

TRANSACTIONS.

I.—*On the Anatomy and Classification of the Heteropoda.* By JOHN DENIS
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(Read 30th January 1862.)

Notwithstanding the rapid progress of zoology in other departments, the *Heteropoda* still remain imperfectly known, if one may form a judgment from the scantiness of definite information respecting them to be found in systematic works. Nearly all the available space is usually occupied with an exposition of the errors and doubts of the great men who gave us the first outlines of the order, while comparatively little is done to improve the subject, or make it intelligible to the student.

Having had favourable opportunities of examining all the veritable genera of existing *Heteropoda*, I have attempted the arrangement of my notes in a connected form; and as they have been taken directly from nature, I am led to hope that some little may be thus added to what may be already known of the particular species investigated.*

It is usual to divide the *Heteropoda* into two families,—viz., *Firolidæ* and *Atlantidæ*; but it appears to me that there is as little difference between *Oxygyrus* and *Cardiapoda*, as there is between the latter genus and *Firoloides*, while all three differ sufficiently *inter se* to warrant their separation into three distinct families, in each of which two well-defined genera may be included; thus—

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|-----------------|------------------------------|--------------------------------|
| 1. Firolidæ, | <i>Firoloides</i> (Lesueur), | <i>Firola</i> (Perou and Les.) |
| 2. Carinariidæ, | <i>Cardiapoda</i> (D'Orb.), | <i>Carinaria</i> (Lamarck). |
| 3. Atlantidæ | <i>Oxygyrus</i> (Benson), | <i>Atlanta</i> (Lesueur). |

* Not having had the opportunity of consulting many of the original figures of the French naturalists, I have to acknowledge the great advantage I have derived from the study of Mrs GRAY's excellent etchings, in helping me to determine species, as also the descriptive letterpress of Dr GRAY. Many of the anatomical particulars detailed by me had, of course, been previously observed by others; and though I have not clogged the paper with the separate announcements, dates, and authorities of every addition to our knowledge of *Heteropoda*,—which, indeed, would be no small task,—I can vouch for it, that all the facts embodied in the text have fallen under my own observation, and they may therefore be regarded either in one sense as original matter, or in another, as confirmation of what had been already made known.

The zoological characters of these three families and their genera are given in the following Table of Classification :—

Heteropoda.

- I. GYMNOSOMATA* (Firolidæ). Animal wholly naked or without a shell.
 - 1. With slender tentacula, and destitute of true branchiæ. Visceral mass near the root of the filiform process of the metapodium,—*Firoloides*.
 - 2. With rudimentary or no tentacula, but furnished with true branchiæ. Visceral mass considerably in advance of the base of the filiform process of the metapodium,—*Firola*.
- II. THECOSOMATA INOPERCULATA (Carinariidæ). Animal in great part naked, but having the visceral mass protected by a shell.
 - 1. Shell corneous, with an involute nucleus. Swimming-plate nearly opposite the visceral mass. Metapodium with filiform appendage,—*Cardiapoda*.
 - 2. Shell calcareous, with spiral nucleus. Swimming-plate considerably in advance of the visceral mass. Metapodium laterally compressed, without filiform appendage,—*Carinaria*.
- III. THECOSOMATA OPERCULATA (Atlantidæ).
 - 1. Shell corneous, with an involute nucleus. Operculum subtrigonal, with small lateral subapical nucleus,—*Oxygyrus*.
 - 2. Shell calcareous, with a spiral nucleus. Operculum oval, with a large median subapical nucleus,—*Atlanta*.

I have thus far anticipated myself in the construction of the preceding table, but as it affords a bird's-eye view of the subject, it will be found convenient for reference as occasion may require.

General Outline of the Order.

The *Heteropoda* are pre-eminently distinguished by the laterally compressed and fin-like configuration of the body of the foot and propodium; the rudimentary state of the creeping disc (*mesopodium*), and the great length of the operculigerous lobe (*metapodium*), or its homologue, often continued into a kind of caudal appendage.

The remarkable transparency of the tissues of these animals reveals a great part of their internal structure to the anatomist without dissection, which is often a matter of great difficulty, arising from the same circumstance. They are all furnished with a cylindrical proboscis-like muzzle, and a well marked neck, large, mobile, and singularly beautiful eyes, lying in socket-like spaces, though invested with the common integument at the posterior part of the base of simple conical tentacula, except in the true *Firolæ*, in which the tentacula are absent, or at most very rudimentary.

The auditory sacs in all contain single spherical otoliths, increasing by exogenous layers, and revolving like planets on their axes, by the action of vibratile cilia lining the sacs. The large size of the lenses of the eyes, as compared with that of the otoliths, affords a character, which, although of a relative nature, is

* I have made use of the convenient terms *Gymnosomata* and *Thecosomata* in a similar sense to that in which De BLAINVILLE applied them to the *Pteropoda*.

of much importance in distinguishing the *Heteropoda*. In *Cardiapoda* and *Carinaria*, as well as in the naked genera, the acoustic sacs are, as it were, appended to the auditory nerves, which are of considerable length, and arise from the supra-oesophageal ganglia. In the latter particular the heteropods differ from most of the true gasteropods, in which the special centre of audition is incorporated with the suboesophageal ganglia.

The oral aperture is circular, and at the extremity of a lengthy muzzle, within which the "buccal," or rather the lingual mass, appears to occupy but a small space. There are no labial or maxillary dental organs, but the lingual armature is highly characteristic of the order. In accordance with the laws of its development, the lingual ribbon gradually increases in breadth from before backwards. The rachis consists of a single series of plates, while there are three members in each pleura; and all the dental points are simple, sharp, and conical, either perfectly straight and projecting backwards, or slightly curved and inclined more or less inwards.

The segments of the rachis bear a variable number of simple teeth; but the internal pleural plates, whose attached surface occupies nearly, or quite the whole breadth of the pleuræ, generally present one large dental process at the inner extremity, with a much smaller one somewhere near its base. The absence of this smaller tooth, or, when present, its internal or external position with respect to the larger one, may be taken into account in classification; but as the two outer members of the pleuræ in all the *Heteropoda* are in the form of simple claw-shaped uncini, any specific characters afforded by them can only be of a relative nature, as to proportionate length, amount of curvature, thickness, &c. On exhibiting my preparations and drawings to my respected friend, Mr W. S. MACLEAY, he saw very plainly that generic characters might be drawn from the rachis alone; and it was with no small satisfaction that I enjoyed the concurrence of so great a man in my first attempt to effect a classification of the *Heteropoda*, by their lingual dentition, which so often outlives the decay of the soft parts generally.

The gills, or branchiæ, usually consist of a linear series of short claviform or tapering processes, with a loose cellular investment, presenting a longitudinal zigzag fold on the inner surface, giving rise to the plumose appearance sometimes so incorrectly represented in figures of these animals. In *Firoloides*, however, I have never seen any vascular appendages of the nature of gills, and they are frequently absent, or inconspicuous even in *Atlanta*.

In closing this general sketch, it only remains to be stated, that the sexes are distinct in *Heteropoda*, as was first suspected by M. LAURILLARD, who assisted the great CUVIER in his dissections. Mr MACLEAY further informed me that CUVIER, on the same account, was deterred from placing them amongst his *Tectibranchiata*. Modern anatomists, however, have thought fit to contradict this opinion, though upon what grounds, except hearsay, it is difficult to determine.

I had originally intended to pass all the genera in review, dealing with the whole anatomy of each in the order observed in the foregoing table ; but this would extend the paper beyond reasonable limits, and perhaps prove monotonous to the reader, from the frequent repetitions of essentially the same anatomical particulars, however striking their modifications may be, in the different members of this natural order.

I shall therefore first make selection of *Firoloides* and *Atlanta* for especial description, occupying, as I conceive them to do, the two extremes of the group ; and those modifications to which I have alluded may be briefly noticed in a passing glance at the remaining genera, or at least the particular species which have casually fallen under my observation.

Firoloides (Lesueur).

While cruising in the South Seas, and subsequently in the neighbourhood of the West India Islands, I was fortunate enough to obtain numerous specimens of a solitary species of *Firoloides*, and which I find, if I am not very much mistaken, has been several times named by different writers who may have met with it under such deceptive conditions as to mask its identity. Thus, the male and female of this species are represented in Plate XVI., *Voy. la Bonite*, figs. 8 and 1 respectively, though the former has been designated *Firola de Keraudren*, as also *Eydouxii*, and the latter *F. de Desmarest*. I have traced it, moreover, under other names in certain less definite figures, illustrating the works of the French naturalists, who appear to have had most to do with the *Heteropoda* from the very foundation of the order, though it is scarcely reconcilable with Lesueur's figure of *Firola Demerastiana* (l, c, i, 39, t. 2, f, 1), which Dr GRAY seems to regard as the type of the genus *Firoloides*. Now, though all this may be justly regarded as a stumbling-block to the student, he has still more to encounter in the literature of other genera. I shall therefore eschew the naming mania altogether, and simply attempt succinctness of description, aided by fidelity in the figures, so as to render the species in question just as definite as if I were to add fresh synonyms to the existing confusion. It is a cheering reflection, however, to know that we have in the lingual dentition a guide that cannot be gainsayed, and whose expunging power may be safely applied to a host of *mis*-applied cognomina with their bracketed italics.

On entering Bass' Strait in H.M.S. "Torch," I obtained my first *Firoloides*, which was so perfectly transparent that, but for the brilliancy of its eyes, relieved by the dark pigment coat protecting the retinae, it would probably have passed unobserved. When immersed in sea-water, the eyes were seen rapidly swaying from side to side with the undulatory movement of the elongated and pliant body, no other parts being visible but the faintly rose-tinted visceral nucleus and the little buccal mass.

The whole length of the animal did not exceed an inch and a quarter; and when placed under the microscope, the principal features of its anatomy were traceable through the integuments. (Plate I. figs. 1, 2, 3 and 4.)

The head supported two delicate tentaculæ of moderate length and taper form, and a large and beautiful eye occupied a considerable dilatation at the back part of the base of each. The muzzle was rather slender, with a small truncated extremity, within which was contained a minute buccal mass, lodging a short lingual sac. At the posterior part of this organ, the buccal artery terminated between two nodules of nervous matter (*buccal ganglia*) (Plate I. fig. 2, d), while a narrow œsophagus proceeded from its upper and fore parts.

The principal viscera were clustered together at the hinder extremity of the body, which is abruptly truncated above, but produced inferiorly into a suddenly tapering tail (Plate I. fig. 4, g), terminating in a filamentous appendage (Plate I. fig. 1, n, fig. 4, h), marked at certain intervals by slightly dilated joints or rings, softly tinted with brownish pigment. This appendage is highly sensitive and mobile, trailing in an undulatory manner after the animal as it swims. I can safely say that it is neither a tapeworm nor an oviduct, though I am as yet unacquainted with its use.

The characteristic laterally compressed and fan-like foot (Plate I. fig. 1, g) of the *Heteropod* crested the ventral surface of the body at a little distance posterior to the centre, and near the fore part of the free margin of this organ a minute sucker-disc (Plate I. fig. 1, f) was distinctly visible.

The body in this species is everywhere enveloped by a perfectly transparent homogeneous-looking integument, the inner surface of which is studded at irregular intervals with small clusters of cells, surrounding a larger vesicle (most probably cutaneous glands). Internal to this there is a stout muscular sheath (Plate I. fig. 2, o), which includes the buccal mass in front, and the visceral nucleus behind where it extends into the tail, the homologue of the operculigerous lobe of the foot in ordinary gasteropods.

The preceding sketch will suffice to give a general idea of the animal; but we shall now proceed to consider more in detail the anatomy of the organs of sense and the several organic systems, which will enable us to understand more thoroughly the modifications of this type occurring in the other genera.

Organs of Sense and Nervous System.—The eyes of *Firoloides* (Plate I. fig. 1, b, fig. 2, l), like those of other *Heteropoda*, are very large and beautiful, and situate at the posterior part of the base of the slender tentacula. They are invested by the common integument, and exhibit a very remarkable structure. A little bulb, somewhat compressed from above downwards and constricted in front, forms the body of each. This is usually of a pale reddish-brown tint, and sparingly lined with darker pigment granules. A perfectly spherical lens of highly refracting material rests in a depression at its fore-part, and the lens itself is capped over by a strongly

curved meniscus, in which a cell-structure is often distinctly visible beneath the cutaneous covering.

The acoustic capsules (Plate I. fig. 1, c, fig. 2, m) contain each a transparent globular otolith, which is very much smaller than the lens of the eye. Several little prominences, on the inner surface of the capsules, represent those which poise off the crucial otolith of *Sepia*, from the wall of the vestibule in which it lies. The ear-sacs, moreover, appear to float freely within the muscular sheath, being connected with the cerebroid ganglia by long and delicate auditory nerves.

The nervous system of this creature, from the peculiar mode of distribution of its ganglia and communicating or commissural cords, not a little resembles the *homo-gangliate* type.

Two elliptical knots of nervous matter lying side by side, and blended together by their contiguous borders, compose the cerebroid ganglia (Plate I. fig. 2, i) in which the combination of several smaller centres may be distinctly traced in recent specimens.

Two large nerve-trunks, derived from the cerebroid ganglia anteriorly, communicate with the before-mentioned buccal ganglia, lying at the posterior extremity of the lingual cartilages, and give off nerves to the buccal mass and mouth.

The optic nerves (Plate I. fig. 2, h) emerge from the posterior part of the outer border of the cerebroid ganglia, by a club-shaped base, and taper gracefully towards the eyes, at the back part of which they form a remarkably thick retinal expansion.

The delicate auditory nerves arise immediately behind the optic, and thence passing outwards and backwards some little distance, reach the acoustic sacs (Plate I. fig. 1, c, fig. 2, m), upon the walls of which other more delicate filaments are also distributed. On examining the origin of the larger nerves, it would appear as though they communicated with each other in the median line by very faint striæ traversing the substance of the cerebroid ganglia. From the posterior border of the latter bodies, two large nervous chords (Plate I. fig. 2, n) pass directly backwards, including between them the œsophagus (Plate I. fig. 1, e, fig. 2, g) and buccal artery (Plate I. fig. 2, e), and having reached the root of the swimming-fin, they join the fore part of the pedal ganglia (Plate I. fig. 1, h, fig. 3, a)—two nearly circular but laterally compressed masses of nervous matter connected with one another by their contiguous surfaces.

These ganglia give off numerous branches to the neighbouring parts, but from the inferior border of each a special nerve descends with the pedal artery, and is ultimately distributed to the swimming-plate, while two stout trunks, arising from the posterior part of the ganglia, blend together in a loose plexiform manner, and course backwards as a single chord. This at first accompanies the œsophagus, to which it supplies several branches, next sends off a nerve of communication to the visceral ganglia, and, finally subdividing in the tail, is lost in the filamentous appendage.

As far as I have yet discovered with any certainty, the visceral ganglia are two in number—viz., 1st, A minute nodule of neurine (Plate I. fig. 4, d), joined by the commissural nerve above mentioned, and situate at the angle between the origin of the visceral artery and the continuation of the main trunk; and, 2dly, a much larger oblong subquadrilateral ganglion (Plate I. fig. 4, e), lying on the right wall of the intestine near its origin. From the superior angles of the latter body distinct branches take their rise; one in particular joining the former ganglion, while others are distributed to the heart and everted mantle with its sphincter-like opening. The digestive and internal generative organs are supplied with nerves from the inferior angles of the same nervous centre.

Digestive System.—The proboscis of *Firoloides* is susceptible of retraction and protrusion to a considerable extent, in which movements the fore-part of the common muscular sheath, and even the œsophagus itself, plays an important part (Plate I. fig. 2, g).

The oral orifice (Plate I. fig. 2, a) is terminal, rounded, and unfurnished with labial plates or mandibles of any kind. The buccal mass (Plate I. fig. 2, d) is small, and placed near the extremity of the muzzle, as above-mentioned. The lingual cartilages, in which the cell structure is beautifully marked, are oval in shape, wrapped together by ligaments, and supplied with muscles to effect their varied movements.

The tongue-sac is scarcely longer than the cartilages, terminating posteriorly in a rounded extremity, and the dental area exhibits a remarkable increase in its breadth from before backwards. The rachidian plates (Plate I. fig. 5, o) being concave both in front and behind, are broadly (H) shaped, and bear a large central tooth, with a little comb of denticles on either side. The first or inner pleural plates (Plate I. fig. 5, l) are destitute of a small inner tooth near the base of the large cusp, and the uncini very nearly equal the breadth of the pleuræ, as given in Plate I. fig. 5.

An elongated and somewhat flattened salivary gland (Plate I. fig. 2, c) lies along the lingual cartilage on either side, and communicates with the mouth by a very short duct.

The œsophagus, proceeding from the upper and fore-part of the buccal mass, takes a course directly backwards, in close relationship with the buccal artery and nerves, and having reached the visceral nucleus, the canal exhibits a slight gastric enlargement, which receives the biliary ducts inferiorly from the supero-posterior wall of the stomach; a short intestine passes upwards and backwards between the heart and the abdominal viscera, and terminates in the anus (Plate I. fig. 4, o) on a little prominence above the latter organs, and below and between two small anal lobes or leaflets (Plate I. fig. 4, p).

The lining membrane of the stomach and intestine is richly ciliated, but the cilia increase both in size and activity as they approach the vent, around which they may be very distinctly observed. The apparently undulatory movement

produced by the consecutive action of the cilia within the canal, proceeds in a forward direction, though of course the current to which it gives rise takes an opposite course.

As compared with the bulk of the animal, the liver (Plate I. fig. 4, f) is of small size; and its minute lobuli may be traced along the posterior wall of the short intestine and stomach, and for some little distance farther, in front of the internal organs of generation, which occupy the remainder of the visceral chamber.

The Mantle, Respiratory and Circulatory Systems.—In *Atlanta*, *Carinaria*, and *Cardiapoda* the mantle permanently envelopes the viscera, and, keeping pace with the development of these organs, furnishes the materials of growth to the protecting shell. The course of the intestine, and the position of the heart and respiratory surface, all of which constantly preserve a definite relationship to each other, exhibit, with reference to the extremities of the body, the usual arrangement prevailing amongst the so-called *praso-branchiate* gasteropoda,—that is, the alimentary canal being bent upon itself, the rectum passes forwards, and the anus terminates it anteriorly; the branchiæ also lie in advance of the heart, through which the circulation proceeds in a backward direction. In *Firoloides*, on the contrary, the mantle is everted and thrown backwards; and the parts above mentioned being more or less intimately connected with it, suffer a remarkable change of position, which will be better understood when we have considered the anatomy of the organs contained in the visceral nucleus. Thus, the free border of the mantle is, as it were, turned inside out, and so very much constricted as to circumscribe a small oval opening (Plate I. fig. 4, n) on the right side of the visceral mass, and immediately in front of the rectum. This opening is surrounded by a little sphincter muscle, which is intersected by numerous radiating fibres, so that ample provision is made for its contraction and dilatation, frequently observed with a degree of rhythmical precision in very recent specimens.

I have never seen any branchial appendages, properly so called, in *Firoloides*, although one would imagine, had such been present, that they would be still more apparent in consequence of the eversion of the mantle. Apart from the idea that the general surface of the body may be more or less subservient to respiration, the position of the auricle of the heart points out the locality in which we might expect to find the organs especially adapted to this function. It must be observed, however, that immediately behind the heart, and above the anal lobes, a richly ciliated space or fossa (Plate I. fig. 4, q), with a prominent margin, is constantly present; and I am inclined to think that the little clusters of spherical cells, represented in Plate I. fig. 4, r, as occurring upon the pallial wall of the pericardium, may possibly be concerned in respiration, and in some way associated with the modification of the mantle above explained.

The heart, consisting of a single auricle and ventricle, rests upon the mantle-chamber which lies between it and the rectum. The muscular fibres of the auricle

(Plate I. fig. 4, s) divide and interlace with one another, leaving angular and irregular spaces between them. They are not so clearly to be traced in the ventricle (Plate I. fig. 4, t), the walls of which, nevertheless, seem to be somewhat thicker than those of the auricle. A circular constriction marks the union of the two chambers, and two valves guard the auriculo-ventricular opening. The base of the aorta is slightly dilated and highly contractile, being furnished with valves at its origin from the ventricle. It very soon gives rise to a large vessel which passes downwards and backwards to supply the viscera; but the great podoccephalic division (Plate I. fig. 4, b) crosses over the alimentary tube from the left to the right side, and, having formed a few flexures, runs forwards alongside the œsophagus until it arrives a little in front of the pedal ganglia, where it curves downwards to give rise to the pedal artery (Plate I. fig. 3, c), which opens directly into the great ventral sinus at the root of the swimming-plate. From the origin of the latter vessel the main trunk courses forwards as the buccal artery, and, having reached the fundus of the tongue-sac, it is no further traceable.

Generative System.—The external male organ lies on the right side of the body near its posterior extremity, and consists of two portions, one of which is of considerable length, terminating in a bulbous enlargement (Plate I. fig. 1, m), but the other is short, with the orifice or terminal part usually inverted. The follicles of the testicle converge to a duct, which exhibits a fusiform, though twisted dilatation (Plate I. fig. 1, l) in its course, and which is, moreover, distinguished by its coating of black pigment cells; but the duct does not appear to reach the external organ, or, if it does in this case, nothing of the kind is discoverable in the other genera of Heteropoda.

The female orifice (Plate I. fig. 4, i) is situated immediately above the root of the tail, and guarded on each side by a small laterally compressed leaf-like process, somewhat larger than the anal lobes previously noticed. The oviduct (Plate I. fig. 4, l) is rather capacious, and once or twice doubled upon itself. The ovarian sacculi communicate with its inner extremity; and the impregnated ova, with which the duct is sometimes found distended, may be observed in all stages of yolk-cleavage, exhibiting further advancement as they approach the external opening, from which a delicate nidamental chord with ova, in single or two alternating series, may be frequently seen protruding (Plate I. fig. 6).

Atlanta (Lesueur).

As the remarks which I have to make on the anatomy of *Atlanta* have wide reference to all the species of the genus, I shall defer the perplexing question of specific determination to a future paper.

General Sketch of the Genus (Plate II. Fig. 1).

The shell of *Atlanta* is dextrally-spiral in the young state; but it subse-

quently becomes plan-orbicular, laterally compressed, and nearly symmetrical, bearing a dorsal keel of variable depth, literally nothing more than a thin fold of the shell itself, which thus presents a deep notch or slit at the corresponding part of the outer lip.

The animal admits of complete retraction within its shell, and is furthermore protected by a delicate oval operculum, with a large *sinistrally*-spiral median, and subapical nucleus (Plate II. fig. 1').

The head of *Atlanta* is supported by a kind of neck, with which the proboscis forms an angle more or less obtuse. The eyes are proportionately very large, and fronted by small conical tentacula; and all the parts of the foot are more compact than in *Firoloides*. Thus, the part corresponding with the tail in the latter genus is an obvious metapodium, bearing an operculum in the former. The swimming-plate is relatively stronger, and the sucker-disc better defined. The visceral mass also bears a larger proportion to the rest of the body.

More Particular Description of the Foot and Retractor Muscle.

The muscular fibres which fix *Atlanta* to the shell arise from a short oblique line commencing near the nucleus, and extending some little distance outwards and forwards on the upper or right wall of the tube. From this origin they pass round the columellar wall, gradually diverging from one another as they approach the mouth of the shell. Here they commence to blend with the proper muscular fibres of the foot, but more especially with those of the operculigerous lobe. This lobe forms the posterior part of the foot, from the inferior surface of the base of which the vertical fin bearing the sucker-disc springs. Thus the foot altogether may be said to consist of three distinct portions—viz., the swimming-fin (Plate II. fig. 1, j) in front, the operculigerous lobe (Plate II. fig. 1, θ) behind, and the sucker-disc (Plate II. fig. 1, k), holding an intermediate position. These structures are mainly composed of a basis of muscular and areolar tissue, overlaid with common integument. The muscular fibres are disposed in ribbed bundles at the central parts requiring the greatest support, and cross one another diagonally over the general surface, so that mobility in every direction is amply provided for; but as all the parts of the foot lie in one vertical plane, corresponding with that of the shell, all the lateral movements of the animal are necessarily the more vigorous.

The fin-shaped swimming-plate supports the mesopodium or sucker-disc on its posterior border near the base. The latter disc is divided by a longitudinal depression into two lateral lips or lobes, which meet together when the organ is contracted; but when it is fully expanded and brought into action, after the manner of its homologue, the creeping disc of the true gasteropod, it exhibits a more circular form, and as I have particularly observed in the case of *Oxygyrus*, glides over any resisting surface with imperceptible undulations. Into its central or concave part a muscular fasciculus, derived from the fibres of the great retrac-

tor, is fixed, so as, probably, to assist in forming a vacuum when the animal is entirely supported by this small disc; and the epithelial cells on its outer surface are frequently tinted with a yellowish, red, or purple pigment.

The metapodium bears the operculum (Plate II. fig. 1, λ , and fig. 1'.) on its dorsal surface, and terminates in a point posteriorly. The inferior surface of this curiously constructed tail-piece presents a median vertical fold or reel, which gradually decreases in depth as it approaches the pointed extremity where it ends. On either side of this fold is a little fossa, deepening in front, and passing some little distance within the anterior margin. To this latter part is appended a small moveable and valve-like process (Plate II. fig. 1, ι), whose use I have not yet discovered; but it is probable that it has some office in directing the path of the respiratory currents, when the animal is retracted into its shell; and this view is favoured by the fact that the floor of each fossa is richly ciliated, with the undulations proceeding from behind forwards.

Organs of Sense and Nervous System.—The eyes (Plate II. fig. 1, e), as above-mentioned, are proportionately very large, and situated immediately above and in front of the cerebroid ganglia, capped over by a portion of common integument, which bulges out to enclose them. The outer and fore-part of this covering is beautifully rounded, smooth, and transparent, so as to form a kind of external cornea, lying directly over a brilliant spherical lens. Commencing at a zone corresponding with the limits of the cornea, the cell-pavement of the integument, and the deeper muscular tissue, become more apparent; and in front of each cornea, towards its inner side, is a conical and contractile tentaculum (Plate II. fig. 1, c) of small size compared with that of the eye. The lens, which is compressible to a certain extent, and invested with a capsule of homogeneous membrane, lies in front of a cylindrical case, which is somewhat fuller at the inner and posterior part, where the optic nerve expands into the retina, and all stray luminous rays are absorbed by a dense coating of reddish-purple or black pigment cells extending forwards to the lens, upon which it encroaches in an annular form to about one-fourth of its diameter.

At the inner side of the base of each eye there is a small projection upon which it rolls, obedient to the action of numerous small muscular bands that spring from the borders of a kind of socket, and are inserted into the organ at different points of its circumference. Thus the eyes enjoy a considerable range of motion, quite independent of the outer covering; and often, when the bright lens rolls within the margin of the pigmentary coating, the singular appearance of winking is produced. Both eyes generally move in concert, but each organ enjoys its own intrinsic movements irrespective of the other.

The acoustic capsules (Plate II. fig. 1, g), consisting of homogeneous membrane with a ciliated lining, contain each a single vitreous-looking otolith, usually with a small cavity in its centre, around which the successive deposit of concentric layers

is distinctly apparent. In *Firoloides*, *Firola*, *Cardiapoda*, and *Carinaria*, the auditory nerves are of considerable length, so that the ear-sacs are, as it were, appended to them; but in *Atlanta*, which embraces more of the characters of the true gasteropods, those sacs are closely applied to their proper ganglia.

The gullet and anterior or buccal division of the aorta pass through a nervous collar consisting of four supra (Plate II. fig. 1. f), and two sub-oesophageal (Plate II. fig. 1. i) (pedal) ganglia, connected by two lateral commissural chords, each of which arises from the two superior ganglia of the corresponding side by distinct slips. The two anterior cerebroids supply the short but stout optic nerves to the eyes, while the acoustic sacs lie in the outer angle between these and the posterior ganglia, having no connection whatever with the sub-oesophageal or pedal nervous bodies.

The two principal nerves supplied to the buccal mass and mouth arise from the anterior superior ganglia, pass forward on either side of the buccal artery, and at some little distance behind the lingual cartilages divide into a superior and inferior branch, and thus, communicating also with the buccal ganglia, are equally distributed to the muscular and other structures in this locality.

The pedal ganglia give off branches to the several parts of the foot, and to the muscular sheath of the body, and two stout commissural nerve-trunks arise from their posterior border and join the visceral ganglia, which preside over the heart's action and the functions of the neighbouring organs and parts. As there is much difficulty in tracing out the filaments derived from those ganglia in *Atlanta*, their homologues in *Firoloides* may be studied with advantage.

Digestive System.—Although the cylindroid proboscis exhibits great pliancy in itself, the range of its movements is much augmented by the mobility of the neck. Destitute of labial teeth, the lining membrane of the mouth is prolonged into the fauces and oesophagus above and behind, being continuous with the lining of the tongue-sac inferiorly, blending with the borders of the dental ribbon, which doubles over the fore-part of the supporting cartilages (Plate II. fig. 1. h), and thus projects into the oral cavity. The cartilages just noticed form the basis of the tongue, and consist of two principal pieces of an oblong figure, forming, by their union along the mesial line, a grooved pulley-like surface, over which the lingual strap glides. In many gasteropods, a smaller piece of cartilage is articulated to the posterior extremity of each of the principal ones, so as to admit of greater mobility, and a certain amount of compression in the longitudinal direction; and I have reason to believe that corresponding pieces exist in the framework of the tongue of *Atlanta*. The cartilages are connected together and acted upon by transverse and oblique slips of muscular fibres, and small bundles pass from the inner surface of the tegumentary covering, to be inserted into them at different points.

The lingual strap, commencing by a small point beneath the anterior extremity of the basal cartilages, at first passes a little forwards, then turns upwards and

backwards, gradually increasing in breadth, and finally forms the floor of the tubular tongue-sac.

The rachidian plates (Plate II. fig. 5, g, fig. 8, o) are quadrilateral, and thicker posteriorly than in front, so that the corresponding angles are much more clearly defined. Each plate bears a single sharp conical tooth, arising directly from the middle of the posterior border.

The anterior and internal part of the first series of pleural plates (Plate II. fig. 8, 1.) abuts upon the members of the rachis, and there is never a small tooth on the inner side of the large terminal fang, though there is very generally a characteristic minute spine-like tooth (Plate II. fig. 8, 1'') a little to the outer side of its base.

The two outer series of the pleuræ (Plate II. fig. 8, 2, 3), as in all the other Heteropods, consist of simple tenaculiform hooks, varying in relative length, strength, and curvature, in the different species of the genus.

The configuration of the teeth, and the mode of action of the whole dental apparatus, are adapted for seizing and transfixing living prey; indeed, all the Heteropods are eminently carnivorous, and commonly bolt their victims whole. I have taken a *Firola*, which I recognised by its dentition, from the stomach of *Carinaria*. I also found a whole *Eurybia* impacted in the gullet of another specimen; and it is not an uncommon thing to meet with one of its own kind in the stomach of *Atlanta*, although it more usually preys upon the smaller *Pteropods*, *Spiralis*, or *Creseis*, for example.

From the so-called buccal mass (Plate II. fig. 1, h) a lengthy œsophagus courses directly backwards, and having entered the base of the visceral chamber, it soon opens into the anterior and inferior wall of a simple sub-globular stomach (Plate II. fig. 1, γ). This latter viscus lies a little below, and posterior to the heart (Plate II. fig. 1, y), and from its upper and fore part, a short intestine (Plate II. fig. 1, x) passes forwards above, and nearly parallel with, the œsophagus, and in close relation to the heart, to end in the vent (Plate II. fig. 1, s), deeply within the mantle cavity.

The liver (Plate II. fig. 1, e) is a beautifully sacculated gland, of a pale-brown tint, often mottled with amber, black and red, commencing by a small pointed extremity near the nucleus of the shell, and gradually increasing in bulk, until it reaches near the posterior wall of the stomach, into which a single short and stout biliary duct opens.

I may notice here a conspicuous glandular body, which appears to me to be a renal organ (Plate II. fig. 1, u). This lies immediately above the rectum, and between the latter and the auricle of the heart, and is made up of densely clustered, minute, and rounded follicles, communicating freely with each other; but I cannot tell whether its very distinct oval outlet (u) opens into the heart, pericardium, or into the cavity of the mantle. Between the apparent position of this orifice and the arms there is a small prominence, bearing a well-defined pore (Plate II. fig. 1, t) that may communicate with it, or with an aquiferous system.

The Mantle, Respiratory, and Circulatory Systems.—The free border of the mantle (Plate II. fig. 1, n) is often beautifully fimbriated, and beset with cilia, both stationary and vibratile; and in the extended state, an angular fold of it (Plate II. fig. 1, o) occupies the dorsal slit of the shell, and extends for some little depth between the laminæ at the base of the keel.

The branchiæ consist of a variable number of clavate bodies (Plate II. fig. 1, p), in single longitudinal series floating from the dorsal wall or roof of the mantle; and to the left of these, but passing forwards more obliquely, there is a narrow, strongly ciliated band (Plate II. fig. 1, q), in all probability in some way connected with respiration, when the animal is retracted into its shell.

Large venous sinuses (Plate II. fig. 1, r), distinctly observable between the layers of the mantle, appear to convey the return blood from the gills to the auricle of the heart (Plate II. fig. 1, w). The extent of this chamber is very much less defined than that of the ventricle (Plate II. fig. 1, y), which communicates with it by a large opening, guarded by a couple of valves. The muscular bundles of the ventricular walls are also much stouter than those of the auricle, and form a close interlacement, in the interstices of which the lining and investing membranes seem to meet together.

The great vessel arises posteriorly from the apex of the ventricle, and forms a short dilated axis (Plate II. fig. 1, α), from which two arterial trunks originate; one of these (Plate II. fig. 1, β) passes backwards to supply the abdominal viscera, while the other (Plate II. fig. 1, z) runs forwards beside the œsophagus and the root of the swimming-plate, divides into the pedal and buccal arteries, in every respect conformable with those already described in *Firoloides*.

Generative System.—It is very remarkable that there is, as nearly as possible, an equal distribution of males and females in the genus *Firoloides*, while the proportion of males to females in *Atlanta* is so very great, as to render it difficult to form a correct estimate. In my own experience, out of many hundreds of *Atlantæ*, I have only met with about twenty females.

The follicles of the testicle (Plate II. fig. 1, ζ) somewhat resemble those of the liver, but they are at once distinguished by their lighter colour and the nature of their contents, which usually present a finely granular basis, with fasciculated striæ in the axis of every cavity and passage. The whole organ, though very similar in shape, is much smaller than the liver, between which and the inner wall of the shell-tube it lies. A stout *vas deferens* leads forwards from the base of the gland, and soon forms a fusiform enlargement (Plate II. fig. 1, δ) coated with black pigment; and from the small fore-part of which the duct still passes forwards a little way, and then terminates in a leaf-like expansion (Plate II. fig. 1, v), having a fine cellular structure in the space between the adductor-muscle (Plate II. fig. 1, η) and the rectum (Plate II. fig. 1, x).

The external male organ is situated at the base of the neck, and may be

represented as bifid, having an anterior part, conical and grooved, and a posterior apparently glandular and trumpet-like segment (Plate II. fig. 1, m). I have never been able to trace the *vas deferens* to this organ in any of the *Heteropoda*; and having found the mantle-cavity full of spermatozoa in *Carinaria*, I am disposed to think that the scheme must be similar to that which obtains amongst ordinary gasteropods, when the penis is imperforate.

The ovary in the females is very similar to the testicle, both in shape and position, but the contained ova at once decide the difference, and the large thick-walled and convoluted oviduct, without the dark-coloured fusiform dilatation characteristic of the male sperm-duct, still further settles the question of sex. The aperture of the oviduct would appear to lie deep within the mantle. I could discover no opening in the position occupied by the penis in the male, though I have observed ova escape from beneath the margin of the mantle.*

The characters of the operculum are also significant,—viz., as to its general form, the course of the lines of growth, the position, size, and appearance of the nucleus, the muscular impressions, and its smooth or dotted surface.

Oxygyrus (Benson).

The genus *Oxygyrus*, established by Mr BENSON, includes the *Atlantæ* of RANG, KERANDRIEN, and LAMANON, characterised by having an involute instead of a spiral nucleus to the shell, greater fulness in the whorls, and a comparatively small amount of calcareous matter as a component, particularly near the mouth and in the keel (Plate II. fig. 3).

The most striking difference that I have noticed between the soft anatomy of *Atlanta* and of *Oxygyrus* is that the testis is short and broad, lying at the base of the liver in the latter case; whereas it is much elongated in the former, extending far inwards between the liver and the columnellar wall of the shell.

The rachidian plates in all the *Oxygyri*, instead of a single dental process of *Atlanta*, bear three conical teeth on their posterior border; and these teeth are either all large and nearly equal in appearance (Plate II. fig. 5, e), or the middle tooth alone is well developed, while the lateral ones are rudimentary (Plate II. fig. 5, f).

The pleuræ are essentially similar to those of *Carinaria* and *Cardiapoda*, presently to be described, the most important character in all being the presence of a small conical, and often incurved tooth (Plate II. fig. 7, 1'), on a little shoulder

* All the species of *Atlanta* present so close a general resemblance, that their nice discrimination requires careful examination and comparison. The keel may be more or less, or not at all interposed between the peristome and the body whorl. It may be plain or wavy, though the shell never exhibits this latter character, as it does in *Carinaria*. The spire, as to its prominence, depression, evenness or obliquity, closeness or openness of its whorls, smoothness, dotted surface, or linear markings, affords us characters which do not appear to have been hitherto sufficiently recognised. There is, moreover, in colour, which one would naturally regard as being of little importance, a scarcely ever failing peculiarity of species.

at the inner side of the principal fang of the first or internal pleural series (Plate II. fig. 7, 1); whereas, if a smaller tooth is at all present in *Atlanta*, it is at a corresponding distance to the outer side of the larger one (Plate II. fig. 8, 1").

Firola (Lesueur).

I have only met with one species of *Firola* (Plate I. fig. 7), which appears to be equally plentiful in the tropical parts of the two great oceans, Pacific and Atlantic. It is, I believe, *F. Lesueurii*, and about two inches long, or nearly the same size as *Carinaria Gaudichaudi* (Plate II. fig. 4). The body is elongated and cylindrical, with a full and rounded cephalic region, a muzzle reminding one of an elephant's trunk, and a laterally compressed rudder-like tail. The filamentous appendage in my first specimens was either absent or accidentally broken off, and the latter accident happened to the head of several examples of this species taken in the West Indies. No tentacula, or even frontal processes, were at all visible; but the eyes were well developed, and appeared to make a nearer approach to the eyes of *Carinaria* and *Cardiapoda* than do those of *Firoloides*.

The acoustic capsules may be readily recognised by the brilliancy of the contained otoliths, a little internal and posterior to the eyes; the auditory nerves being about equal to the optic in length, but very much more slender (Plate I. fig. 8, g).

A fan-like foot (Plate I. fig. 7, g) springs from about the middle of the under surface of the body, the rudimentary mesopodium (Plate I. fig. 7, f) being situated on the free margin of the organ, somewhat nearer its anterior than its posterior extremity.

The visceral nucleus (Plate I. fig. 7, k) occupies a deep notch on the dorsal surface of the body, near its hinder end, and is enveloped in a glistening fibrous coat, tinted with a madder-brown pigment. It is rather small, as compared with the size of the whole animal, but, being surmounted with distinct branchiæ, one more indication is afforded of the propriety of placing *Firola* between *Firoloides* and *Cardiapoda*; and this conclusion is strengthened by the position occupied by the sucker-disc of the foot, and also by the characters of the generative organs, which indicate something intermediate between the two genera alluded to.

The comparison of the lingual dentition of *Firoloides*, *Firola*, and *Cardiapoda*, will not only show how intimately they are related, but afford some assistance in determining their relative position with regard to the other *Heteropoda*.

The rachidian plates of *Firola* (Plate I. fig. 9, o; Plate II. figs. 5, 6) are quadrilateral in figure, but about three times broader than they are long; the dental points, as in *Firoloides*, form a broad comb, with a stout central fang; but the teeth gradually diminish in size towards the sides, and are so strongly marked, as compared with those of *Firoloides*, that it would be impossible to mistake the one for the other.

The first series of pleural plates very rarely exhibit a slight rudiment of the small internal tooth so characteristic of *Cardiapoda*, *Carinaria*, and *Oxygyrus*,

but the two lateral uncini present only the relative character of being comparatively long and slender.

Cardiapoda (D'Orb.)

Looking upon *Cardiapoda pedunculata*, *carinata*, *caudina*, and *placenta* (figured respectively in *D'Orb. Voy. Amer. Merid.*, t. 11, figs. 5, 3, and 4; and *Voy. la Bonite*, t. 17, f. 11, 1-5), as probably the same species, I am at a loss to know what I should call *my* species, which is evidently the same thing.

My first specimen, of which I immediately made a drawing (Plate I. fig. 10), was obtained in the S.W. Pacific, and scarcely exceeded $\frac{3}{4}$ inch in length. The muzzle was much fuller and more cylindrical than that of *Firoloides*, and the buccal mass equalled about one-third of its extent. The eyes were remarkably broad, and closely resembled those of *Carinaria* and *Oxygyrus*. They were fronted by simple conical tentacula. The auditory sacs were visible through the stout integument at some little distance behind the eyes.

The muscular sheath of the body exhibited a close and even tissue round the snout, head, and neck; but, on approaching the position of the foot, it formed itself into a number of longitudinal linear bundles, which passed, on the one hand, into the pedicle of the viscera, and, on the other, into the tail.

The propodial foot (Plate I. fig. 10, g) crested the middle of the ventral surface, and on its posterior border it bore the mesopodial disc (Plate I. fig. 10, h), which was laterally bilobed, and more highly developed than it is either in *Firoloides* or *Firola*.

The tail (*metapodium*) was rather remarkable in its appearance. Thus, being at first cylindrical, it soon exhibited a subterminal enlargement, from which again it suddenly tapered into a lengthy filiform appendage (Plate I. fig. 10, k). The enlargement just noticed was convex above, corresponding with the position of the operculum in *Atlanta* and *Oxygyrus*, while its inferior surface was expanded into a kind of disc, with a jagged, prominent ring-like border, densely coated with black pigment (Plate I. fig. 10, i). The use of this organ is yet unknown to me, but it appears to be homologous with the peculiar structure above described, as occurring on the under surface of the metapodium of *Atlanta*.

The whole extent of the visceral nucleus, shell, keel, and all, scarcely equalled the expansion of the foot; and the internal organs in general were so invested with pigmentary matter that the heart (Plate I. fig. 10, m) was the only one distinctly apparent at a cursory glance.

Numerous branches (Plate I. fig. 10, n), with a plain external surface and a zig-zag internal fold, protruded from beneath the dorsal lip of the shell, which was semicartilaginous, shallow, or scoop-shaped, with an involute nucleus, and a deep but very thin and delicate keel.

The external male organ (Plate I. fig. 10, o) resembled that of *Carinaria*, con-

sisting of an interior grooved, and a posterior glandular portion,—the latter being homologous with the trailing bulb of *Firoloides*, and, I believe, also with the trumpet-like segment of *Atlanta*.

The rachidian plates of *Cardiapoda* (Plate I. fig. 11, o ; Plate II. fig. 5, c), are broad and slightly concave in front, but rather more so behind, with the angles obtuse in front, and sharp and incurved posteriorly. The dental processes are only three in number,—the central one being large and broadly conical, and the lateral ones very small.

The little tooth on the inner side of the principal fang of the first pleural series is distinctly developed, but the uncini do not appear to differ in any essential particular from those of *Firola*.

Carinaria Gaudichaudi (Plate II. Figure 4.)

This species I found to have as wide a range as the *Firola* and *Firoloides* previously described. Its length varies from $1\frac{1}{2}$ to 2 inches, and altogether it looks like an *Atlanta* whose head and body had much outgrown the capacity of its shell. On comparing the shells of the two genera, they will be found to resemble one another in several particulars. Thus, they are both dextrally-spiral, with a distinct umbilicus in the axis of the spire, and a prominent keel on the dorsal border of the whorls ; but both shell and keel in *Carinaria* are beautifully crimped transversely, and the last whorl increases very rapidly in keeping with the development of the animal, so that the mouth of the full grown shell is widely separated from its spiral nucleus.

The body is pellucid and colourless, but slightly, or not at all, tuberculated. The inner surface of the integument, however, is studded at pretty equal distances with little clusters of cells like those of *Firoloides*. M. Rang believed that a tuberculated epidermis was always present in *Carinaria*, forming a distinguishing feature between it and *Firola*, in which, according to him, the outer integument is always smooth (?) He makes allusion evidently to the little clusters of cells above noticed as the representatives in *Firola* of the tuberculations of *Carinaria*.

The proboscis is abruptly truncated at its extremity, and very variable as to its length and fulness. The eyes are fronted by small tentacula, and the acoustic sacs, as in *Cardiapoda*, &c., are appended to long and delicate auditory nerves. The ciliated lining of the sacs in this species I have been enabled to observe more distinctly than in any of the other Heteropods described above.

The abdominal fin is fan-shaped, with a thin transparent margin ; and the sucker-disc is represented by a little cup-like dilamination of its posterior border. The tail, or metapodium, is laterally compressed, and tapers to a point, without supporting an obvious rudder-fin, like that commonly given in figures of *Carinaria mediterranea*.

The visceral mass under protection of the shell is elevated, as it were, upon a short pedicle springing from the dorsal region, at a point considerably posterior to the swimming-fin.

A row of reddish-tinted branchiæ protrude beyond the mantle margin, and, as in *Cardiapoda*, the heart and intestine are distinctly visible through the shell (Plate II. fig. 4', b, d).

The rachidian plates of *Carinaria* (Plate II. fig. 5, d, and fig. 6, o) are not unlike those of *Cardiapoda*, but the dental processes in each are perfectly characteristic. Thus, *Carinaria* is distinguished by three large subequal teeth, flanked on each side by a rudimentary tubercle.

The small internal tooth of the first pleural series is more highly developed in *Carinaria* than in *Oxygyrus*; and all the members of the pleuræ (Plate II. fig. 6, 1, 2, 3.), are much stouter in the former than in the latter genus, though they are somewhat exceeded in this respect by those of *Cardiapoda* (Plate I. fig. 11, 1, 2, 3.)

REFERENCES TO THE FIGURES.

PLATE I.

Fig. 1. *Firoloides*.

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|------------------|---------------------------|
| a. Tentacula. | h. Pedal ganglia. |
| b. Eyes. | i. Heart. |
| c. Auditory sac. | k. Rectum. |
| d. Buccal mass. | l. Vas deferens. |
| e. Œsophagus. | m. Bulbous portion of the |
| f. Sucker-disc. | penis. |
| g. Swimming fin. | n. Caudal appendage. |

Fig. 2. *Head and Muzzle of Firoloides*.

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| a. Mouth. | i. Cerebroid ganglia. |
| b. Lingual sac. | k. Tentacles. |
| c. Salivary glands. | l. Eyes. |
| d. Buccal ganglia. | m. Auditory sacs. |
| e. Buccal artery. | n. Nerve trunks connect- |
| f. Buccal nerves. | ing i with the pedal |
| g. Œsophagus. | ganglia. |
| h. Optic nerves. | o. Muscular sheath. |

Fig. 3. *Pedal Ganglia and Great Vessels of Firoloides*.

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| a. Pedal ganglia blended together by their contiguous surfaces, and giving off nerves to the foot and neighbouring parts. | b. Anterior division of aorta. |
| | c. Pedal artery. |
| | d. Buccal artery. |

Fig. 4. *Visceral Mass, &c., of Firoloides (female)*.

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| a. Great nerve supplying branches to the tail, and connecting the pedal with the visceral ganglia. | on the sides of the ♀ opening. |
| b. Anterior division of the aorta. | l. Oviduct. |
| c. Œsophagus. | m. Flexure of l. |
| d. Cardiac ganglion? | n. Oval opening of the mouth. |
| e. Principal visceral ganglion, sending a conspicuous nerve to the mouth and its sphincter muscle. | o. Anal aperture in front of a ciliated papilla. |
| f. Liver. | p. And between, two little leaflets like k. |
| g. Metapodium. | q. Ciliated elevation, with depressed centre, probably a respiratory organ. |
| h. Caudal appendage. | r. Little clusters of cells, noticed at p. 8. |
| i. Vagina. | s. Auricle of the heart. |
| k. Small leaflets or lobes | t. Ventricle. |
| | u. Muscular sheath. |

Fig. 5. *Lingual Dentition of Firoloides*.

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| o. Rachis. | 1-3. Pleuræ. |
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Fig. 6. *Nidamental Chord of Firoloides*.Fig. 7. *Firola (considerably enlarged)*.

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| a. Buccal mass. | g. Swimming-fin |
| b. Œsophagus. | h. Penis. |
| c. Eye. | i. Branchiæ. |
| d. Auditory sac. | k. Visceral mass. |
| e. Pedal ganglia. | l. Metapodium. |
| f. Mesopodium. | |

Fig. 8. *Brain and Organs of Sense of Firola.*

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| <p>a. Upper cerebroids, sending off anterior and posterior branches.</p> <p>b. Lower cerebroids, giving off motor nerves to the eyes.</p> <p>c. Buccal nerves.</p> <p>d. Motor nerve of the eye.</p> | <p>e. Optic nerves.</p> <p>f. Trunks communicating with the pedal ganglia.</p> <p>g. Auditory nerve.</p> <p>h. Acoustic sacs.</p> <p>i. Lens.</p> <p>k. Body of the eye.</p> <p>l. Retina.</p> |
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Fig. 9. *Lingual Dentition of Firola Lesueuri.*

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| o. Rachis. | 1-3. Pleuræ. |
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Fig. 10. *Cardiapoda in motion.*

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| <p>a. Buccal mass.</p> <p>b. Œsophagus.</p> <p>c. Tentacula.</p> <p>d. Eyes.</p> <p>e. Ear-sacs.</p> <p>f. Pedal ganglia.</p> <p>g. Swimming-plate.</p> <p>h. Sucker-disc.</p> | <p>i. Curious structure noticed at p. 17.</p> <p>k. Caudal process.</p> <p>l. Visceral mass.</p> <p>m. Heart.</p> <p>n. Branchiæ.</p> <p>o. Penis.</p> |
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Fig. 11. *Lingual Dentition of Cardiapoda.*

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| o. Rachis. | 1' Small inner tooth of first pleural series. |
| 1-3. Pleuræ. | |

PLATE II.

Fig. 1. *Atlanta.*

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| <p>a. Mouth.</p> <p>b. Buccal mass.</p> <p>c. Tentacula.</p> <p>d. Tentacular (?) tubercle at the inner and fore part of the eye.</p> <p>e. Eyes.</p> <p>f. Cerebroid ganglia.</p> <p>g. Ear-sac.</p> <p>h. Salivary glands.</p> <p>i. Pedal ganglia.</p> <p>j. Propodium.</p> <p>k. Mesopodium.</p> <p>l. Œsophagus.</p> <p>m. Penis.</p> <p>n. Mouth margin.</p> <p>o. Carinal fold of n.</p> <p>p. Branchiæ.</p> <p>q. Ciliated line.</p> <p>r. Venous sinuses.</p> <p>s. Vent.</p> <p>t. Aquiferous pore?</p> | <p>u. Glandular organ, probably renal.</p> <p>v. Expanded orifice of the sperm-duct.</p> <p>w. Auricle of the heart.</p> <p>x. Intestine.</p> <p>y. Ventricle.</p> <p>z. Anterior division of aorta.</p> <p>α. Aortic axis.</p> <p>β. Visceral artery.</p> <p>γ. Stomach.</p> <p>δ. Dilatation of sperm-duct.</p> <p>ε. Liver.</p> <p>ζ. Testicle.</p> <p>η. Origin of retractor muscle.</p> <p>θ. Metapodium.</p> <p>ι. Tongue-like process.</p> <p>κ. Fossa.</p> <p>λ. Operculum.</p> <p>μ. Vertical fold.</p> |
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Fig. 1'. *Operculum of 1, magnified.*Fig. 2. *Oxygyrus.*

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| <p>a. Buccal mass and muzzle.</p> <p>b. Tentacula.</p> <p>c. Eyes.</p> | <p>d. Propodium.</p> <p>e. Mesopodium.</p> <p>f. Metapodium.</p> <p>g. Operculum.</p> |
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Fig. 2'. *Operculum of 2, magnified.*Fig. 3. *Oxygyrus, n. s.*

References as in Fig. 2.

Fig. 4. *Carinaria.*

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| <p>a. Buccal mass.</p> <p>b. Tentacula.</p> <p>c. Eyes.</p> <p>d. Ear-sacs.</p> <p>e. Impacted food in the gullet.</p> <p>f. Pedal ganglia.</p> | <p>g. Propodium.</p> <p>h. Mesopodium.</p> <p>i. Metapodium.</p> <p>k. Penis.</p> <p>l. Branchiæ.</p> <p>m. Visceral mass.</p> |
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Fig. 4'. *Shell and Viscera magnified.*

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| <p>a. Gullet.</p> <p>b. Rectum.</p> | <p>c. Branchiæ.</p> <p>d. Heart.</p> |
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Fig. 5. *The Rachidian Plates characteristic of the genera of Heteropoda.*

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| <p>a. Firoloides.</p> <p>b. Firola.</p> <p>c. Cardiapoda.</p> <p>d. Carinaria.</p> | <p>e and f. Two divisions of Oxygyrus, probably distinct genera.</p> <p>g. Atlanta.</p> |
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Fig. 6. *Lingual Dentition of Carinaria.*Fig. 7. *Do. do. Cardiapoda.*Fig. 8. *Do. do. Atlanta.*

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| <p>o. Rachis</p> <p>1-3. Pleuræ.</p> <p>1'. Tooth common to Car-</p> | <p>diapoda, Carinaria, and Oxygyrus.</p> <p>1". Tooth characteristic of Atlanta.</p> |
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