterior region of *Bispira volutacornis*, Mont. The dorsal muscles are proportionally small and somewhat rounded, the bristles are still at the dorsal edge, and the ventral longitudinal muscles are somewhat pointed externally, though little weight is to be placed on this feature. A complex series of muscular fibres passes from the dorsal longitudinal muscles downward to the inner border of the nerve-area, and above the point of meeting is the ventral blood-vessel, *vv. s.*, blood-sinus around the œsophagus. Enlarged.

Fig. 9. Transverse section a little behind the former. The dorsal and ventral longitudinal muscles are larger, whilst the absence of the sheets of muscle passing from the dorsal to the ventral aspect permits the oblique muscles, *om.*, to be seen passing to the edge of the nerve-cords. The commissure between the ganglia is marked, the ventral vessel being above it. The hypoderm in the mid-ventral line remains massive. Enlarged.

Fig. 10. Portion of the chordoid skeleton. The passage of processes

---

* I am indebted to the Carnegie Trust for the artists' aid with these Plates.

from the external mass, *pr.*, throughout the reticulated central region and their fusion with the inner edge are indicated. *m.*, muscle. × 650 diam.

Fig. 11. Transverse section of the anterior region of *Bispira*. *d.*, œsophagus surrounded by firm muscular bands; *tg.*, thoracic glands with pale membranous tubes of chloragogenous tissue, *chl.*, attached; *nc.*, great nerve-cords. × oc. 4, obj. A.

Fig. 12. Transverse section of two branchial filaments with their chordoid axes before separation. × oc. 4, obj. D.

Fig. 13. Transverse section of a ventral longitudinal muscle in the posterior region of the annelid, with portions of a segmental organ, *so.* × oc. 4, obj. A.

Plate III.

Fig. 14. Transverse section of the ganglionic region of *Bispira volutacornis*, showing the eyes, *oc.* *cp.*, last trace of the external cephalic pit; *vf.*, ventral fimbriæ. × oc. 4, obj. A.

Fig. 15. Transverse section of the ganglionic region with the great nerve-cords, *nc.*, at the sides of the œsophagus and about the level of the chordoid skeleton, *ch.*, the external margin of which is not smooth, but has processes. Cells and fibres intervene between the dorsal muscles, *dm.*, and strong transverse fibres below them, whilst under these are vertical fibres, more or less mesenterial, in which the common duct of the thoracic glands, *tgo.*, lie. The massive ventral hypoderm, *hp.*, occurs inferiorly. The dorsal region is only partially represented, and the lower division of the great muscular mass is only indicated at *m.* The preparation is somewhat stretched inferiorly. Enlarged.

Fig. 16. Transverse section toward the termination of the thoracic glands, *tg.*, which are represented by two tubes. *om.*, connective tissue with nuclei and muscular fibres, probably part of the oblique muscle of the side. × oc. 4, obj. A.

Fig. 17. Transverse section of the region of the nerve-cords in the middle of the body. *hp.*, hypoderm; *nc.*, nerve-cords; *vv.*, ventral blood-vessel with a coating of chloragogenous cells, *chl.* × oc. 4, obj. A.

Fig. 18. Slightly oblique section of a branchial filament of *Pomatocerus triqueter*. *bv.*, blood-vessel; *cœ.*, cœlomic space; *n.*, nerve. × oc. 2, obj. D.

Fig. 19. Transverse section of a branchial filament toward the base and where its inner edge is produced into a groove with ciliated sides. × oc. 2, obj. D.

Plate IV.

Fig. 20. Transverse section of the anterior region of *Pomatocerus triqueter*, L., near the origin of the opercular stalk (*op.*). *d.*, the vestibule; *ds.*, dorsal pit; *hpi.*, modified hypoderm covering the inner surface of the thoracic collar or jacket and the outer side of the body-wall. The dorsal surface is to the right. × about 35 diam.

Fig. 21. Transverse section of the body-wall in front of the foregoing. The opercular stalk (*op.*) projects much further, the dorsal pit (*ds.*) is larger, and the slits (*bf.*) indicating the spaces between the branchial filaments are present. Spaces (*cœ.*), apparently cœlomic, occur on each side. × about 35 diam.

Fig. 22. Transverse section of the region in front of fig. 21, in which the opercular stalk is separating and the slits (*bf.*) for the formation of the branchial filaments making rapid progress on the other side. On the ventral surface (left in the figure) the thoracic collar is free. Similarly magnified.

Fig. 23. Transverse section after the separation of the opercular stalk and when slits are appearing on the left or opercular side (upper in the figure). The great expanse of the vestibule, *d.*, is noteworthy; *n.*, branchial nerve, the others lie toward the inner ends of the slits. Only the inner branchial nerve, *n.*, is indicated in this figure.

Fig. 24. Transverse section of the tip of a branchial filament of the foregoing. The blood-vessel occupies the centre. It is richly ciliated in life. × oc. 2, obj. D.

Fig. 25. Longitudinal section of a filament of *Pomatocerus triqueter*, L., with portions of pinnules. × oc. 2, obj. D.

Plate V.

Fig. 26. Transverse section of the anterior region of *Pomatocerus triqueter*, L., with the thoracic glands, *tg.*, in full development, that on the left showing the origin of the duct which joins that of the opposite side at the median outlet (*tgo.* in Pl. III. fig. 15 for *Bispira*). *cm.*, cellular appendix of the thoracic gland; *d.*, œsophagus with its chloragogenous coat; *dm.*, dorsal longitudinal muscles; *hyp.*, modified hypoderm; $m.^1$, special anterior median muscular layer on the dorsum; $m.^2$, special ventral layer of muscle; *nc.*, nerve-cords. Above the gullet is the dorsal blood-vessel in the median mesentery, and a space occurs above it between folds of mesentery, but soon disappears. × about 35 diam.

Fig. 27. Transverse section of the body-wall toward the posterior region. The dorsal muscles, *dm.*, are of great size, with scarcely a trace of separation in the mid-dorsal line; *vm.*, ventral muscles; *vv.*, ventral vessel with chloragogenous cells externally. The outline of the gut is T-shaped. × about 35 diam.

Fig. 28. Transverse section of an anterior foot with the hook-pad about the level of the diminishing thoracic gland, *tg.*; *ab.*, incipient muscular fibres of the process opposite the external papilla, *p.* In this section none of the peculiar clavate nucleated cells are visible. × oc. 2, obj. A.

Fig. 29. Section behind the foregoing cutting the superficial part of the hook-pad, and showing the greatly developed hypodermic cells with the nuclei situated externally, and forming an elastic cushion in connection with the dense row of minute hooks. *tg.*, thoracic gland. × oc. 2, obj. A.

Fig. 30. Transverse section of the opercular stalk in another example, in which the central area is chordoid or areolar in aspect. The nerves are not entered. × oc. 4, obj. A.

Fig. 31. Transverse section of the alimentary canal, showing lateral folds of the mucous membrane, almost valvular in appearance. × 350 diam.

PLATE VI.

Fig. 32. Transverse section of the opercular stalk (now shaped like a cocked hat) after the lateral ridges have appeared. The great development of the modified hypoderm (*hpi.*) is conspicuous. *n.*, nerves; *bt.*, basement-tissue, which is highly developed. × oc. 4, obj. A.

Fig. 33. Oblique section of the distal end of the operculum, showing on the right the presence of the ridge and on the left a reticulated aspect of the region beyond after decalcification. × oc. 2, obj. A.

Fig. 34. Oblique section of the tip of the tail of a mature female specimen. *ov.*, ova; *vm.*, ventral longitudinal muscles; *ao.*, external aperture of the modified segmental organ; *d.*, anus. The canal is richly ciliated in this region. × oc. 2, obj. A.

Fig. 35. Transverse section of the œsophageal region, with its thick mucous lining internally, its chloragogenous coat (*chl.*) externally, with its plexus of blood-vessels (*bv.*). *dv.*, dorsal blood-vessel. × 280 diam.

II.—*New Forms of* Dendromus, Dipodillus, *and* Gerbillus. By OLDFIELD THOMAS.

(Published by permission of the Trustees of the British Museum.).

Dendromus (*Poemys*) *exoneratus*, sp. n.

Closely allied to *D. nigrifrons* of East Africa and Uganda, but larger and with whitish ear-patches.

General colour as in *nigrifrons*, but the blackish frontal patch and the dorsal line less developed. At the anterior base of the ears, just in front of the base of the proectote, there is a pair of whitish patches, each about 3 mm. in diameter, which throw up by contrast the blackish frontal patch. These whitish patches are found in all the six specimens from Nigeria available, and in none of those from Uganda and British East Africa.

Skull decidedly larger than that of *nigrifrons*.

Dimensions of the type (measured in flesh by collector):—

Head and body 61 mm.; tail 71; hind foot 18; ear 13.

Skull: greatest length 21·3; condylo-incisive length 19; zygomatic breadth 10·5; interorbital breadth 3; breadth of brain-case 9·7; palatal length 8·7; upper molar series 3·2.