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# THE ANATOMY OF MEGALATRACTUS.

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## I.—INTRODUCTION.

The material used in the present investigation was derived from three sources:—(1) examples of *Siphonalia maxima*, Tryon, obtained during the Trawling Expedition of H.M.C.S. "Thetis" in 1898; (2) specimens taken by the "Deep Sea and Trawling Syndicate" off Broken Bay in 1891; and (3) a large example of *Megalatractus aruanus*, Linn., obtained by Mr. C. Hedley at Mapoon, at the mouth of the Batavia River, Gulf of Carpentaria, Queensland, in May, 1903. Although the apex of the shell and part of the body-whorl of the latter were broken off, the state of preservation of the soft parts was not all that might be wished. The visceral coil was in a thoroughly satisfactory condition, but the preservative used, a mixture of formalin and alcohol, was not strong enough to permeate the muscular tissue of the body, and as a result the organs at the anterior end of the body cavity were far from well preserved. The ganglia of the nerve-ring, the salivary glands, the anterior portion of the œsophageal loop and œsophageal gland, were found to be completely destroyed. The nerves lay loose among these decomposed organs, connective tissue and muscle strands, filling this part of the body cavity.

Nevertheless it is to this specimen that the present paper owes a great deal of its completeness, for, whilst the organs of the body cavities of most of the specimens of *S. maxima* were in a condition fitting them for investigation, the visceral coils of these were almost useless for the purpose, and Mr. C. Hedley* had suggested a relationship between the two molluscs.

* Hedley—Aust. Mus. Mem., iv., 1903, p. 375.

When, therefore, it was found that the "Thetis" material did not allow of a complete investigation, the Curator decided that I should examine the Gulf specimen, and see if it was possible to recover therefrom the details lost from the primary source. The double investigation was rewarded with even better results than we had expected.

The two species prove to belong to one genus, and from the second most of the details lost in the first were recovered.

The following is a concise summary of the results obtained from each investigation, in the order in which they are treated in the following pages.

MEGALATRACTUS ARUANUS, *Linn.* :—

(1) *External features* generally and the organs of the *pallial complex* are described.

(2) *Digestive system.* The alimentary canal itself was dissected out and is described; its position and relation to the other organs are noted, except as regards the anterior end of the œsophageal loop and the nerve-ring.

(3) *Nephridium.* Its shape and macroscopic appearance generally are described.

(4) *Vascular system.* All the principal vessels and sinuses are described, and the circulation of the blood discussed.

(5) *Nervous system* not known.

(6) *Reproductive system.* The specimen was a female; only the ovary and uterus are described.

SIPHONALIA MAXIMA, *Tryon* :—

(1) *External features* and organs of the *pallial complex.*

(2) *Digestive system.* Particular attention was paid to the anterior portion of the system; the relation to the nerve-ring, the œsophageal and salivary glands, are described.

(3) *Nephridium* practically unknown.

(4) *Vascular system.* The only particulars gleaned relate to the heart and aorto-cephalica.

(5) *Nervous system.* All the ganglia and their relations *inter se* are described, except the visceral ganglia.

(6) *Reproductive systems.* Nothing is added to the account of the female complex given under the last species, but the male complex is described in its entirety.

(7) *A section through the proboscis.*

Throughout the two investigations, when the same organ or portion of an organ was obtained in both, it was found to be essentially similar, the differences being of minor importance and such as may well be regarded as specific. It has, therefore, as

already intimated, been concluded that both molluscs belong to the one genus, and are not worthy of even subgeneric distinction. Under these circumstances two courses were open to the writer; one was to sink the term *Megalatractus* and regard *M. aruanus* as a *Siphonalia*, the other was to regard *S. maxima* as a *Megalatractus* and retain both generic terms. This latter is the course adopted, for the following reasons. If we sink the term *Megalatractus*, we, without sufficient evidence, suppose that all the species ranged under *Siphonalia* have the same anatomical characters as the two here discussed. Although all these species probably do possess the same characters, it is better to leave the matter open until additional, and more typical examples have been investigated.

I find that *Siphonalia maxima* has already been listed under the generic name *Megalatractus* by Miss M. Lodder in a list of shells in the Tasmanian Museum.*

The sense of my title, "The Anatomy of *Megalatractus*," and my reason for treating *M. aruanus* first, will now be apparent; the anatomy of the genus, or a summary of the two specific investigations, is rendered in Part IV. of the paper.

The absence of histological details is to be deplored, but the state of preservation of my material put such investigations quite out of the question.

## II.—ANATOMY OF *MEGALATRACTUS ARUANUS*, LINN.

### 1. EXTERNAL FEATURES AND PALLIAL COMPLEX.

#### *a.—External Features.*

(Pl. xxxix., fig. 5, and Pl. xl., fig. 2.)

It is unnecessary to describe the shell; this has already been done several times, perhaps the best figure being that of Reeve.†

Fig. 119. (nat. size.)

The *protoconch* (Fig. 119) "has a literature of its own," as stated by Hedley in his "Studies on Australian Mollusca, Part i."‡ This literature is there reviewed, and the synonymy of the species discussed. My use of the specific name *aruanus* is adopted from this paper.

Pilsbry§ described the protoconch thus:—"Cylindrical, white, fragile, hardly tapering, consisting of 6½ remaining whorls, each carinated and obtusely nodulose in the middle, and obsoletely spirally lirate. Last whorl with one or two

* Lodder—Proc. Roy. Soc. Tas., 1900, p. 130.
† Reeve—Conch. Icon., iv., *Fusus*, 1847, sp. 15.
‡ Hedley—Proc. Linn. Soc. N.S. Wales, xxv., 1900, p. 98.
§ Pilsbry—*The Nautilus*, viii., 1894, p. 17.

spiral cords below the peripheral keel, and more distinctly spirally lirate, the base nearly smooth. Aperture one-third the length of the shell; outer lip thin and fragile, columella lip distinctly sigmoid, smooth. Alt. 21, diam. 6 mm." I am favoured with a particularly fine series from the mass of nidamental capsules described by Hedley,* and am able to add to this description. The number of whorls may be stated to be five; I exclude the last of Pilsbry's description, but as the protoconch is ill-defined from the succeeding neanic structure, the number of whorls may vary with the development of the sculpture and in personal opinion. The whorls may be so sharply angulated as to be aptly described by the term "carinated," or they may be evenly rounded. The character "obtusely nodulous" may vary from the verge of extinction to a degree of development quite as great as that indicated in Tryon's figure.†

The obsolete spiral liræ are the first signs of the ultimate adult sculpture, which may extend up the protoconch for three or four whorls, or may only reach the penultimate; but invariably the actual line of extinction is not to be found. Pilsbry's description and the above remarks apply to the decollated protoconch; the portion lost is only a small thimble-shaped cup; it varies both in the direction of its long axis and apparently in size—to what extent may be gathered by a reference to fig. 120. This apical portion, or veliger shell, is quite smooth, and is divided from the rest of the protoconch, or neanic (?) shell, by a deep groove or constriction. The apparent variation in size is due to the fact that the nucleus is shed in the same manner that a human tooth decays and deposits fresh dentine, viz., as the outer layers are corroded off, new layers are deposited inside.

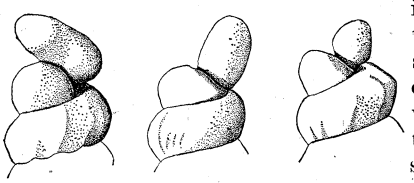

Fig. 120.

The shell of six and one-half whorls described by Pilsbry is possessed of the number of whorls that are present in most of my specimens which were taken from the capsules, but it lacks four or five millimetres of their length. The largest specimen contained in the mass consists of nearly seven whorls, and measures 33 mm. in length; the apical whorl has a diameter of 5 mm., the last whorl is 10·5 mm., whilst the penultimate is only 6 mm. in diameter. This suddenly swollen whorl may be regarded as the first of the true conch, though I believe that the whole protoconch, except the thimble-like apex, is neanic structure.

* Hedley—Proc. Linn. Soc. N.S. Wales, xxv., 1900, p. 508.
† Tryon—Man. Conch., ix., 1887, pl. xxvi., f. 16.

The *operculum* is of the fusoid type (Pl. xl., fig. 1), mytiloid in shape, the nucleus being anterior. There is a slight ridge along the right side, this ridge being more pronounced at the posterior end than at the nucleus.

The sole of the *foot* is of a light burnt umber; the sides also have this colour for a base, but are so flecked and splashed with black as to appear in places quite black. The front margin of the foot bears a groove for the conduction of mucous (?).

There is no *snout*, and the tentacle lobe (*tent. lb.*), which overhangs the orifice of the proboscis sheath is placed far forward, so that that orifice is almost down on the front margin of the foot.

The *tentacles* (*tent.*) are short and thick, and bear the eyes on prominences about a quarter of their length from the end. It would better describe these organs to say that just beyond the position of the eyes they become suddenly thinner.

The dorsal region of the body and the surface of the mantle are of a yellow colour.

The *mantle* along its anterior edge, along the sides, and the siphonal fold, is thick and tough; over the body it is thin. The siphonal fold (*s.*) is rather long, and can apparently be protruded for some length.

The *columellar muscle* is long, though not very thick; it is of a yellow colour, and extends up the columella for a little more than a whorl and a half; the visceral coil is attached to it for as far back as the posterior end of the pericardium.

### *b.—Pallial Complex.*

(Pl. xli., fig. 2.)

The *pallial cavity* extends back to the posterior end of the body, and is there bounded by the nephridium as usual. To the usual number of organs in the pallial cavity there is added a ureter.

The *osphradium* (*osph.*) is oval, tapering at both ends, but rather more gradually posteriorly than anteriorly. It is dark green in colour, and of a large size, therefore a prominent organ. The lamellæ are broader distally than at the point of attachment to the centre cord.

The *ctenidium* (*cten.*) is curved-lanceolate in shape, tapering more gradually posteriorly than anteriorly. It is a dull flesh-pink colour, and extends from well forward in the cavity, on a level with the anterior end of the osphradium, almost to the posterior end of the cavity. Its lamellæ reach their maximum breadth a little distance from their free ends.

The *hypobranchial mucous gland* (*m.g.*) is very large; of the same shape as the ctenidium, it occupies an area as large on the

right side of the cavity, parallel with and mesial to the rectum. Its colour is a dirty brick-red, approaching to brown, and on the tops of the ridges grey. The excreting area is much increased by the throwing of the surface into ridges; of these ridges the most prominent are those which run transversely and diagonally to the long axis of the organ, and between them are smaller ridges arranged longitudinally.

Next to the mucous gland, and parallel thereto, is the rectum (*rect.*); this partly overlies the uterus (*ut.*), which is the organ nearest to the body on the right side. These organs will be described with the systems to which they belong.

## 2. Digestive System.

(Pl. xlii., figs. 1 and 2.)

The absence of a *snout* has already been noted. The orifice of the proboscis-sheath lying below the tentacle lobe is beset with some eight or nine short thick papillæ.

The *proboscis-sheath* (*pb. sh.*) extends back for some little distance and opens into the proboscis-sac. This sheath is not evaginable, but is fused dorsally with the body wall; ventrally it is attached by numerous muscle strands to a spongy connective tissue which completely fills the body cavity below it; its walls are thick and tough. The cuticle of the inner wall at the posterior, or deeper end of the sheath, is raised up into circularly disposed filamentose lamellæ. As to their function, one can only suggest that they serve to clean the proboscis as it is retracted, and so prevent dirt from getting into the proboscis-sac.

The *proboscis-sac* (*pb. sac*) is an ovoid compartment with thin but tough walls, in which the proboscis is coiled. To the outside of the "sac," just close to the aperture from "sheath" and on the right hand side, there is attached a band of muscle (*p. mus.*) which passes back beside the sac, becomes suddenly thickened when the posterior end thereof is reached, and is attached to the body wall on the right side near the posterior end of the body cavity; but for this muscle the sac lies free in the cavity.

The *proboscis* (*pb.*) is very long, and lies coiled up within the sac; its walls are thick and muscular; it is attached to the left side of the sac near the posterior end.

In typical Prosobranchiata Proboscidea, when the proboscis is fully evaginated there is a portion lying within the proboscis-sheath, and this is the portion which is evaginable. On the other hand, when the proboscis is completely invaginated the anterior end still lies within the sheath.*

* *Vide* "Acrecbolic introvert," fig. 48 in Lankester's article on Mollusca —*Ency. Brit., ed. 9, xvi., Mollusca, 1884.*

In *M. aruanus* what is here termed the proboscis-sheath is the homologue of the proboscis-sheath as generally found, *i.e.*, the permanently invaginated portion, though it is not produced into a pseudo-snout, but lies wholly in the body cavity. The "proboscis-sac" of this mollusc is the homologue of the evaginable and invaginable portion of the typical proboscis. Whether or not it is evaginable cannot be said with certainty, but it seems probable that the posterior half is turned into the anterior half. That it is evaginated so far as to lie within the sheath seems unlikely, in view of its large size, as compared with the cavity of the sheath. The portion here termed "proboscis" is therefore obviously the homologue of the non-invaginable, but protrusible portion of the typical proboscis.

The *mouth* is situated at the anterior end of the proboscis; it is small for so large a mollusc, and is not armed with jaws.

The *odontophore* is large and occupies the greater part of the buccal cavity.

The *radula* is short, and the radular-sac, which is straight, lies below the œsophagus. The teeth on that portion of the radula contained in the sac are on the surface directed ventrally; as the radula enters the buccal cavity it is turned back, so that the teeth come to lie uppermost.

The dental formula is 1, 1, 1 (Pl. xlii., fig. 3). The rachidian is tricuspid, all three cusps close together in the centre of the base, the central cusp largest, the other two much smaller. The base of attachment is broad, but not particularly deep. The laterals are unicuspid; the cusp is a long, bent blade attached to the inner margin of the broad base of attachment. This dentition has been already very briefly described by Macdonald.*

The *œsophagus* (*ant. œs.*) originates from the dorsal surface of the pharynx or buccal cavity and proceeds directly backwards through the proboscis; it is a remarkably small tube for so large a mollusc, in fact the smallness of the cavity of the whole tract is particularly noticeable; it passes out of the proboscis and through the wall of the sac, where the two are attached; thence it turns sharply forward attached to the outer wall of the sac, on the left side thereof, by fine strands of connective tissue; at the anterior end of the sac it bends down and passes forward along the floor of the cavity towards the anterior end; its final position here was lost in the general decay. It was found on the left side of the cavity passing backwards (*post. œs.*) along the floor; after passing out of the body cavity its course is through the pericardium, thence along the axis of the coil to the stomach.

The *stomach* (*stom.*) (Pl. xxxix., fig. 2) is tubular, its lumen not very much greater than that of the posterior portion of the œsopha-

* Macdonald—Ann. Mag. Nat. Hist., (4), i i.,1868, p. 243.

gus, the latter enters it on the axial side of the coil, whence it takes an irregularly spiral course from left to right and anteriorly, and part of the spiral is buried in the digestive gland. The spiral course ends on the axial side on a level with the posterior end of the nephridium. Only very little more than that portion of the spiral lying between the hepato-pancreatic ducts is stomach, the rest is intestine. The wall of the former is thrown into narrow lamellæ and bears two rows of hard nodules along the deeper side; the wall of the latter is thrown into lamellæ so broad and numerous as to almost fill its lumen.

The *intestine* (*int.*) passes forward along the axis through the nephridium to the *rectum* (*rect.*), which extends from the posterior end of the mantle cavity forward to the level of the anterior end of the ctenidium. The lumen of the intestine is only slightly smaller than that of the stomach, whilst that of the rectum is a good deal larger.

A small portion of the *œsophageal gland* or *Leiblin's gland* was found; this was dark sage-green in colour and ribbon-shaped. It lay above the left half of the œsophageal loop, and the main branch of the aorta-cephalica, extending from the anterior limit of investigation to about the middle of the proboscis-sac. The anterior end and its connection with the œsophagus were lost in the general decay in this region.

The *hepato-pancreas* (*hep.*) is a large brown gland occupying the greater part of the visceral coil; it is bounded anteriorly by the nephridium and pericardium, and posteriorly is overlaid by the gonad. The hepato-pancreatic ducts are two in number; the first (*hep. du.'*) opens into the stomach just beyond its junction with the œsophagus, and it evidently bears the secretion of the posterior portion of the gland. The second (*hep. du.''*) opens half way down the first turn of the spiral; this carries the secretion from the anterior portion of the gland.

The *salivary glands* were not found.

### 3. The Nephridium.

(Pl. xli., fig. 1, and Pl. xxxix., figs. 1 and 3.)

*The nephridium* (*neph.*) is very large, its shape is somewhat that of a bean, the convex side corresponding to the axis of the coil. The left wall, which separates this organ from the pericardium, is thick and non-glandular, except that portion which contains the pericardial gland. The right wall bears the "glandular mass" of the organ. This glandular mass is in the form of closely packed lamellæ; these are of a dark brown colour, broad and short, but thin. They are arranged somewhat in transverse series between the branches of the nephridial veins; the individual lamellæ running, for the most part, in a direction parallel to the long

axis of the organ. The cavity opens by a large aperture into the *ureter* (*ur.*); this is a muscular pocket, somewhat ovoid in shape, situated in front of the nephridium in the depth of the mantle cavity. The aperture of the ureter is large and easily seen (*ap.*); it can probably be closed by the muscles surrounding it.

The *nephridial gland* (Pl. xxix., fig. 3, *neph. gl.*) is situated in, and about the middle of the wall dividing the pericardium and nephridium; it is largest at the posterior end of the pericardium, and is enclosed by the above-mentioned wall, and it here hangs into that cavity as a thick lamella. As the anterior end of the pericardium is reached this lamella becomes smaller till the gland lies flat in the integument of the wall. The colour of the gland is dirty pink, and it is of a spongy texture. Its shape in transverse section and position may be gleaned by a glance at Pl. xxxix., fig. 3. A large number of pores (*pr.*) allow the blood to pass from the cavity of the nephridium into the gland. An injection through one of these pores was seen to diffuse through the gland and collect in the vena cava.

No *reno-pericardial canal*, properly so called, exists, but a connection between the two organs is found in the two branches of the vena-cephalica. For reasons stated later on it is regarded as unlikely that any exchange of contents takes place by this means.

## 4. The Vascular System.

(Pl. xxxix., figs. 1 and 3.)

The *pericardium* (*p.c.*) is large, and is not nearly filled by the contained organs. Its shape is somewhat that of an *Anodonta*, the umbones representing the dorsal surface; since it is of this shape it cannot be said to bound the mantle cavity, although situated immediately behind it on the left hand side of the nephridium. The outer left hand wall differs only from the posterior part of the mantle in being slightly thicker. The right hand or inner wall is common to both pericardium and nephridium, and has been described with this latter organ. No *pericardial gland* was found.

The *heart* (Pl. xxxix., fig. 4) is of the usual monotocardian type. The auricle (*aur.*) is thin-walled and smaller than the ventricle (*v.*), and they might be aptly compared, as to shape, to two pears attached at their thick ends. The atrio-ventricular valve is composed of several small flaps; that which prevents the return of the blood from the aortæ into the ventricle is of the single flap type. At their inception the aortæ are fused together, but their cavities are separated by a thick partition. There is no main aorta, and the ventricle opens directly into both. A glance at

Plates xxxix., fig. 4, and xli., fig. 3, will explain their arrangement better than words.

The *aorta-cephalica* (*ao. ce.*) passes forward above and is attached to the œsophagus; it gives off no branches till it enters the body cavity, where it immediately bifurcates; the smaller branch crosses to the right side of the cavity, and passes forward, giving off branches in its course; it finally bifurcates, both arms turning down into the foot. The larger branch continues forward along the left side, and the greater number of its branches carry blood to the tissues of the foot and the mantle on the left side, but one particularly large branch crosses towards the right side of the cavity, and turns down into the foot, below the posterior end of the proboscis-sac. The extreme anterior end of this main branch was lost in the general decay.

The *aorta-visceralis* (*ao. visc.*) passes backwards along the axis of the coil; it gives off several small branches in its course.

Of the two, the cephalic artery is very much the larger; their courses and branches were followed by injecting them with prussian-blue, as were all the vessels of this system; and, so small is the visceral artery, immediately behind the pericardium, that it could not have been followed without the injection.

Some of the veinous sinuses are very distinct vessels, and one at least has distinct walls of its own, and is a veritable vein.

For the convenience of description and discussion it has been found advisable to give these sinuses names. They are, therefore, termed—*vena-maxima*, *vena-cephalica*, *vena-cava*, *venæ-pericardiales*, and *efferent branchial vein*.

The *vena-maxima* (*ve. mx.*) is the largest of the sinuses; posteriorly it communicates freely with the lacunæ of the visceral coil, and passes forward along the lower or axial side of the nephridium to communicate with the large *rectal sinus* (*rect. si.*), and a smaller sinus lying between the uterus and body proper. In the nephridium it gives off large but short branches which pass up the right wall or glandular mass of the nephridium towards the dorsal side. These branches are self-contained, that is, they are provided with walls of their own. The wall of the *vena-maxima*, which separates its cavity from that of the nephridium, may be well regarded as serving that purpose only, so that in the nephridium this sinus might almost be looked upon as a veritable vein.

The walls of the rectal sinus (*rect. si.*) and mantle adjacent to it are of a spongy texture, owing to their being perforated by innumerable small sinuses; the largest of these pass below the mucous gland towards the ctenidium. There is no large sinus connecting any part of the vena-maxima with the vena-cephalica.

The *vena-cephalica* (*ve. ce.*) is a large, well-defined sinus, not having distinct walls of its own, but lying in the integument connecting the visceral coil and body. This sinus communicates

freely with the hæmocœle of the body cavity, and is, in fact, a prolongation of that cavity. Just anterior to the nephridium this sinus bifurcates, each branch being about half the size of the main trunk. One, the pericardial branch (*ve. ce. per.*), passes back in the wall dividing the pericardium and nephridium, and opens into the former at the anterior end, below the nephridial gland. The other, or nephridial branch (*ve. ce. neph.*) pierces the wall of the nephridium, and at once becomes a veritable vein. It passes upwards and along the dorsal edge of the glandular wall of the nephridium, sending down branches which lie between those of the *vena-maxima*, and, like them, end in fine capilliaries on the glandular lamellæ.

The *vena-cava* (*ve. ca.*) is a short sinus not having distinct walls of its own, but with a large and well defined cavity. It lies along the lower edge of the nephridial gland, and continuing forward in the wall dividing the nephridium and pericardium, it passes through the mantle to join the branchial vein, a little anterior to the auricle.

The *efferent branchial vein* (*ve. br.*) also has no distinct walls of its own, but lies in the mantle; it is, nevertheless, a well-defined vessel, and its course is as usual along the ctenidium to the auricle.

The *venæ pericardiales* (*ve. per.*) are two large veins which might almost be regarded as posterior prolongations of the pericardium. Without using any force the injection passed through them along the axis of the coil for a short distance, and then became diffused around the hepato-pancreas. These two veins have no distinct walls of their own, but lay in the tissues and muscles of the axis of the coil.

As previously stated, there is a possible reno-pericardial communication by means of the two branches of the vena-cephalica, but, for reasons stated below, it is regarded as extremely unlikely that this communication or interchange of contents does take place.

*Circulation.*—It is evident from the arrangement of the vessels of the system, that blood may pass from the aorta-cephalica to the efferent branchial vein by means of lucunæ, and also that it passes direct from the nephridium, through the nephridial gland and vena-cava, to the auricle, but the direction of flow of the blood in the veins is not so evident. It seems that both the nephridial veins are afferent vessels, and that all the purified blood passes through the nephridial gland to the heart. The considerations which lead to this conclusion are :—

1. The vena-maxima is obviously an afferent nephridial vein.

2. The greater portion of the blood which passes through the heart is conveyed to the body by the aorta-cephalica, it therefore

seems unlikely in the extreme that the vena-cephalica also conveys blood to that region.

3. Since the pericardial branch of the vena-cephalica is smaller than the main trunk, it is highly improbable that the nephridial empties into the other branch, because, in that case, the trunk must *also* empty into the pericardial branch.

In view of these facts it is evident that *neither* of the nephridial are efferent veins.

There are, it seems, three circuits of circulation in this mollusc: one branchial and two nephridial.

(1) The *branchial* circuit is that of portion of the blood carried forward by the cephalic artery; its course is from the aorta-cephalica by lacunæ to the efferent branchial vein, and by this vessel back to the heart.

(2) The *cephalico-nephridial* circuit is also that of a portion of the blood carried by the aorta-cephalica; from this vessel it collects into the sinuses in communication with the vena-cephalica and rectal sinus, and by these vessels is conveyed partly to the nephridium, partly to the pericardium. From the cavity of the nephridium it passes through the pores into the nephridial gland and is carried thence to the heart by the vena-cava.

(3) *Viscero-nephridial* circuit. That portion of the blood carried posteriorly by the vena-cephalica, which enters the pericardium, passes through that cavity to reach the visceral coil by the venæ-pericardiales. From the lacunæ of the visceral coil it passes through the vena-maxima, accompanied by the blood from the aorta-visceralis, to reach the nephridium; thence its course is as in the *cephalico-nephridial* circuit.

### 5. Nervous System.

No trace of this system was found. The central ganglia, *i.e.*, the cerebral, pleural and pedal, had rotted away, and the nerves were washed about and became indistinguishable from the numerous muscle strands lying in the body cavity before it was realised that they were no longer attached to their respective ganglia.

### 6. Reproductive System.

(Pl. xxxix., fig. 1.)

As stated in the introductory remarks, the single specimen was a female; nothing is therefore known of the male organs, and of the female only the macroscopic aspects of the gonad and uterus.

The *gonad* (*go.*) is rather small; it is situated near the apex of the visceral coil, there it overlies the digestive gland, and it is of a yellow colour.

The *uterus* (*ut.*) is a large uncoiled tube with very thick glandular walls, lying in the mantle cavity, on the right side close to the body. The anterior end, which communicates directly with the exterior through the genital aperture, is on a level with the anus; the posterior end is continued up the coil for a short distance on the right side of the nephridium. This end is probably a blind cæcum, for it is unlikely that the oviduct opens into it; rather would the oviduct pass forward below the nephridium and open into the uterus at the posterior end of the mantle cavity. The glandular masses which are attached to the wall of the uterus, and occupy the greater part of its cavity, resemble pieces of tallow candle; these masses are arranged in longitudinal rows.

The mass of egg capsules has been figured by Hedley in his "Studies on Australian Mollusca" from material forwarded him from Bundaberg, Queensland, by Dr. T. H. May.*

## III.—ANATOMY OF *MEGALATRACTUS MAXIMUS*, TRYON.

### 1. EXTERNAL FEATURES AND PALLIAL COMPLEX.

(Pl. xl., fig. 5.)

The shell has recently been redescribed and figured by Hedley† in the paper already referred to.

The *protoconch* (Fig. 121) is present in only one of the many specimens at my command; it consists of about two smooth, rounded whorls of equal diameter. It is not defined from the succeeding neanic structure, but, as in *M. aruanus*, the sculpture of that portion of the shell ascends on to the protoconch and fades out so gradually that the actual line of extinction cannot be found. The nucleus has been cast from my single example, and the two whorls described are the homologue of the six and a half angulated whorls of the protoconch of the last species.

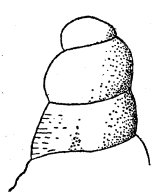

Fig. 121.

The *operculum* (Pl. xxxix., fig. 7) is similar to that of *M. aruanus* except that the ridge described as being on the right side of that operculum is absent from this.

The *foot* and body also agree with the last species in shape, differing only in being smaller and flecked with brown instead of black.

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* Hedley—Proc. Linn. Soc. N.S. Wales, xxv., 1900, p. 508, pl. xxv., f. 18.

† Hedley—Aust. Mus. Mem. iv., 1903, p. 374, pl. xxxviii.

Of the *pallial complex* it is sufficient to say that the *osphradium*, *ctenidium*, *rectum*, and *uterus* differ from those organs in *M. aruanus* only in being proportionately smaller.

The *hypobranchial mucous gland* is more than proportionately reduced; it presents none of the complex arrangement of ridges in this species which it does in the last.

The *ureter* is absent.

The position of the *vas-deferens* and *penis* will be described in connection with the reproductive organs.

## 2. Digestive System.

(Pl. xxxix., fig. 6.)

The *orifice* of the *proboscis sheath* (*pr. sh.*) is situated, as in the last species, close down to the front margin of the foot, and is overhung by the tentacle lobe and tentacles. The sheath itself is not so intimately fused with the dorsal body wall as in *M. aruanus;* on the contrary, it is a self-contained portion of the proboscis, and though attached to the body wall by numerous strands of muscle and connective tissue, may be dissected out, only a few millimetres of the anterior end being completely fused with the wall, nevertheless, it is not evaginable.

The *proboscis sac.* (*pb. sac.*) is longer and smaller in diameter than in the last species, but is otherwise essentially similar.

The *proboscis* is longer in this species than in the last.

The *mouth*, *buccal mass* and œsophagus within the proboscis, are all essentially similar to what was found in *M. aruanus.*

The *radula* (Pl. xl., fig. 4) is of the same length and dental formula (1, 1, 1) as in the last species, but the individual teeth are somewhat different. The rachidian is tricuspid, cusps nearly equal sized, the central slightly the largest, the lateral cusps attached much nearer the margin of the base than in *M. aruanus;* base of attachment half as deep as broad. Laterals tricuspid, base of attachment not deep; the outer cusp the largest, placed at the extreme outer margin of the base, the other two cusps equal in size, attached near the inner margin.

The *œsophagus* issues from the proboscis at the posterior end of the sac, and passes forward attached to the left side thereof (*ant. œs*). At the anterior end of the sac it bends down and comes to lie on the floor of the body cavity. It here becomes suddenly swollen, and then slightly narrowed again, but is thence for the rest of its length a larger tube than that portion which lies between the swelling and the buccal cavity. These two portions may be distinguished as the "anterior" and "posterior" œsophagi. The posterior œsophagus (*post. œs.*) continues forward to the anterior end of the body cavity, where lie the main ganglia,

and is then bent back upon itself. The returning arm passes through the nerve ring, and back along the left side of the cavity, through the pericardium to the stomach, which is similar in form and position to that of *M. aruanus*.

The *intestine* and *rectum* also conform to the description given under the last species.

The œsophagus in passing through the nerve ring, lies above the right half of the cerebral loop and the right pleural ganglion, under the centre and left half of the cerebral loop, above the left pleural ganglion and the sub-intestinal ganglion, and below the supra-intestinal. After passing through the nerve-ring the œsophagus receives the duct of the œsophageal gland; this duct (*du.*) is short and very large, and its calibre is quite half as large as that part of the posterior œsophagus, into which it opens.

The *œsophageal, or Leiblin's gland*, (*œs. gl.*) is a large lamelliform organ of a dark brown colour. It consists of three parts, two anterior oval portions connected together in the middle line, and a posterior ribbon-like prolongation attached to the left anterior piece. The duct arises from the right anterior piece, which is situated on the floor of the body cavity; the isthmus joining this to the left-hand piece rises toward the dorsal aspect of the cavity, and the left-hand portion lies just below the body wall above the posterior œsophagus. The isthmus which joins this to the posterior prolongation bends downward, and the œsophagus lies above it. This isthmus is not connected to the anterior end of the posterior prolongation, but a little behind it, and the anterior end is bent up so as to lie above the œsophagus; the rest of this ribbon-like portion lies on the floor of the cavity, just to the right of the main branch of the aorta-cephalica. The walls of the gland are delicate, though thick, owing to the epithelium of the inner sides being raised into fine closely placed ridges. The cavities of all the portions are in free communication through the isthmuses. The sudden swelling at the junction of the œsophagi is to be looked upon as the much reduced *œsophageal cœcum* (*œs. cœ.*).

The shape of the *salivary glands* was not ascertained, owing to their being mixed up with the connective tissue filling the anterior end of the body cavity. They are both of a yellow colour, and apparently the right is somewhat the larger. Whether the ducts pass through the nerve-ring was not ascertained, probably they do not, judging from the position of the glands, which is posterior to the ring. No trace of the ducts was found elsewhere than in the proboscis; here they lie one on each side of the œsophagus; they open as usual into the buccal cavity.

The *hepato-pancreas* is of the same size (proportionately) and appearance as in *M. aruanus*. Only one duct was found—that which corresponds to the first described in that species—this is

not to say that the other does not exist; it probably does, but owing to the poor condition of my material was not found.

### 3. Nephridium.

Of this organ I can only say that its external appearance is similar to that of *M. aruanus*. The glandular lamellæ and reticulation of blood vessels were completely destroyed. One or two pores were found occupying a position similar to that of the pores of the nephridial gland in the last species, but no trace of the gland was found. There is no *ureter*, and the *reno-pallial orifice* is large and easily seen.

### 4. Vascular system.

(Pl. xxxix., fig. 6.)

The most careful attempts at injection met with complete failure, as the walls of the vessels were too soft to retain the fluid. This section is, therefore, confined to the pericardium, heart and aorta-cephalica.

The *pericardium* is disproportionately smaller than that of *M. aruanus*, and is almost filled by the contained organs, namely, heart, aortæ and posterior œsophagus.

The *heart* almost exactly resembles that of the other species, and is hardly, if at all, smaller.

The *aortæ* are fused at their origin, as in the other species; only that short piece of the aorta-visceralis, lying within the pericardium, was seen.

The *aorta-cephalica* (*ao. ce.*) passes forward in the same course as in the species just discussed, but the right branch is quite insignificant when compared with this branch in that species. At the anterior end of the body cavity the artery lies in the middle line; just posterior to the nerve-ring it gives off a branch which passes down into the tissues of the foot; it then passes through the nerve-ring, in the same course as the œsophagus, and immediately divides into three. Two of these pass down into the tissues to supply the propodium, the third branch bends back, and accompanies the œsophagus along the proboscis sac, and into the proboscis.

### 5. Nervous System.

(Pl. xl., figs. 2 and 3.)

This system was only dissected out with difficulty. The trouble arose from two causes, one was that the material had been in weak alcohol for nearly thirteen years; but more serious than this was the fact that the anterior end of the body cavity was, as in the

other species, filled with connective tissue, among and attached to which were the numerous fine muscle strands which retained the proboscis sheath in position.

The nerve ring is situated at the extreme anterior end of the body cavity, almost under, but slightly behind, the orifice of the proboscis sheath. The pedal ganglia are not imbedded in the tissues of the foot, but lie just on the surface of the floor of the cavity. The most noticeable feature is, as in related genera, the fusion, not only of ganglia, but also of their commissures.

The *cerebral ganglia* and their commissure (*ce. g.*) are fused into one loop, on the left hand side the cerebro-pedal commissure also enters into the composition of the "loop." This "cerebral loop" is placed somewhat diagonally; on the left hand side it is attached to the pedal ganglion of that side, and here it has the corresponding cerebro-pleural and pleuro-pedal commissures fused with it (*c. pl. pd. com.*). On the right side it is fused with the corresponding pleural ganglion, and gives off a pedal commissure which is fused with the pleuro-pedal commissure of this side for the greater part of its length (*c. pd. com.*)

The *left pleural ganglion* (*l. pl. g.*) is represented by a short stout cord, which, as already stated, is fused at its base with the cerebral loop and pedal ganglion, this basal portion being the fused cerebro-pleural, pleuro-pedal, and cerebro-pedal commissures. At its distal end this cord is slighty constricted, and then swells into the sub-intestinal ganglion. The *right pleural ganglion* (*r. pl. g.*) is rather better differentiated from its pedal commissure (*pl. pd. com.*), but is intimately fused with the cerebral loop on this side; it may, however, be distinguished from it to a certain extent by a depression between the two on the inner side of the ring. The commissure which connects this with the supra-intestinal ganglion, although short, is well differentiated from both ganglia.

The *pedal ganglia* (*pd. g.*) are large, and, as usual, give off a multitude of nerves to the foot, the largest pair of which are metapodial nerves, springing from the inner, mesial side of each ganglion. The various pedal commissures have already been described.

The *sub-intestinal ganglion* (*sb. int. g.*) is, as already stated, but a differentiated portion of the left pleural ganglion; it is attached by a very short commissure to the right cerebral ganglion. There is thus a condition of zygoneury on the right side.

The *supra-intestinal* (*sp. int. g.*) is a well-defined oval ganglion attached by a short commissure to the right cerebral ganglion.

The *buccal ganglia* are situated below the œsophagus, in the angle formed by its insertion into the buccal cavity; the buccal commissure was not found.

The *visceral ganglia* were not found.

The *left visceral connective* (*l. v. con.*) rises from the right hand side of the supra-intestinal ganglion. The *right visceral connective* (*r. v. con.*) rises from the left hand side of the sub-intestinal ganglion.

The *right mantle nerve* (*r. m. n.*) rises from the right hand side of the sub-intestinal ganglion. The *left mantle nerve* (*l.m.n.*) takes origin from the left cerebral ganglion near its base. There is a *branchial nerve* (*br. n.*) given off by the supra-intestinal ganglion. This branchial nerve and the left mantle nerve anastomose, and give rise to a dialyneurous condition on the left side.

The *columellar nerve* (*col. n.*) arises from the left cerebral ganglion, just above the mantle nerve.

The *cerebro-buccal connectives* (*c. buc. con.*) originate from the cerebral ganglion; the left from near the base of the loop on that side; the right from near the top of the loop on the corresponding side.

Between the right visceral connective and mantle nerve there arises a nerve (*gen. n.*) which I am inclined to regard as genital, but am doubtful about it, not having been able to find its ultimate branches.

Three or four nerves arise from the right cerebral ganglion, about which nothing is known.

## 6. Reproductive Systems.

(Pl. xl., fig. 5.)

Male—The *gonad*, as is usual, is situated around the digestive gland near the end of the visceral coil, it is of a yellow colour and not very large.

The *vas-deferens* passes forward along the right side of the digestive gland, on the surface of which, just behind the nephridium, it is much coiled; it then turns down to the axis and passes forward below the nephridium. In the mantle cavity it lies on the mantle close to the body on the right side, about half way forward along the cavity it makes an S-shaped curve and comes to lie on the body (*v.d.*), where it is plainly seen as a ridge passing forward to the base of the penis.

The *penis* (*p.*) is remarkably large; it is carried folded back upon itself, and lying in the mantle cavity along the right side of the body parallel with and just to the left of that portion of the vas-deferens attached to the body. In the figure the penis is represented raised up and bent slightly to the left, so that the vas-deferens may be shown. The former is attached to the body well forward, just a little behind and to the right of the tentacle lobe; in transverse section it is oval, its shape otherwise is shown in the figure. The *ductus ejaculatorius* passes through the penis

and opens at the tip of the organ on a papilla which is partly enclosed in a muscular sheath or depression. Whether this papilla is extensile or not I am unable to say; it certainly is not evaginable, but is a solid piece of soft tissue.

FEMALE—The *ovary* and *uterus* conform in all particulars to the descriptions of these organs given under the other species. The *oviduct* was not found, and for this omission I must again plead the poor state of preservation of the material examined.

### 7. A SECTION THROUGH THE PROBOSCIS.

(Fig. 122.)

Although the state of preservation of the specimens was such as to make the use of the microtome valueless for histological research, I have made a few thick sections (at about 20 $\mu$) of the

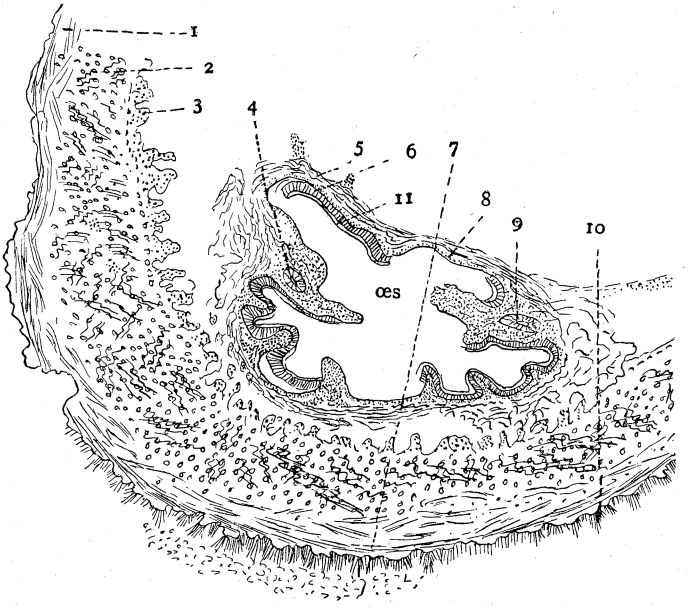


Fig. 122.

Camera lucida sketch of the œsophagus, salivary ducts, and portion of the wall of the proboscis, on a level with the middle of the radular-sac.

1, Circular muscle strands; 2, a layer composed of muscle strands and connective tissue; 3, longitudinal muscle strands; 4, salivary duct; 5, circular muscle strands; 6, enteric epithelium; 7, cuticle; 8, longitudinal muscle strands; 9, salivary duct; 10, deric epithelium; 11, cuticle; œs., œsophagus.

anterior end of the proboscis for anatomical research. The tissues are very much spoiled and displaced, but the organs lie

in what must be approximately their natural position, as also do patches of tissue, so that I am enabled to give the sequence of tissues (it is, however, quite out of the question to attempt to describe them), as well as describe the position of the organs.

The wall of the proboscis is made up of five layers of tissue, they are cuticle (7), deric epithelium (10), circular muscle strands (1), a layer composed of connective tissue, diagonal and longitudinal muscle strands (2), and the innermost layer, longitudinal muscle strands gathered into bundles (3).

The *radular-sac* occupies the greater portion of the cavity of the proboscis anteriorly; its wall consists of, from without inward, circular muscle strands, longitudinal muscle strands, columna epithelium of which the cells are of medium length, and a layer of cuticle. No sign of cœlomic epithelium was found, nor was it expected. The odontophore cartilage is saddle-shaped, but the "flaps" are thicker than the "seat." Owing to the general destruction I was unable to see the arrangement of the tissues of the odontophore. There seems to have been a band of transverse muscle strands across the convex side of the seat; down the sides there was apparently a layer of longitudinal strands, and outside this a layer of short epithelial cells.

The *œsophagus* is placed dorsally to the radular sac, and lies just under and attached to the dorsal wall of the proboscis. Its wall, which is much folded inwardly, consists of a layer of circular muscle strands (5), one of longitudinal strands (8), enteric epithelium (6), and a thick layer of cuticle (11).

The *salivary ducts* (4 and 9), lined with a flat epithelium, are situated in two isthmuses which extend into the lumen of the œsophagus; they are imbedded in connective tissue and longitudinal muscle strands.

## IV.—ANATOMY OF THE GENUS.

### 1. External features.

*The shell.* As in the specific descriptions, so in the generic, I must refer my readers to descriptions already published; these will best be found by reference to Hedley's papers previously quoted.

The *protoconchs* differ in the two species, but these differences are of degree rather than of kind, and both are referable to the one type, which may be termed the *Perostylus* protoconch.

*Operculum* fusoid, nucleus anterior, component rings slightly imbricating.

The *foot*, as far as may be judged from contracted spirit specimens, is large, and bears along the anterior margin a well-developed mucous (?) groove.

There is no *snout*, and the tentacle lobe is far forward, so that the orifice of the proboscis-sheath is close down to the front margin of the propodium.

The *tentacles* are short and are suddenly reduced in diameter above the position of the eyes.

The *columellar muscle* is fairly long, though not very thick ; it extends up the visceral coil as far as the posterior end of the pericardium.

The *mantle* is thick and tough anteriorly and along the sides, but over the body rather thin.

The *siphonal fold* is long, thick and tough; it may evidently be protruded for some little distance.

### 2. Pallial complex.

The *pallial cavity* as usual is co-extensive with the dorsal surface of the body, and is bounded at the posterior end by the nephridium.

The *osphradium* is large, situated well forward on the left-hand side of the cavity, of oval shape, and dark green colour.

The *ctenidium* is also large, and a prominent organ on the left side of the cavity ; it is of a flesh-pink colour, and extends from, on a level with the anterior end of the osphradium, almost to the posterior boundary of the cavity.

The *hypobranchial mucous gland* is well developed, and may have a much folded surface.

The *rectum* and *uterus*, or *vas-deferens*, lie parallel with one another on the right side.

The cavity may or may not contain a *ureter* at the posterior end.

### 3. Digestive system.

The proboscideal complex consists of three well differentiated parts.

A *proboscis-sheath*, neither invaginable nor evaginable, but firmly attached throughout its length, to the dorsal body wall.

A *proboscis-sac*, probably slightly evaginable, and containing the :—

*Proboscis*, which is protrusible and retractile, but not invaginable.

The *mouth*, situated at the end of the proboscis, opens into the small buccal cavity.

The *radula* is of the *Fusacea** type. The presence of only one cusp on the laterals of *M. aruanus* is of very secondary importance.

The *œsophagus*, owing to the great length of the proboscis, is very long ; it consists of anterior and posterior sections. The

* Troschel—Das Gebiss der Schnecken, ii., 1868, pp. 69-86.

*anterior œsophagus* is bent sharply forward, where it issues from the proboscis, at the posterior end of the sac. The *posterior œsophagus* is bent back on itself, where it passes through the nerve-ring, at the anterior end of the body cavity; it then receives the duct of the œsophageal gland, and passes back, along the left side of the cavity, through the pericardium, and up the axis of the coil to the stomach.

The *stomach* is tubular, and has a lumen not very much greater than that of the posterior œsophagus; near their junction it takes a somewhat spiral course on and through the digestive gland, and is joined by the *intestine*; this passes through the nephridium to the *rectum* lying along the mantle on the right side of the cavity, the *anus* being situated well forward almost on a level with the anterior end of the ctenidium.

The *œsophageal gland* is an irregularly shaped lamella, lying mostly in the anterior end of the body cavity, but having a ribbon-like prolongation continued back for some distance.

There is one pair of *salivary glands* situated in the anterior end of the body cavity, just posterior to the nerve-ring. The salivary ducts are long, in conformity with the length of the proboscis.

The *digestive* gland is large; there are two ducts, one opening into the proximal, the other into the distal end of the stomach.

### 4. Nephridium.

This organ is situated in the usual position, immediately behind the pallial cavity, on the right-hand side of the visceral coil. It is rather large, and approaches somewhat to a bean in shape, the convex side being in the axis of the coil.

The *glandular mass* is very thick, and occupies the whole of the right side of the organ; the individual lamellæ are broad and short.

The *cavity* of the organ is spacious, and communicates with the pallial chamber either through a simple *reno-pallial orifice* or per medium of a small, somewhat ovoid, muscular *ureter*.

The *nephridial gland* is well differentiated, and lies in the wall separating the pericardium and nephridium; with the cavity of the latter it communicates by numerous pores; along its lower edge is the sinus which is here termed the vena-cava.

### 5. Vascular system.

The *pericardium* may be either large or rather small; besides the heart and aorta, it contains a section of the posterior œsophagus.

The *heart* is of the usual monotocardian type.

The *aorta-cephalica* is very much the larger of the two arteries, and its name implies its function; the main branch lies along the left side of the body cavity.

The *aorta-visceralis* is a very small vessel for so large a mollusc; it passes up the axis of the visceral coil, giving off small branches in its course.

The *vena-maxima* is a large venous sinus, which places the lacunæ of the visceral coil in communication with the *rectal sinus*, and gives off numerous branches to the glandular mass of the nephridium.

The *vena-cephalica* is a very much reduced posterior prolongation of the body cavity, and places that large sinus in communication with the pericardium and nephridium. The nephridial branch gives off numerous branches which lie on the surface of the glandular mass and between the branches of the vena-maxima.

The *vena-cava* is a short sinus placing the pericardial gland in communication with the auricle.

The *efferent branchial vein* forms a distinct ridge along the left side of the ctenidium; its cavity is well defined.

The *venæ-pericardiales* are two sinuses connected with the posterior end of the pericardium, and placing that cavity in communication with the lacunæ of the visceral coil.

For the course of circulation, see p. 429.

### 6. The Nervous System.

As absolutely nothing is known of this system in *M. aruanus*, a generic summary of the characters is impossible; it is, therefore, unnecessary to repeat the description given under *M. maximus*.

### 7. Reproductive Systems.

Male.—The *gonad* is not large; it has the position usual in the Monotocardian Prosobranchs.

The *vas-deferens* is coiled for a short distance, but for the greater part of its length takes a direct course. In the posterior half of the pallial chamber it lies on the mantle, thence to the penis it lies on the body.

The *penis* is large, oval in transverse section, attached on the right side of the body, just behind the tentacle lobe. It is carried folded back and appressed to the body on the right side, in the pallial chamber.

Female.—The *gonad* is macroscopically similar to that of the male.

The *uterus* is large, situated in the pallial cavity on the right side between the rectum and body, and it extends for a short dis-

tance up the visceral coil on the right of the nephridium. The walls bear numerous large glandular swellings. The *orifice* is situated well forward on a level with the anus.

The characters which have been seen in both species are :—The external features generally and the organs of the pallial complex, the proboscideal complex, the alimentary canal (except the anterior portion of the œsophageal loop), the ribbon-like posterior prolongation of the œsophageal gland, the hepato-pancreas and the first hepato-pancreatic duct, the external appearance of the nephridium and the pores of the nephridial gland, the pericardium, heart and cephalic artery, and finally the uterus and ovary.

The most important points of difference are :—The presence in one and absence from the other of a ureter, the degree of development of the hypobranchial mucous gland, and the form of the individual teeth on the radula.

With these two exceptions all the organs observed in both species are essentially similar.

The most important omissions from the account are :—The visceral ganglia and visceral commissure, the otocysts and otocyst nerves, and the oviduct.

## V.—COMPARATIVE.

*The protoconchs* of the two species are (p. 438) stated to be of the one type, which is there termed the *Perostylus* protoconch. The name is adopted from Pilsbry's* two papers on the larval shell of *M. aruanus*. It must, of course, be admitted that they are rather extremes of this type, which may be defined as :—A turretiform protoconch, having whorls not increasing, or increasing very slightly in diameter, and having a comparatively large nucleus. Besides the two apices here discussed, those of the following are also referable to this type:—*Fusus hexagonalis*, Tate,† *Turbinella regina*, Heilprin,‡ and perhaps also that of *Chrysodomus contraria*, Linn.,§ but the figure of this is poor and the protoconch itself has not been seen by the writer.

A glance at the figures referred to and those on pp. 421 and 431 accompanying this paper will show that these apices may reasonably be grouped together, and that the most important differences between them lie in the number of whorls. This fact may be further demonstrated by covering up so much of the figures that all shall appear with the same number of whorls.

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* Pilsbry—*The Nautilus*, viii., 1894, pp. 17 and 67.

† Harris—Brit. Mus. Cat. Tert. Moll., i., Australasia, 1897, p. 131, pl. v., f. 5.

‡ Dall—Tert. Moll. Florida, (Trans. Wagner Free Inst. Sci.), iii., 1, 1890, p. 98, pl. iii., f. 4.

§ Baker—Ann. N.Y. Acad. Sci., ix., 1897, p. 694, fig. 33.

"It is obvious from the bulk of the larval shell that *M. aruanus* can have no free-swimming stage."* A careful study of this protoconch has led me to conclude that the latter whorls are neanic, the thimble-shaped cap probably veliger structure. I have discussed the stages of growth represented by the first of these protoconchs more fully in a paper on "The Ontogenetic stages represented by the Gasteropod Protoconch," now in the press.

Of the *operculum*, it is almost sufficient to say that it is of the fusoid type. There is, perhaps, a closer resemblance to the Turbinellid operculum than to any of the many others of this type.

In the absence of a *snout*, and the position of the tentacles and tentacle lobe, *Megalatractus* resembles *Fasciolaria filamentosa*, Lamk., as figured by Quoy and Gaimard.† In this respect it differs from *Melongena ("Pyrula") tuba*, Lamk., which is figured by Souleyet‡ as having a very long snout.

It agrees with *M. tuba* in the development of the *hypobranchial mucous gland*, the form of *osphradium*, and *ctenidium;* in the possession of a well developed mucous (?) groove along the front margin of the foot; in the position of the vas-deferens on the body, and the point of attachment of the penis; the last organ, however, is larger in our genus than in Souleyet's example. A description of the hypobranchial gland of *Fasciolaria tulipa* by F. Bernard§ is, in the main, equally applicable to our first species, *M. aruanus;* whilst the osphradium is similar to that of *Cassidaria*, as described by the same writer.‖

I can find no description of a proboscideal complex which resembles that of our genus; that of *Pyrula ficus* (Linn ?), as described by Amadrut,¶ being that which perhaps most nearly approaches the arrangement obtaining in *Megalatractus*. In that species we find a proboscis-sheath, "le trocart," and sac, which, however, this author terms "la gaine"; but the proboscis, instead of lying simply coiled up in the sac, is invaginated into itself, and so lies in that cavity as an irregularly pyriform mass. The complex of *Melongena tuba* is probably the same as that of *Megalatractus*. The proboscis is very long, and is represented by Souleyet as lying coiled up in the body cavity when retracted.** I find it hard to understand these drawings, and it seems possible that they are somewhat incorrect. If they are correct, then no portion of the proboscis is invaginable or evaginable. There is only a short length of the œsophagus

* Hedley—Proc. Linn. Soc. N.S. Wales, xxv., 1900, p. 508.
† Quoy and Gaimard—Voy. "L'Astrolabe," Atlas, pl. 55, f. 2.
‡ Souleyet—Zool. "Bonite," ii., 1852, Atlas, pl. 43.
§ Bernard—Ann. Sci. Nat., (7), ix., 1890, p. 337.
‖ Bernard—*Loc. cit.*, p. 140.
¶ Amadrut—Ann. Sci. Nat., (8), vii., 1898, p. 20.
** Souleyet—Zool. "Bonite," 1852, Atlas, pl. 43, f. 5 and 6.

between the end of the fully retracted proboscis and the nerve-ring; further, this section issues from the proboscis, and is not attached along the inturned wall of it. This section of the œsophagus is not long enough to allow of any evagination, unless we are to suppose that in the proboscis it is coiled as in *Pyrula ficus*, and this, in view of the rather small diameter of the proboscis, seems unlikely. What looks like the anterior end of the "sac" and posterior end of the "sheath," is represented in the two figures referred to. If it be supposed that the rest of the sac had been cut away, the figures become explicable, and the absence of that portion of the proboscis which should be attached on the one hand to the inner end of sheath, and on the other to the posterior end of the proboscis would be explained.

Haller* has discussed *Melongena* ("*Pyrula*") *tuba*, but adds nothing to our knowledge of this part of the anatomy.

The length of the œsophagus depends on that of the proboscis, and is, therefore, not, *per se*, of comparative value from a systematic point of view.

*Leiblin's gland* in *Megalatractus* is particularly large; those of *Purpura lapillus* and *Jopas sertum*, as described by Amadrut,† appear to be nearly as large, whilst those of *Concholepas peruvianus*‡ and *Murex trunculus*§ are even larger. But from all those examples it differs in being lamelliform.

The stomach of *Melongena melongena*, Linn., so closely resembles that of *Megalatractus* that the two might almost be described in the same words. The following abstracts from Vanstone‖ supplement my own description:—"This organ is very small in proportion to the size of the animal's body. . . The calibre of this organ is but slightly in excess of that of the œsophagus and intestine, and in this it differs from *M. tuba*, in which the stomach is more expanded and sac-like.

"The chief point of interest, however, is not seen until the stomach is opened, and, if present in *M. tuba*, was overlooked by Souleyet. Within the stomach of *M. melongena*, on the upper and lower walls, there is a longitudinal series of hard cuticular plates and knobs lineally disposed on a median ridge."

In *Megalatractus* there are numerous narrow, longitudinal lamellæ in the stomach, as well as the two rows of knobs; these are not mentioned by Vanstone as occurring in *M. melongena*, nor does he show them in his fig. 4, which otherwise represents the stomach of our genus.

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* Haller—Morph. Jarb., xiv., 1888, pp. 158-162.
† Amadrut—*Loc. cit.*, pp. 243 and 246.
‡ Haller—*Loc. cit.*, fig. 1.
§ Haller—*Loc. cit.*, fig. 9.
‖ Vanstone—Linn. Soc. Journ., Zool., xxiv., 1893, p. 370.

Vanstone only mentions one "bile" duct, whereas in *Megalatractus* there are two. In the two species of *Fusus* described by Haller,* there are two ducts, but they are fused into one near the stomach, so that there is only the one orifice.†

I know of no extended description of the vascular system of a Gastropod with which one may compare the present. Perrier's valuable memoir—"Sur l'anatomie et l'histologie du rein des Gastéropodes Prosobranches"‡—has given to us details of the vascular system affecting the nephridium of the numerous types he studied. The earlier memoir by Haller§ is not so extensive, and I have, therefore, confined my comparison to that of the French writer.

The arrangement and origin of the nephridial veins in *Megalatractus* do not find an exact parallel in any of Perrier's examples, yet, on page 156, he gives the following general definition which includes our example. The definition is in section v.: "Rein proprement dit. Son irrigation.—Sur la surface libre de cette masse spongieuse se voint presque partout des *vaisseaux sanguins*, abondamment ramifiés, et constituant un réseau vasculaire de la plus grande richesse. Ces vaisseaux naissent d'un ou de plusieurs troncs, dont les principaux partent du sinus abdominal antérieur, que nous avons vu exister près du rectum.

"D'autres branches de moindre importance peuvent venir des autres sinus veineux, soit de la masse viscéral du tortillon, soit de la cavité générale anterieure. . . .

"Ce réseau intérieur de vaisseaux constitute le *système afférent* du rein, comme pemettent de la conclure ses connexions avec les sinus de la cavité générale."

He then (p. 157) proceeds to describe the *efferent veins*. This part of the definition, however, is not applicable, no efferent veins of the type he describes being present in our first species. The nephridium was in a sufficiently good state of preservation to allow me to speak definitely on this point.

The form of the nephridium, and the arrangement of the afferent veins on its internal surface in *Buccinum*, resemble closely what has been found in *Megalatractus*, but the origin of the veins differs. The following is Perrier's‖ description of the afferent system:—

"Comme toujours, dans le voisinage du rectum, et du péricarde se trouve un vast sinus sanguin, faisant communiquer la cavité générale du corps proprement dit avec les lacunes de la masse viscéral du tortillon. C'est de ce sinus, le sinus abdominal

* Haller—*Loc. cit.*, p. 161.
† Haller—*Loc. cit.*, figs. 18 and 20B.
‡ Perrier—Ann. Sci. Nat., (7), viii., 1889.
§ Haller—Morph. Jarb., xi., 1886.
‖ Perrier—*Loc. cit.*, pp. 252-3.

antérieur, que partent les vaisseaux destinés à irriguer l'appareil urinaire."

(Page 255):—"L'irrigation de celui-ci [the accessory system] est elle-mème tres particulière. Du même sinus abdominal antérieur qui donne naissance aux vaisseaux du rein, part, à la partie antérieure, un dernier vaisseau, qui à lui seul distribue le sang à tout le second système rénal."

The points of difference are:—(1) That the vena-maxima, or "sinus abdominal antérieur," does not serve to place in communication the body cavity and lacunæ of the visceral coil, but places the latter in communication with the rectal sinus; (2) that the nephridial branch of the vena-cephalica, or "un dernier vaisseaux," etc., arises from the main trunk of the vena-cephalica, and not from the vena-maxima.

On page 246, Perrier describes in the Olividæ a structure resembling the ureter of *M. aruanus*.

The nephridial gland apparently is of the same shape, and occupies the same position in *Buccinum* as it does in *Megalatractus*; but Perrier's* description is a general one applied to several examples, and one comes to this conclusion from a study of his figures (59 and 61, to 64), as well as a perusal of his description.

The nervous systems of all the genera ranged by Bouvier† under his group "Stenoglosses" are of the same concentrated character as that here described. The following four systems resemble that of *Megalatractus*. They are arranged in the order of their resemblance:—

*Purpura persica*, Lamk. (Haller).‡
*Voluta ancilla*, Solander (Woodward).§
*Voluta neptunei*, Gmelin. (Bouvier).‖
*Fusus syracusanus*, Linn. (Haller).¶

All four systems differ from that under consideration in having very short cerebro-buccal commissures, and with this exception the figures and descriptions of the first two of the above systems apply almost perfectly to our genus. The third system differs not only in the length of the cerebro-buccal commissures, but also in the less degree of concrescence of cerebral, pleural, and pedal commissures and the better differentiation of each cerebral ganglion from the other. The last system, which we might have expected to most closely resemble that of *Megalatractus*, adds to

* Perrier—*Loc. cit.*, p. 251.
† Bouvier—Ann. Sci. Nat., (7), iii., 1887.
‡ Haller—Morph. Jarb., xiv., 1888, pp. 147-149, pl. v., f. 56 and 57.
§ Woodward—Proc. Malac. Soc. Lond., iv., 3, 1900, pp. 117-125, pl. x.
‖ Bouvier—*Loc. cit.*, pp. 301-306, f. 74-75.
¶ Haller—*Loc. cit.*, pp. 158-159, f. 35.

the differences itemised under the last a better differentiation of the left cerebral ganglion, not only from the sub-intestinal ganglion, but also from its own cerebral and pedal commissures.

In the character that this system differs from the four mentioned above, viz., the increase in length of the cerebro-buccal commissures, it seems to agree with that of *Melongena ("Pyrula") tuba*, Lamk. Souleyet* has figured and described two long nerves, arising from the cerebral ganglion and terminating under the buccal mass, which may be justly regarded as cerebro-buccal commissures. Unfortunately, as noted by Bouvier,† Souleyet's figure of the centre of the nervous system of *M. tuba* is "very difficult to interpret," so that one cannot compare the rest of the two systems.

With the first two of the above four nervous systems, I might have bracketed those of *Fulgar perversum*, Linn., and *Chrysodomus contraria*, Linn., as described and figured by Fischer and Bouvier,‡ were it not that they are of sinistral mollusca, and therefore turned left for right.

From what is known of the reproductive systems of *Megalatractus*, they resemble those of *Melongena ("Pyrula") tuba*, Lamk., as described by Souleyet, in essential characters; an unimportant difference is found in the absence from Souleyet's example, of the coiling of the vas-deferens on the surface of the digestive gland.

"The plan of construction of this ovisac (that of *M. aruanus*) somewhat corresponds to that of *Pirula (Sycotypus) canaliculata*, Linn., figured by Fischer."§ (Hedley.‖)

## VI.—THE SYSTEMATIC ALLOCATION OF THE GENUS.

Throughout the last section of this paper it will have been noticed that the various organs and systems of organs have been more satisfactorily compared with those of *Melongena* than those of other genera. This repeated resemblance will have forestalled the present section, for it has become obvious as the concluding portion of the section was reached that *Megalatractus* is closely allied to *Melongena*, or *Semifusus;* it therefore occupies a position in the family Turbinellidæ, Fischer.¶

This conclusion is another testimonial to the wonderful ability of Dr. Paul Fischer to seize upon the salient points of a shell

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* Souleyet—Zool. "Bonite," iii., 1852, p. 618, Atlas, pl. 43, f. 8 and 9.

† Bouvier—Ann. Sci. Nat. (7), iii. 1887, p. 254.

‡ Fischer and Bouvier—Journ. de Conch., (3), xxxii., 1892, p. 150, pls. i. and ii.

§ Fischer—Man. Conch., 1887, p. 92.

‖ Hedley—Proc. Linn. Soc. N.S. Wales, xxv., 1900, p. 508.

¶ Fischer—Man. Conch., 1887, pp. 618-623.

when assigning it a systematic position. He regarded *Megalatractus* as a subgenus of *Semifusus*. It is, however, worthy of full generic rank; the absence of a snout is alone worthy of such recognition.

The names *Melongena* and *Semifusus* seem to be applied indifferently by different writers to most of the species that have been assigned to either; are they both valid and useful genera?

In his paper on the Prosobranchs of the "Vettor Pisani," so many times referred to already, Haller* describes the anatomy of a *Fusus proboscidiferus*, Lamk. (or in the explanation of plates "*proboscideus.*") Now, the only mollusc which I can find to have ever been known by that name is the one which I have here described as *Megalatractus aruanus*, yet that which Haller described is certainly not the same as my example, as the most casual examination of his figures and mine will suffice to show. The explanation of this confusion lies in the facts that Linneus described two species under the name of *M. aruanus*, an American, and an Australian. Lamarck subsequently named the Australian species *Fusus proboscidiferus*, whilst the American species had already been designated *Murex carica* by Gmelin. There were then three names to the two species, and it seems possible that Dr. O. Boettger adopted Lamarck's name and short description to the American species now known as *Fulgur carica*, Gmel. Had Dr. Boettger's systematic and geographic account of the "Vettor Pisani" collection been published† it would have been possible to identify Haller's "*Fusus proboscidiferus*, Lam." As it is, we must rest content with the above suggestion till *F. carica* is again anatomically examined.

Haller's sentence,‡ "Der Rüssel der Fusiden ist bekanntlich sehr lang und bei F. proboscidiferus, wo er wohl die grösste Länge erreicht, diente er Lamarck sogar zur Benennung der Art," is altogether without foundation, for Lamarck§ said of the species—"Ce fuseau est extrêmement remaquable par la partie supérieure de la spire qui ressemble à une trompe droite, comme implantée et terminale," and it was doubtless this feature which suggested to him the specific name.

There is another case of slight doubt which must be drawn attention to, and this time in the work of a French writer, and this is rather surprising, for the French writers err rather on the side of too much historical detail than too little. Amadrut‖ describes portion of the anatomy of a *P.* (*yrula*) *ficus* for which he quotes neither author nor specific description. Now

* Haller—Morph. Jarb., xiv., 1888.
† Haller—Morph. Jarb., xiv., 1888, p. 55.
‡ Haller—*Loc. cit.*, p. 159.
§ Lamarck—Anim. s. Vert., vii., 1822, p. 126.
‖ Amadrut—Ann. Sci. Nat., (8), vii., 1898, p. 20.

there are two Prosobranchs to which this name has been given: one the *Bulla ficus*, Linneus,* a Tænioglossate, the other the *Murex ficus*, Gmelin,† a Rachiglossate. I have concluded that he referred to the Linnean species, because Gmelin's is better known under another name, but the doubt still remains.

In view of this confusion and doubt about the above two species, I think I am justified in appealing to malacological anatomists to not only make certain that their material is correctly named, but also to give such references to figures and specific descriptions as will enable subsequent readers to satisfy themselves of that point also. This is particularly necessary in view of the unsettled state of conchological nomenclature.

* Linnæus—Syst. Nat., edit. 12, p. 1184.
† Gmelin—Syst. Nat., edit. 13, p. 3545.

## EXPLANATION OF PLATES.

Figures 1, 3, 4, and 6 of Plate xxxix., and 1 and 2 of Plate xli., are diagrammatic, and are not drawn absolutely to scale; it was desired to show the arrangement of the organs rather than their exact size; many drawings of Molluscan anatomy are rendered unintelligible through an unnecessary amount of detail in drawing the dissections as they are seen. The rest of the figures are absolutely to scale.

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## EXPLANATORY LETTERS.

*an.* anus.
*ant. œs.* anterior œsophagus.
*ap.* reno-pallial orifice.
*ao. ce.* aorta-cephalica.
*ao. vis.* aorta-visceralis.
*aur.* auricle.
*br. n.* branchial nerve.
*c. buc. con.* cerebro-buccal connective.
*ce. g.* cerebral ganglion.
*col. mus.* columella muscle.
*col. n.* columella nerve.
*c. pl. pd. com.* the fused cerebral, pleural and pedal commissures of the left side.
*c. pd. com.* cerebro-pedal commissure.
*cten.* ctenidium.
*du.* duct of Leiblin's gland.
*gl. ut.* glandular uterine wall showing through a break in the mantle.
*gen. n.* penis nerve (?).
*go.* ovary.
*grv.* mucous (?) groove.
*hep.* hepato-pancreas.
*hep. du.'* first; *hep. du."* second hepato-pancreatic duct.
*int.* intestine.
*l. m. n.* left mantle nerve.
*l. pl. g.* left pleural ganglion.
*l. v. con.* left visceral connective.
*m. g.* hypobranchial mucous gland.
*m. p.* metapodium.
*neph.* nephridium.
*neph. gl.* nephridial gland.
*œs. cœ.* œsophageal cæcum.
*œs. gl.* œsophageal gland.
*op.* operculigerous lobe of the foot.
*osph.* osphradium.
*p.* penis.
*pb.* proboscis.
*pb. sac.* proboscis-sac.
*pb. sh.* proboscis-sheath.
*p. c.* pericardium.
*pd. g.* pedal ganglia.
*pl. pd. com.* pleuro-pedal commissure.
*p. mus.* a strand of muscle attached to body wall and proboscis-sac.
*post. œs.* posterior œsophagus.
*pr.* pores leading to the nephridial gland.
*r. m. n.* right mantle nerve.
*r. pl. g.* right pleural ganglion.
*r. v. con.* right visceral connective.
*rect.* rectum.
*rect. si.* rectal sinus.
*s.* siphon.
*sb. int. g.* sub-intestinal ganglion.
*sp. int. g.* supra-intestinal ganglion.
*stom.* stomach.
*tent.* tentacles.
*tent. lb.* tentacle lobe.
*ur.* ureter.
*ut.* uterus.
*v.* ventricle.
*v. d.* vas-deferens.
*ve. br.* efferent branchial vein.
*ve. ca.* vena-cava.
*ve. ce.* vena-cephalica.
*ve. ce. neph.* nephridial branch of the vena-cephalica.
*ve. ce. per.* pericardial branch of the vena-cephalica.
*ve. mx.* vena-maxima.
*ve. per.* venæ pericardiales.

## PLATE XXXIX.

Fig. 1.—*Megalatractus aruanus*, Linn. Blood system.

Fig. 2.—*M. aruanus*, Linn. Stomach.

Fig. 3.—*M. aruanus*, Linn. A section through the anterior part of the visceral coil.

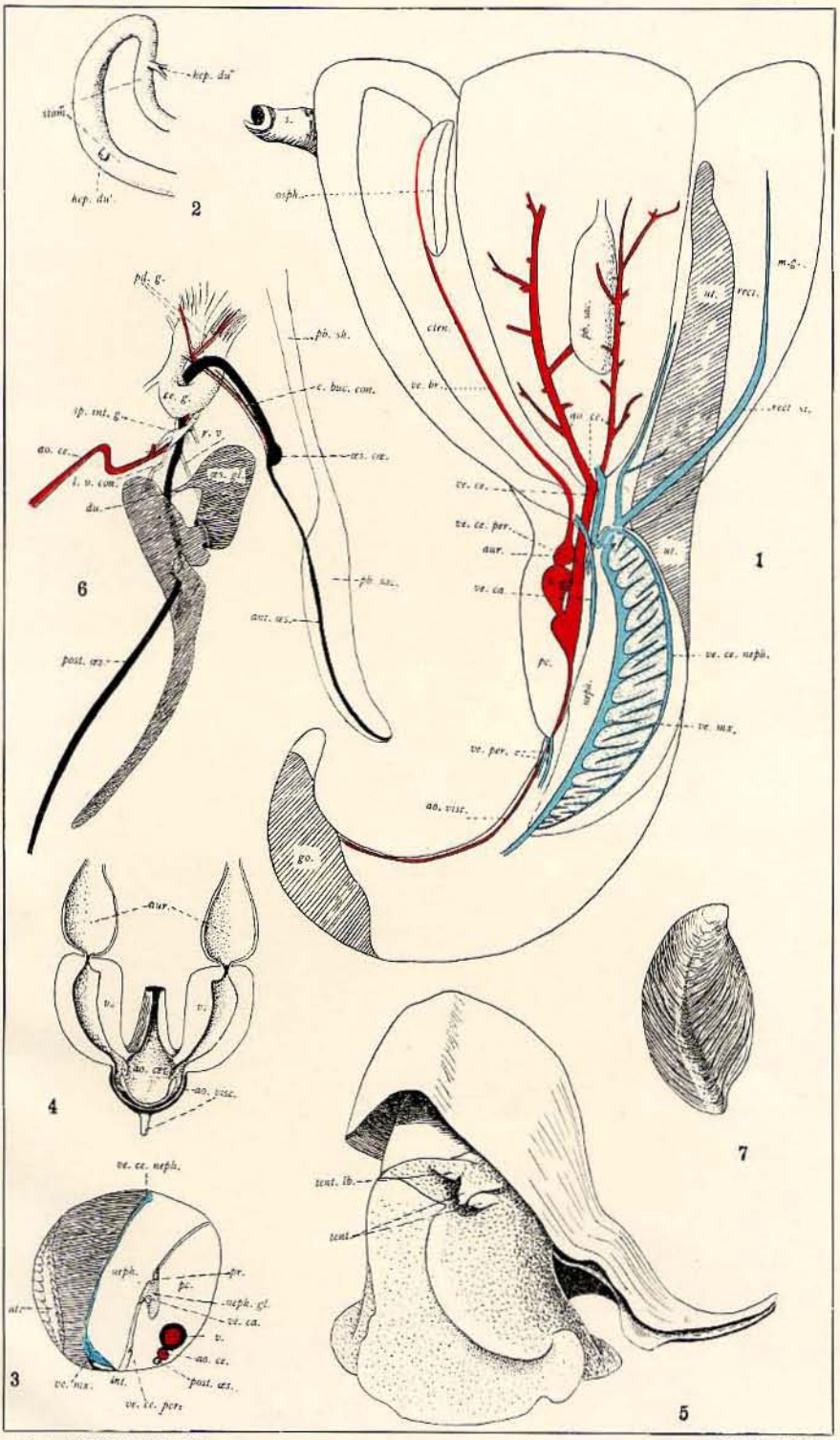
Fig. 4.—*M. aruanus*, Linn. Auricle, ventricle and fused portion of the aortæ, cut through the centre and laid back.

Fig. 5.—*M. aruanus*, Linn. Anterior view of body proper.

Fig. 6.—*M. maximus*, Tryon. Organs in the body cavity.

Fig. 7.—*M. maximus*, Tryon. Operculum.

For explanation of letters, see p. 450.

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## PLATE XL.

Fig. 1.—*Megalatractus aruanus*, Linn. Operculum.

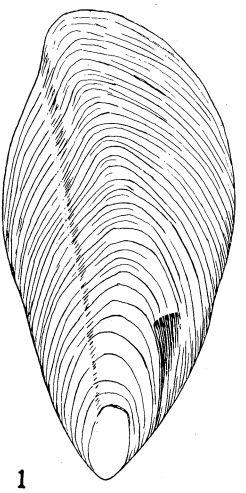
Fig. 2.—*M. maximus*, Tryon. Nervous system, as seen *in situ*.

Fig. 3.—*M. maximus*, Tryon. Nervous system; the cerebral loop cut through and laid back, so as to show the ganglia below.

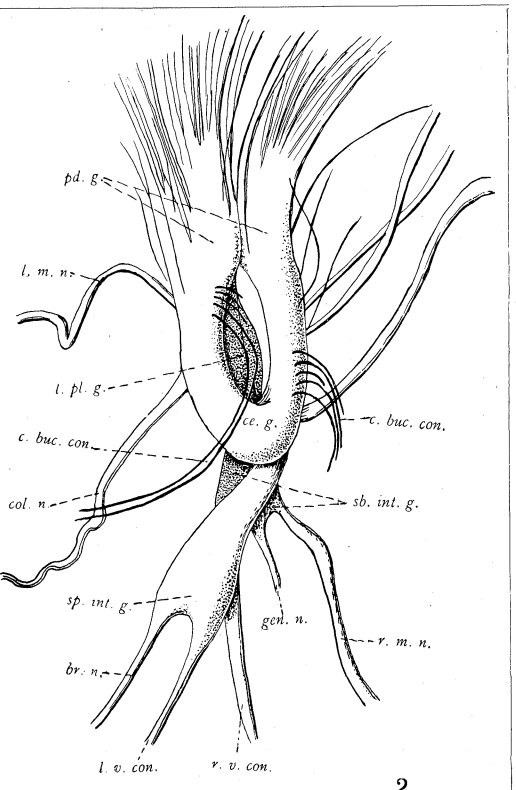
Fig. 4.—*M. maximus*, Tryon. Dentition.

Fig. 5.—*M. maximus*, Tryon. Dorsal view of body showing penis, and *vas-deferens*.

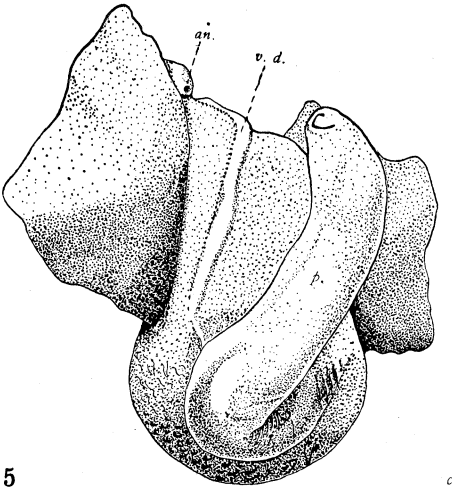
For explanation of letters, see p. 450.



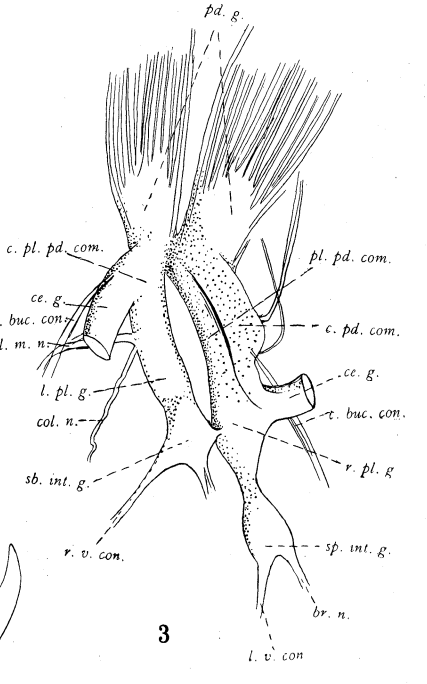
1


pd. g.
l. m. n.
l. pl. g.
ce. g.
c. buc. con.
c. buc. con.
col. n.
sb. int. g.
sp. int. g.
gen. n.
r. m. n.
br. n.
l. v. con.
r. v. con.

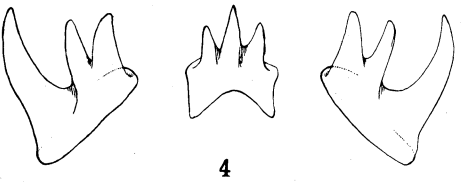
2


an.
v. d.

5


pd. g.
c. pl. pd. com.
pl. pd. com.
ce. g.
c. buc. con.
c. pd. com.
l. m. n.
ce. g.
l. pl. g.
c. buc. con.
col. n.
r. pl. g
sb. int. g.
r. v. con.
sp. int. g.
br. n.
l. v. con

3



4

## PLATE XLI.

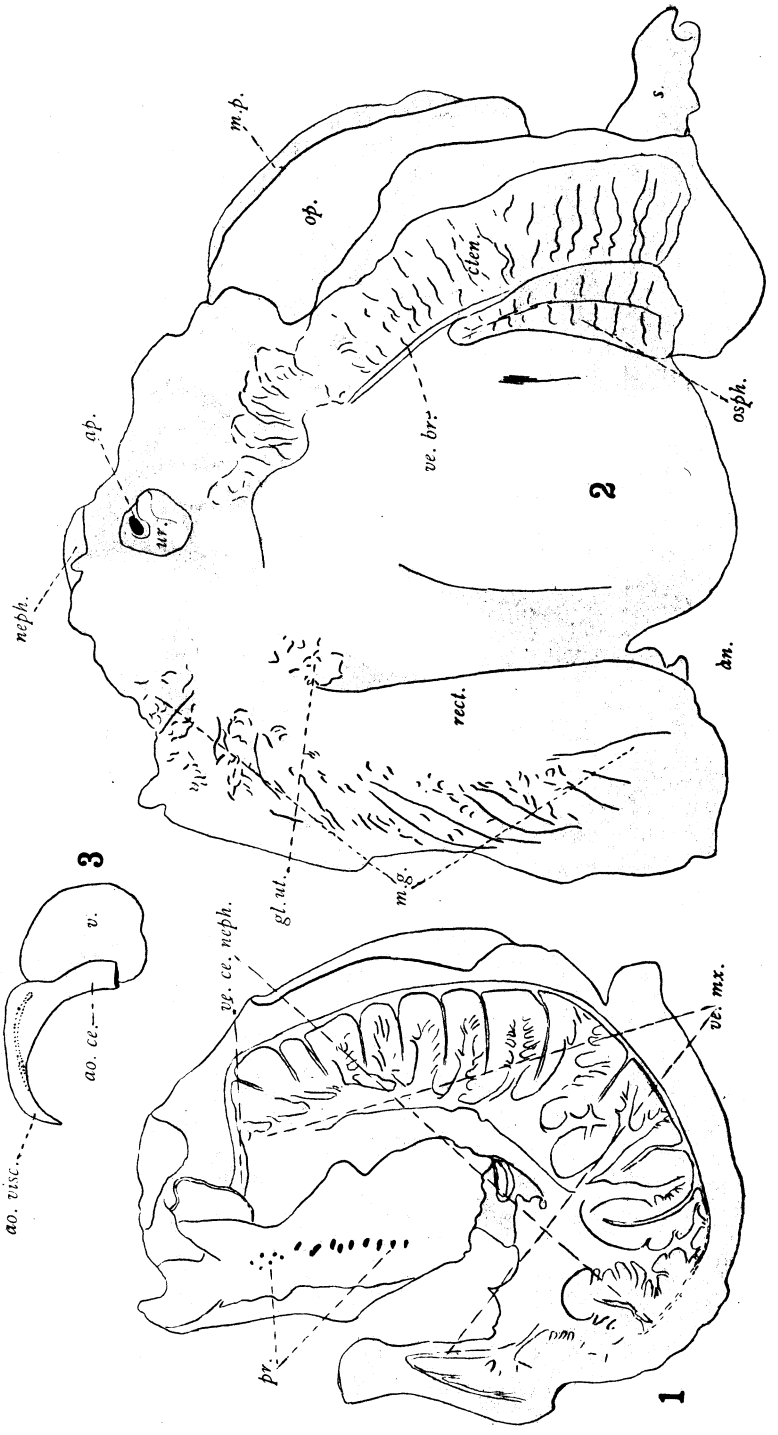
Fig. 1.—*Megalatractus aruanus*, Linn. Nephridium laid open, showing the ramification of blood vessels on the glandular mass, and the pores of the nephridial gland.

Fig. 2.—*M. aruanus*, Linn. Pallial complex.

Fig. 3.—*M. aruanus*, Linn. Ventricle and fused portion of the aortæ. The dotted lines in the tracing show where lies the partition between the two arteries.

For explanation of letters, see p. 450.

Overlay for plate XLI
Ed: L. Brown 20/03/2009



H. BARNES, JUNR., Photo. AUST. MUS.

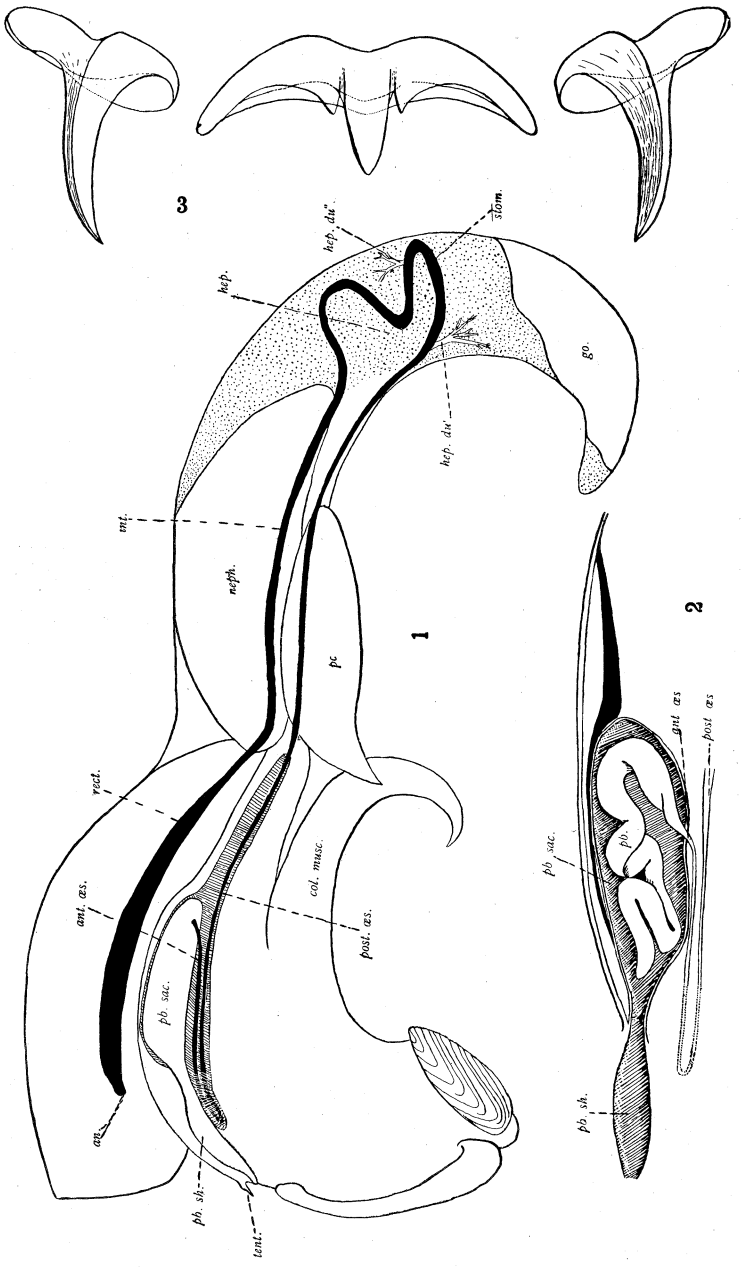
## PLATE XLII.

Fig. 1.—*Megalatractus aruanus*, Linn. Digestive system.

Fig. 2.—*M. aruanus*, Linn. Proboscis lying coiled in the proboscis-sac.

Fig. 3.—*M. aruanus*, Linn. Dentition.

For explanation of letters, see p. 450.


3
hep. duct
stom.
hep.
go.
hep. duct
vnt.
nephr.
pc
1
2
rect.
ant. oes.
post. oes.
col. musc.
pb. sac.
pb. sac.
pb.
ant oes
post oes
an.
pb. sh.
tent.
pb. sh.

[These corrections were printed 5 September 1914 in Part 18 of Memoir IV at p.[xiii], they relate to other Parts of Australian Museum Memoir IV as follows:
"Page 245" refers to p. 245 in Part 3. Whitelegge. Crustacea. Part II. Isopoda. Part I
"Page 305" refers to p. 305 in Part 5. Hedley. Mollusca. Part I. Brachiopoda and Pelecypoda
"Page 441" refers to p. 441 in Part 8. Leighton Kesteven. The anatomy of Megalatractus
"Page 480" refers to p. 480 in Part 9. Whitelegge. Sponges. Part I (note that Plate xlv is printed in Part 10)—Sub-Editor, April 2009]

## CORRECTIONS.

Page 480—DENDORYX PUMICEA—*after* Plate xliv., fig. 15, *read* and Plate xlv., fig. 24.

Page 245—*for* fig. 20*f*, *read* 23*f*.

Page 441, line 16—*for* pericardial, *read* nephridial.