TRANSACTIONS
OF
THE ZOOLOGICAL SOCIETY
OF LONDON.


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# TRANSACTIONS OF THE ZOOLOGICAL SOCIETY OF LONDON.

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TRANSACTIONS

OF

THE ZOOLOGICAL SOCIETY.


Received May 6th, read May 9th, 1879.

[Plate I.]

It is somewhat remarkable that no really adequate figure of so well known an animal as the Common Dolphin (Delphinus delphis, Linn.) is to be found in any zoological publication. The best with which I am acquainted is one given by Reinhardt ("Notits om en paa Østkysten af Jylland fanget Delphinus delphis," in Naturh. Forenings Vidensk. Meddelelser, Nos. 10, 11, 1866), from an animal 5 feet 4 inches long, taken near Greonna, on the Jutland shore of the Cattegat in November 1865. This figure, however, is not coloured, and wants the details of the markings seen in the specimen to be described presently.

Perhaps the next best figure, and, indeed, in some respects superior, is that given in the illustrated edition of Cuvier's "Règne Animal," which is stated to be "d'après une peinture originale de Maréchal faisant partie des vêlins du Museum." The figures in the volume on Cetacea in the 'Naturalists' Library,' by Dr. Hamilton, and in Bell's 'British Quadrupeds,' are apparently founded on this, though in the latter the tail is differently formed, the gradations of colour are badly given, and the whole creature has too thick and clumsy an appearance. Klein's figure (Hist. Piscium Naturalis, ii. 1741) professes to be original, from an animal 9 feet 2 inches (Rhenish) in length, in which case it could not have been D. delphis, but was more probably D. tursio, as surmised by Cuvier. It is reproduced by Bonnaterre (Cétologie, 1789) and by
Lacépède (Hist. Nat. des Cétacés, 1804), with the addition of the conventional fountain from the blow-hole, in both cases without acknowledgment.

The earlier figures, all more or less inexact in outline, rude in execution, and wanting in colour, are those of Belon (1551), Rondelet (1554), and Aldrovandus (1613). The two former, especially that of Rondelet, have been repeated with modifications by the various compilers of the last two centuries. Belon’s account of the external characters and anatomy of the Common Dolphin, the Porpoise, and of a third species (of which I shall speak presently), is a very remarkable work for the time at which it was written 1.

On the 13th of March last Mr. F. Buckland kindly informed me that he had just received from Mr. Matthias Dunn, of Mevagissey, a Dolphin which had been caught in the mackerel-nets about twenty miles south of the Deadman Headland, Cornwall. It proved to be a young female Delphinus delphis. The elegance of the form, and the beauty and variety of the colouring, were such that I thought it desirable to obtain a correct coloured drawing of the animal while fresh, which, reduced to the scale of one sixth the natural size, is reproduced in fig. 1, Plate 1. Instead of being simply black above and white below, as usually described, the sides were shaded, mottled, and streaked with various tints of yellow and grey, the distribution of which can be better understood by a reference to the figure than by any description. The under surface was of the purest possible white. Perfect symmetry was shown in the colouring and markings on the two sides of the body.

The length of the animal in a straight line from the tip of the beak to the notch in the middle of the tail was 5 feet 1 ½ inch. The other principal dimensions were as follows:—

<table>
<thead>
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<th>Dimension</th>
<th>Inches</th>
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<tr>
<td>End of beak to anterior end of dorsal fin</td>
<td>31.5</td>
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<tr>
<td>”  ” insertion of anterior end of pectoral fin</td>
<td>16.1</td>
</tr>
<tr>
<td>”  ” angle of mouth</td>
<td>9.0</td>
</tr>
<tr>
<td>Angle of mouth to anterior angle of eye</td>
<td>1.9</td>
</tr>
<tr>
<td>Length of eye-aperture</td>
<td>0.8</td>
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<tr>
<td>Posterior angle of eye to external auditory meatus</td>
<td>1.5</td>
</tr>
<tr>
<td>Length of base of dorsal fin</td>
<td>8.7</td>
</tr>
<tr>
<td>Height of dorsal fin</td>
<td>5.5</td>
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<tr>
<td>Length of anterior margin of pectoral fin</td>
<td>10.0</td>
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<tr>
<td>”  ” posterior</td>
<td>6.9</td>
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<tr>
<td>Breadth of caudal fin</td>
<td>13.8</td>
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The dental formula was \[ \frac{45+44}{45+44} = 185 \], which corresponds nearly with that usually

observed in the species, some individual variation being always met with, even in the
different sides of the mouth. There are fifteen pairs of ribs, the last being unattached
to its corresponding vertebra, and 21 lumbar and 31 caudal vertebrae, making altogether,
with the cervical and thoracic, a total of 74 vertebrae. The skeleton has been pre-
pared for the Museum of the Royal College of Surgeons. The stomach contained the
partially digested remains of numerous fish, apparently mackerel.

This species is the true Dolphin of the ancients, being the most abundant and
characteristic species in the Mediterranean. Its exact geographical distribution has
not yet been defined with precision, owing to the difficulty of distinguishing it from
allied species, a difficulty which it is hoped the present illustration may in some measure
help to overcome. It is not uncommon in the Atlantic, being well known on the
west coast of France; and it frequently visits the English Channel, pursuing the shoals
of pilchards and mackerel. In the Museum of the College of Surgeons is the skeleton
of a fine adult animal, which, when alive, must have been about 7 feet long, taken
near the beginning of the present century at Worthing. Northwards of this locality
it appears to become rare. Van Beneden does not include it among the Cetacea
frequenting the Belgian coast, as he was not able to find any example of its capture
in the North Sea. Specimens, however, are occasionally met with on the coasts of
Norway and Denmark, as mentioned by Lilljeborg and Reinhardt; and it is included
in many of the lists of the Cetacea of the Greenland seas; but it is doubtful whether
some of the species of the allied genus Lagenorhynchus may not have been mistaken
for it.

Judging from the figure and description in Scammon's 'Marine Mammals of the
North-western Coast of North America' (1874), Delphinus bairdii, Dall, is a closely
allied, perhaps identical species inhabiting the North Pacific; but further observations,
especially osteological comparisons, are required before the latter surmise can be con-
sidered proved.

The second species, of which I wish to offer an original and, I believe, faithful
drawing to the Society, is Delphinus tursio of Fabricius¹. The best known figure
of this animal is that given by John Hunter in his classical "Observations on the
Structure and Economy of Whales," published in the 'Philosophical Transactions,'
vol. lxxvii. (1787). This is taken from a young animal caught, with its mother, near
Berkeley, in Gloucestershire, and sent to Hunter by the celebrated Edward Jenner. It
is described in the memoir as "a species of Bottle-nosed Whale, the Delphinus delphis
of Linneaus." It was, however, identified by Cuvier with D. tursio of Fabricius, and so
described by Prof. Owen in his editorial notes to Hunter's collected works (1837).

¹ The identification of the present well-known species with the D. tursio of Fabricius has been questioned.
The description in the 'Fauna Grælandica' (1780, p. 49) is certainly vague and unsatisfactory; but the name
is now so generally accepted that it would cause much confusion to attempt to change it, even if it could be
proved to have been wrongly imposed.
This figure is reproduced on a reduced scale in Bell’s ‘British Quadrupeds.’ Bonnaterre’s figure of the Nesarmak (D. tursio), in his ‘Cétologie,’ 1789, pl. xi. fig. 1, appears to be a modified copy of the same, though without acknowledgment. The three transverse pale lines crossing the dark part of the body below the dorsal fin, which form a marked feature in this figure, have not been observed in other specimens; they somewhat resemble the pale vertical lines which cross the sides of the two specimens of the young of Risso’s Dolphin which have been figured 1.

Another original figure is that given by Dr. Gray in the 10th Plate of the ‘Zoology of the Erebustand Terror.’ It is from a drawing by Mr. R. Templeton, from a specimen caught in the south of Ireland in November 1828, and evidently a young one, as its length was only 7 feet 6 inches. It does not bear the appearance of very great accuracy; the dorsal fin, especially, is more elevated and erect than in any of the others. Schlegel’s figure in his ‘Abhandlungen aus dem Gebiete der Zoologie und vergleichenden Anatomie,’ Heft 1, 1841, from a specimen 11 feet long, taken off the coast of Holland and stuffed in the Leiden Museum, besides differing in form (especially in the very small size of the pectoral fin) from that known to be characteristic of the species, is represented of a uniform black colour; but it is not stated that this was the case when the animal was fresh, and may have been due to changes in the process of preservation.

There can be little doubt of the correctness of Cuvier’s identification of the animal taken at Tréport, on the coast of Normandy, in the beginning of May 1851, exhibited at the Hotel de Nevers at Paris, and described by Belon under the name of “Oudre” or “Orca,” with this species. It was 9½ feet long, and had half as many teeth as the true Dolphin, or eighty in all, not counting some small rudimentary ones in front. Accepting this determination, the three species of which Belon was the first to give original and tolerably accurate figures and descriptions are Delphinus delphis, D. tursio, and Phoena communis.

A good description, but without figure, of a specimen taken upon the Suffolk coast is given by Dr. W. B. Clarke in the Ann. & Mag. Nat. Hist. ser. 2, vol. iv. p. 100 (1849).

The specimen now figured was taken, with several others, near Holyhead, on the 5th of October, 1868. Like the one above described, it was sent to Mr. Buckland, to whose kindness I am indebted for the opportunity of drawing and describing it. The skeleton was prepared for the Oxford University Museum. It was a male, not quite full-grown, as the condition of the epiphyses showed.

The principal dimensions were:—

OF TWO SPECIES OF BRITISH DOLPHINS.

Total length, in a straight line from end of beak to notch in middle inches. 114·0
of tail 
End of beak to anterior edge of dorsal fin 50·0
" " angle of mouth 12·5
" " blow-hole 15·0
" " anterior angle of eye 14·7
Length of eye-aperture 1·1
From hinder corner of eye to aperture of ear 3·25
From angle of mouth to anterior angle of eye 2·6
From end of lower jaw to anterior edge of pectoral fin 24·0
Length of pectoral fin, in straight line 15·5
Greatest breadth of pectoral fin 6·0
Length of base of dorsal fin 13·0
Height of dorsal fin 9·0
Breadth of caudal fin 24·0

All the upper parts were of a shining greyish black, shading off to white below, as seen in the figure, the change of colour following an irregular line from the angle of the mouth to the origin of the pectoral fin and continued backwards at the same level. The edge of the upper lip and the tip of the nose were whitish; both sides of the pectoral and caudal fins were black. There was no other colour to be distinguished on the whole surface but black, white, and the intermediate grey. The usual "screw" form of the caudal fin in the Cetacea was very marked, the upper surface of the right lobe being concave, that of the left lobe convex.

This species is rare in the Mediterranean, though Gervais gives several instances of its capture in the Gulf of Lyons. It probably has a more northern range than D. delphis; but, as in the case of that species, there is still much obscurity as to the exact limits of its distribution.

Mr. Buckland has added casts of both these specimens to his valuable series of models of Cetacea, which exhibit, better than by any other method yet devised, the form, proportions, and colour of these animals, otherwise so difficult of preservation.

DESCRIPTION OF THE PLATE.

PLATE I.

Fig. 1. Delphinus delphis ♂, from an original drawing, by R. W. Sherwin, of a specimen captured off the coast of Cornwall in March 1879.

Fig. 2. Delphinus tursio ♂, from an original drawing, by W. H. Flower, of a specimen captured near Holyhead, October 5, 1868.

Received April 25th, read May 20th, 1879.

[Plate II.]

The largest of the extinct kinds of Kangaroo (Macropodidae)\(^1\) indicated by Australian fossils showed a closer adherence to the typical pattern of the molar teeth than did some of the extinct kinds of intermediate bulk (Procoptodon e.g.)\(^2\). The genus and species Palorchestes azael\(^3\) were founded on two specimens—a large portion of the cranium and a small portion of a mandible.

Through the continued application of his leisure to the collection of fossils in his Queensland locality, our Corresponding Member, George Frederick Bennett, Esq., of Toowomba, has lately supplied me, amongst other instructive illustrations of the extinct mammalian fauna of Australia, with a specimen which, while it is confirmatory of the generic grade of Palorchestes, indicates a second species not inferior, at least in size, to P. azael, but of more robust proportions.

In Palorchestes azael the antepenultimate molar, m\(_1\), equals m\(_2\) in antero-posterior extent of crown; in Palorchestes crassus (Pl. II.) m\(_2\) exceeds in that diameter m\(_1\) by one fifth; m\(_2\) is also relatively broader than m\(_1\) or m\(_3\) (fig. 4).

The cingulum (ib. fig. 1, e), continued from the outer side of the base of the fore lobe to that of the hind lobe, of m\(_2\) is longer and broader in P. crassus; and the same differential character marks m\(_1\), in comparison with that tooth in P. azael. This part of the cingulum is continued uninterruptedly from the fore part of the grinding-surface of the tooth downward, outward, and backward, across the outer valley to the hind talon of the crown (y).

The antero-posterior extent of the three hind molars in P. crassus is 3 inches 7 lines (92 millims.) ; in P. azael it is 3 inches 4 lines (85 millims.).

If the dental differences had been only those of size, the fossil under consideration might have been attributed to a larger individual than the type one, or to a male of the species; but the difference in relative as well as absolute size of the comparable teeth, as well as in the conformation of the tooth-crown, indicates something more than difference of size or sex.

\(^1\) Researches on the Fossil Remains of the Extinct Mammals of Australia, 4to, vol. i. p. 373.
These indications of a distinct species are supplemented by characters of the mandible itself.

In *Palorchestes azael* the inner plate of the ramus descends from the alveolar margin of *m* 1 and *m* 2 with a very feeble convexity, soon changing to as slight a concavity, until this is lost in the beginning of the convex sweep round the lower border of the ramus. The initial convexity from the inner border of the alveolus of *m* 3 in *P. azael* is but little augmented, and soon passes into a rather deeper concavity, closed by the beginning of the inflection of the angular part of the ramus. A tendency to a smooth flatness characterizes all the inner plate of the ramus descending from the molar alveoli to the lower vertical convexity.

In *Palorchestes crassus* the inner wall of the ramus below *m* 1 describes a moderate but uninterrupted convexity as it descends to the lower border; and this convexity increases below *m* 2 and *m* 3 before changing to the concavity (fig. 2, a) indicative of the characteristic marsupial inflection of the hinder third of the lower border of the ramus.

The depth of the ramus below the fore part of *m* 1 in *P. crassus* is 2 inches 10 lines, that behind *m* 3 is 3 inches; the corresponding admeasurements in *P. azael* are 3 inches 2 lines, and 2 inches 7 lines. The depth, or vertical extent, of the ramus augments as the jaw extends forward along the molar series, in *P. azael* (op. cit. Plate cvi. fig. 1), but diminishes in *P. crassus* (Pl. II. figs. 1 & 2); and this diminution seems to have been greater below *d* 4, instead of the increase of depth there shown in *P. azael*.

The tooth *d* 4, in *P. azael*, is broken away in *P. crassus*; but the extent of its alveolus is traceable. A vertical line dropped from its fore part crosses the hind part of the symphysis mandibuli (Pl. II. fig. 2, s), but does not reach so far in *P. azael*. In this species the symphysis begins in advance of such line.

A greater proportion of the symphysial part of the mandible and of the right ramus is preserved in the subject of the present paper than in that of *P. azael*. The symphysial joint (Pl. II. fig. 3) is obliterated by confluence there of both rami, a condition I have not noted in any other Macropodal genus. Some approach thereto is shown in a fossil mandible of the largest species of Procoptodon. In that, e. g., of *P. galgal*, described in the before-cited work, I note: “The symphysis is continued, broadly, to the incisive outlets; it has assured, apparently, an attachment to each other of the rami of this instructive mandible, too intimate to be disturbed by posthumous movements, although ankylosis has not been completed, if it had commenced.”

In the present mandible of a still larger Kangaroo that ankylosis is as complete as

---

in the mandible of the adult *Nototherium*. So much of the inferior surface of the symphysis as is preserved in the subject of this paper is subcircular. In the section made of the fractured end the density of the bony tissue at this part is shown and the absence of all trace of the primitive joint (fig. 3, s); the blind end of the incisive sockets is shown at *i i*. These teeth, with their sockets, have been broken away with the rest of the symphysis.

The outer surface of the ramus (Pl. II. fig. 1) presents a corresponding difference of conformation to that noted on the inner surface, in comparison with the portion of mandible referred to *P. azael*. Besides the minor vertical extent beneath *d 4* and *m 3*, the upper concavity and lower convexity of the outer wall are more marked. The fore border of the coronoid plate, *q*, rises more abruptly and at a more forward position than in *P. azael*.

Finally, accepting the evidence of specific distinction between the present mandible and teeth and those of *P. azael*, the question arises whether the subject of plate evi. *op. cit.* has been rightly allotted to the species represented by the upper jaw and teeth in plate xcvii. (*op. cit.*).

The first test is afforded by the penultimate grinder (*m 2*) of the present fossil (Pl. II. fig. 4); it is conspicuously larger than either the tooth which precedes or that which follows in the series. In the type upper jaw of *P. azael* *m 2* is of the same antero-posterior size as *m 1* and *m 3*; if there is a difference, it is rather smaller. I infer that the upper *m 2* of the species represented by the present mandible would show a corresponding proportional superiority of size as compared with *m 1* and *m 2*; and I conclude, therefore, that the portion of mandible figured in pl. evi. *op. cit.* has been rightly referred to *P. azael*, and that the present specimen indicates a distinct species of that rare and remarkable genus.

The original cranial fossil of *Palorchestes* was obtained from a freshwater deposit of yellowish sand and clay with very small shells in the Province of Victoria; its massive, heavy, much petrified condition are also noted.

Such is the fossilized condition of the subject of the present paper; it was obtained from fluvial deposits in the bed of a "creek," at Gowrie, Queensland.

The following are admeasurements of the fossil above described:

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Value</th>
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<tr>
<td>Length of the portion of mandible</td>
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<tr>
<td>Depth below <em>m 2</em></td>
<td>3.3</td>
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<tr>
<td>Thickness two inches below <em>m 2</em></td>
<td>1.9</td>
</tr>
<tr>
<td>Depth of symphysis behind incisive sockets</td>
<td>1.10</td>
</tr>
<tr>
<td>Longitudinal extent of last three molars</td>
<td>3.7</td>
</tr>
</tbody>
</table>


DESCRIPTION OF THE PLATE.

PLATE II.

_Palorchestes crassus._

Fig. 1. Outer side-view of the right mandibular ramus.
Fig. 2. Inner side-view of the same.
Fig. 3. Section of the symphysis of the same.
Fig. 4. Grinding-surface of the third hind molars

All the figures are of the natural size.
III. On the Brain and other parts of the Hippopotamus (H. amphibius).
By A. H. Garrod, M.A., F.R.S., Prosector to the Society.

Received and read June 17, 1879.

[Plates III. & IV.]

The male Hippopotamus from the Upper Nile, presented to the Society by the late Viceroy of Egypt on the 25th of May, 1850, died on the 11th of March, 1878, without any serious disease of any organ, but after having suffered for some years from ulcers on the legs, which were much more inflamed during the winter than the summer seasons; because then the comparative coldness of its tank did not allow of its remaining in the water for any length of time, and the cutaneous surface became dry as well as cracked.

The animal was about thirty years old, and apparently aged. From the front of the nose to the base of the tail it measured 12 feet along the back, the tail being 22 inches long.

In his monograph on the anatomy of Hippopotamus amphibius1 Professor Gratiolet has fully described and figured the brain of the new-born animal. Nevertheless there is a want of definiteness about the delineation of the convolutions, and a difference in the proportionate size of the cerebellum, which makes me feel justified in asking the Society to grant me opportunities for giving illustrations of the brain of the adult animal. The necessity for a second figure is increased by the peculiarities in an outline sketch of the brain of Hippopotamus liberiensis given by Prof. Macalister in his account of that species2.

In a valuable monograph on the brain of the Ungulata3, recently published, Dr. Julius Kreug has introduced views and adopted a nomenclature which every student of the nervous system cannot help finding of particular service in any special investigation like the present. By an extensive comparison of the convolutions of individuals at different ages, and of different species, Dr. Kreug has arrived at a standard of which are fundamental and which secondary sulci, that has enabled him to represent what is the typical arrangement of the surface of the hemispheres in the Ungulata generally.

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1 Recherches sur l'anatomie de l’Hippopotame, Paris, 1867.
2 Proceedings of the Royal Irish Academy, vol. i. series 2, Session 1873-74, plate xxviii.
The results arrived at by MM. Leuret and Gratiolet\(^1\) tend strongly in the same direction as those subsequently arrived at by Dr. Kreug; nevertheless there is a completeness about the investigation of the last-named author which greatly increases the importance of his work.

As it is my intention on the present occasion to employ the nomenclature adopted by Dr. Kreug, I cannot do better than introduce it by applying it to the description of the typical Artiodactylate brain as represented by that author.

Perhaps no nearer approach to this type can be given than that of the foetal sheep (\textit{Ovis aries}), 27·5 centimeters in length, figured by Dr. Kreug (figs. 1–3). Putting what is to be seen in words, the small upward-directed \textit{processus acuminis (sac)} of the Sylvian fissure is just seen on the outer border of the superior surface of the cerebral hemisphere, along

![Figures 1-3](image)

Sheep's brain: fig. 1. Outer aspect; fig. 2. Superior aspect; fig. 3. Inner aspect. (After Dr. Kreug.)

which latter surface the \textit{supra-sylvian fissure (ss)} courses longitudinally nearly from end to end, slightly concave outwards opposite the sylvian fissure. According to Dr. Kreug, this fissure (ss) has three limbs; but four seems to me to be the more correct number. Of these one is anterior (ssa), the second superior (sss), and the third posterior (ssp). The fourth, according to me, runs downwards (ssd) from the spot of origin of the posterior limb. Typically, all these processes terminate freely.

Next in importance, on the superior surface, is the coronal fissure (co), longitudinal in direction, at no great distance from the middle line of the brain, and situated so far forward that its posterior extremity is in front of the superior limb of the supra-sylvian fissure (sss). It runs forward almost to the anterior margin of the hemisphere.

A minor longitudinal (\textit{lateral}) fissure (l) tends to divide the surface between the posterior branch of the supra-sylvian fissure and the middle line of the hemisphere into two equal parts. The presylvian, diagonal, and posterior fissures, though they appear on the superior surface, are so much better seen in the lateral view of the brain that they will be there described.

The inner aspect of the hemisphere presents, besides the hippocampal fissure (h), a long \textit{fissura splenialis (sp)}, or calloso-marginalis, some distance from the superior margin, curved concavely towards the corpus callosum, opposite the hinder end of which its

\(^1\) 'Anatomie Comparée du Système Nerveux,' Paris, 1839–1857.
posterior extremity ceases, whilst anteriorly it continues nearly as far forward as the perpendicular level of the genu of the corpus callosum, which is partly embraced anteriorly, as it were, by a small *fissura genualis* (γ).

The outer aspect of the hemisphere has a basal fissure running nearly its whole length—the *fissura rhinalis* (ρh), some little distance above which the anterior and posterior limbs of the sylvian fissure (*sa* and *sp*) diverge, the hinder extremity of the latter sending downwards an extension to meet it. The anterior end of the anterior limb of the sylvian fissure also joins the posterior extremity of the small praesylvian (*ps*) fissure, concave upwards, situated low down in the outer frontal region, with another small and very similar *diagonal fissure* (*d*) half way between it and the coronal fissure (*co*). The *fissura postica* (ϕ) is a small one between the hinder part of the fissura rhinalis and the posterior limb of the supra-sylvian fissure.

So much for the typical cerebral convolutions in the Ungulate animal, which undergo special modifications in the different families of the order, some of which are particularly constant, and must be here referred to in order that comparisons may be made between the Hippopotamus and its allies.

The brain of the genus *Sus*, together with *Phacochoerus*, is distinguishable from that of any other Artiodactylate animal by one or two well-marked characters, the most striking of which is the blending of the coronal with the splenial fissure by means of a curved sulcus of so considerable a depth that the convolution between the middle line of the hemisphere and the coronal fissure appears to be quite cut off from the rest of the superior cerebral surface. The praesylvian fissure, however, as usual, runs up on the inner side of the outward-directed anterior extremity of the coronal fissure. Behind the sulcus of communication between the fissures just referred to there is always an equally characteristic second one, parallel to it, and a short distance behind it, joining the fissura splenialis and a prolongation of the superior limb of the suprasylvian fissure. Again, as Dr. Kreug puts it, the posterior extremity of the suprasylvian fissure turns downwards on the outer side of the hemisphere, and ceases near the lower border of the brain; whereas in the Cotylophora it runs backwards and *inwards* rather than outwards. In my opinion this arrangement is better indicated by saying that the descending limb of the suprasylvian fissure is developed in the Swine at the expense of the posterior, whilst in the Cotylophora the posterior limb is large and the descending limb rudimentary. In the Swine, also, the fissura rhinalis and the fore-and-aft prolongations of the sylvian fissure become continuous. In the Cotylophora they do not unite, the former being at a lower level.

A careful comparison of the brain of *Dicotyles tajacu* with Dr. Kreug's illustration of the same in *D. torquatus* does not lead me to see that *Dicotyles* resembles the true Swine so closely as might be expected from that author's sketch. The characteristic descending limb of the suprasylvian fissure is quite wanting in the two specimens at my disposal, and its posterior limb turns inwards slightly, as in the Cotylophora.
one upward branch of the splenial fissure which joins the fissura coronalis, and is not a continuation of it, as in Sus. If it were not for this the fissura coronalis and fissura lateralis would be continuous in Dicotyles.

In Sus there is a minor longitudinal fissure between the fissura splenialis and the fissura lateralis, or there may be two. In Dicotyles it is the same, the outer moiety being the broader.

The convolution between the fissura lateralis and the fissura suprasylvia is broader than that between the fissura lateralis and the middle line—considerably in Sus, not so much so in Dicotyles. Gyri of the included convolution, towards its outer border, make its outer contour less distinctly marked than is its inner boundary, and the complication may be increased by the presence of transverse bridging convolutions.

In Dicotyles the superior limb of the suprasylvian fissure terminates, as in the Swine and Cervidae, without communicating with any other of importance, at the same time that a wedge-shaped convolution is always more or less developed in the region under consideration, with its backward-directed apex formed by the junction of the superior and anterior limbs of the suprasylvian fissure. In the Cervidae it is the rule that the superior limb of the above-named fissure blends with the posterior extremity of the coronal fissure. The specimen of Elaphodus michianus figured by me\(^1\) does not, however, quite conform with this law.

The adult Hippopotamus brain which forms the subject of this communication differs so much in the arrangement of the convolutions of the two sides, that from a study of one or the other singly very different results might be arrived at. This evidently depends upon the considerable development on the right side of bridging convolutions, the great number of which in the brain of the Hippopotamus is laid special strain on by Gratiolet\(^2\), who, whilst referring to the "middle series" of convolutions, remarks:—

"Il acquiert une importance exceptionelle, et si son existence est au premier abord dissimulée, cela tient à la grande quantité de plus de passages verticaux qui lient cet étage supérieur à l'étage inférieur proprement dit." On the left side these bridging convolutions do not exist, and as a result an extra longitudinal fissure is seen, which must be one of the typical sulci of the cerebral hemisphere, it being conspicuous in the brain of Hippopotamus lherenensis, according to Prof. Macalister's outline sketch, though absent in the figures accompanying Gratiolet's memoir on H. amphibiou.

The brain of the Hippopotamus is not richly convoluted. It is about as much so as that of the genus Bos, decidedly less so than Camelopardalis giraffa or the Camelidae. The considerably smaller Rhinoceros, Ceratorhinus sumatrensis\(^3\), has more convolutions.

Its weight immediately after removal from the skull was one pound and seven ounces. The most conspicuous fissure on the superior surface of the brain is one running from

\(^1\) P. Z. S. 1876, p. 757.

\(^2\) Anatomie de l'Hippopotame, p. 325.

AND OTHER PARTS OF HIPPOPOTAMUS.

front to back, not far from the middle line, which it more nearly approaches anteriorly than posteriorly. This continuous fissure must be compound, and made up of the coronal (co) in front, blended with the lateralis (l) behind, between which latter and the splenialis (sp) a secondary longitudinal fissure develops in the usual manner. Though, as far as I am aware, there is no other Ungulate animal with the two above-named fissures actually joined, they are nearly so in the Camelidae, Camelopardalis, Dicotyles, and Bos.

Between the above-described fissure and the fissure of Sylvius there are, on the right side of my specimen, only transverse twisted convolutions of considerable length, five or more in number, according to the way in which they are counted. On the left side an irregular longitudinal and fairly lengthy suprasylvian fissure exists, nearer the sylvian than the lateral fissure, and therefore quite lateral in position, with several smaller sulci joining it. Having the typical Artiodactyle brain before us, it is possible to recognize among these the descending (ssp), posterior (ssp), anterior (ssa), and superior (ss) branches of the main fissure, the first mentioned (if correctly identified) running in the direction so characteristic of the true Swine.

The anterior branch of the suprasylvian fissure has no connexion with the coronal fissure. It ends independently, much as in the Cervidae and Swine, with a downward tendency; nevertheless I am not able to recognize any thing corresponding to the wedge-shaped convolution formed between it and the insignificant superior limb of the same fissure, so well marked in the Swine, as above described.

The fissura splenialis does not curve upwards anteriorly to become superficial, as it does in Sus, but continues onwards to blend with the fissura genualis, at the same time that it sends up a short perpendicular fissure about one third from the anterior extremity of the hemisphere, just long enough to be seen upon the surface. There is a short vertical sulcus, generally more or less developed in the Ungulata, to be noticed, separating the posterior limb of the splenial fissure from the corpus callosum, nearer the latter than the former in the present case.

The sylvian fissure is insignificant, the fissura rhinalis being continuous with it before and behind.

The small size of the optic and the olfactory nerves, and the not great development of the corpora quadrigemina, are sufficiently emphasized by Gratiolet to require no further mention.

If the view here adopted is not the correct one, and what is above described as the lateral fissure is the suprasylvian, then the brain of the Hippopotamus differs from that of all allied forms in the immense breadth of the interval between the sylvian and the suprasylvian fissures, a breadth not to be explained upon any known hypothesis, and opposed by what is found in Hippopotamus luetrensis. There are no analogies, also, in favour of what would then be the correspondingly peculiar narrow interval between the splenial and suprasylvian fissures.
Looked at generally, the brain of the Hippopotamus is evidently very different from that of the genus Sus and its nearest allies. In the great breadth and complicatedness of what, in my paper on the brain of the Sumatran Rhinoceros\(^1\), I term “the middle oblique convolution” (that between the lateral and suprasylvian fissures), it most resembles the Camels and the Giraffe, from the form of which it strikingly differs in the much less “pronation,” as Dr. Kreug terms it\(^2\), of the hemisphere. On the whole, it stands very much by itself.

The enormous stomach, with an axial length of 11 feet, is identical in all respects with the beautifully mounted specimen of a new-born individual in the Museum of the College of Surgeons, the latter, in its long cylindrical bottle, agreeing with that removed from the abdomen of the adult by me, in position also, its axis being longitudinal, the pylorus being situated almost in the pelvis. I could find no confirmation of the peculiar positions of the different parts described by Mr. J. W. Clark in his specimen\(^3\). Along the greater curvature the stomach measures 15 feet. The upper (or vertebrad) compartment is 31 inches in axial length; the second or lower, 44 inches, with a circumference of 45 inches in its broadest part. The cylindrical third stomach is 9 feet 2 inches in axial length, with an average circumference of 40 inches; there are six transverse folds of its mucous membrane. The oesophagus is 9½ inches in circumference.

The small intestine is 147·5 feet in length, and 5 inches in circumference. The large intestine is 21·5 feet in length, and 9 inches round. No colic cecum is developed.

The liver of the adult is quite different from that of the new-born animal. It is extremely simple, elongate transversely, and narrow from above downwards. Its extreme transverse length is 39·25 inches, whilst its average measurement from vertebral to ventral margin is 16 inches, never exceeding 16·5 inches. There are no fissures, but from the position of the very small umbilical notch it is evident that the left lobe is much the more developed of the two. With this is associated the peculiarity of the position of the gall-bladder, which, from the normally situated portal fissure runs directly outwards to the right. The gall-bladder is 2 feet long, its globose fundus projecting free 5 inches beyond the right margin of the liver. There is no trace of a Spigelian lobe, whilst the caudate is represented by a prismatic thickening, with a minute free apex in the position of the lobe when more largely developed. The suspensory

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\(^2\) By this “pronation” or “supination” of the brain is meant the degree of, as it were, inward or outward rotation of the surface which allows less or more of the surface between the corpus callosum and the suprasylvian fissure to appear superficially.

\(^3\) P. Z. S. 1872, p. 185.
ligament had disappeared. The margins of the liver are unbroken; and its oblong shape [rounded at the angles] is only slightly disturbed by a slight extra development upwards [vertebrad] of its left extremity.

This liver does not at all agree with that of *Sus* or its allies, so fully described by Prof. Flower in his Hunterian Lectures of 1872¹.

DESCRIPTION OF THE PLATES.

PLATE III.

Fig. 1. Brain of Hippopotamus, seen from above.
Fig. 2. The same, from below.

PLATE IV.

Fig. 1. View of right half of brain, from outside.
Fig. 2. View of the left half, from the inside.
Fig. 3. View of left half, from the outside.

ss. Suprasylvian fissure.
ssa. Its anterior limb.
sss. Superior limb.
ssp. Posterior limb.
ssd. Descending limb.

¹ Medical Times and Gazette, Sept. 21, 1872, p. 319.
Fig. 1.

Fig. 2.

Fig. 3.

BRAIN OF HIPPOPOTAMUS
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" 7, sec. 1. (1861)...
" 7, sec. 2. (1862)...

VOLUME V. (1862-1866, containing 67 Plates)... Price 5 3 6... 6 19 0

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" 8. (1869)...

Continued on page 3 of Wrapper.]
IV. Further Observations on the Manatee. By James Murie, M.D., LL.D., F.G.S., Assist. Secretary Linnean Society.

Received June 17th, read June 17th, 1879.

[PLATES V.–IX.]

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REVIEWS of recent Researches on Manatus.—Since the publication in the Society’s ‘Transactions’ (vol. viii. pp. 127–202) of my researches “On the Form and Structure of the Manatee,” three important papers on the development and anatomy of this animal have appeared.

1. In the American ‘Journal of Science and Arts,’ vol. x. Aug. 1875, Prof. Burt G. Wilder, of Cornell University, has written a short but trenchant article, with a plate, “On a Fetal Manatee and Cetacean, with Remarks upon the Affinities and Ancestry

1 In the above remarks on the literature I have solely restricted myself to anatomical labour on the Manatee. Short notices, such as those by Dr. Sclater (P. Z. S. 1875, p. 529), Prof. Garrod (P. Z. S. 1875, 529 & 567), W. B. Tegetmeier (Field, July 6, 1875), and E. Harting (Zoologist, 1875, p. 255), need no more than passing mention. I should, though, do justice to two writers did I remain silent respecting their papers, viz.:

1. “On the Affinities of the Sireniens,” by Dr. Theodore Gill (Proc. Acad. Nat. Sci. Philadelphia, 1873, pp. 262–273). In this cleverly put dissertation the author suggests “that the ordinary Cetaceans and the Sireniens are derivatives from a common original stock—a generalized Gyrencephalic type.” He admits we have no clear evidence of such a progenitor. Afterwards he discusses the relations of the Sireniens, analyzing the characters, differentiating Manatus from Cetaceans, and, again, those characters common to the Sireniens and Ungulata, of which latter he allows there are none. Neither does he admit Manatus among the Pachyderms. Lastly he deduces the genealogy of the Sireniens thus:—Proto-Sireniens, whence Halitheridae, Halicoridae, and Rhytiniode on the one hand, and the Trichechoidea on the other.

2. “Description de l’Œuf et du Placenta de Halicore dugong,” par le Dr. Paul Harting (Tijdsch. d. Nederl. Dierk. Vereen. Deel iv. 1879, pp. 1–29, pls. i., ii.). Most interesting, no Sirelian placenta having hitherto been examined. This research is based on a fetus and membranes in the Zoological Museum of Utrecht. A full description of the structural peculiarities is given, showing it to be a diffuse, non-deciduous placenta; and then follows a comparison with that of Cetacea and divers Pachyderms, between which groups it seems to stand midway. The author acknowledges that the diffuse form of placenta is met with in groups so much apart that its taxonomic significance loses all value; even the distinction deciduous and non-deciduous, in his opinion, cannot lead to a natural classification.

2 Pp. 1–6, plate viii. I here quote from a separate copy extracted from the Journal in question, and kindly forwarded me by the author.
of the Sirenia." In this article he points out that in the factual condition the head is abruptly flexed upon the chest, and the tail forms a right angle with the trunk. The general aspect of head and face he regards as Ungulate rather than Cetacean. To this extent the embryo of a lower form resembles the adult of a higher—and hence contrary to the usually accepted rule, that the young of animals resemble their ancestors. He believes this retrograde metamorphosis points to a like retrograde evolution of the Sirenia from prior ungulate forms, and thinks this is confirmed by what is known of the geological succession of Sirenia forms.

2. In the 'Proceedings of the Academy of Natural Sciences of Philadelphia' for 1875 (pp. 452-462) Dr. Henry C. Chapman has recounted his "Observations on the Structure of the Manatee," based on two animals living in the Zoological Gardens of that city. These creatures soon died, and thus enabled him to investigate their anatomy. He states some curious facts in connexion with their habits, refers to the alimentary, respiratory, circulatory, and urino-genital apparatus, comparing the same in the specimens with those previously described by myself. The brain and its peculiarities he fully discusses and figures (l. c. pl. xxvi.); and while he more particularly points out the relative absence of convolutions, he also specifies the extreme singularity of the brain as in contrast to that of all other mammalian forms. Dr. Chapman, in mentioning the cranial nerves, is inclined to consider the 6th as absent; and he suggests a different interpretation of those posteriorly situated; but he agrees with my determination of the cervical plexus. In his representation of the contour of the brain, and in his remarks on the paucity of its convolutions, &c., a different light is shed on the creature's cerebral organization from that given by myself; but of which more hereafter. Notwithstanding these discrepancies, he, moreover, in other respects pretty well corroborates the details of my anatomical descriptions of the various other organs, &c.

3. Furthermore, in our own Society's 'Transactions,' 1877, Prof. Garrod has given his "Notes on the Manatee (Manatus americanus) recently living in the Society's Gardens." He draws attention to and illustrates a remarkable labial action, namely the quite exceptional manner in which the Manatee uses its upper lip as a grasping-organ, but with lateral movements. The liver he figures, showing its considerably truncated aspect anteriorly. The brain he describes afresh, and gives sketches of it basally, laterally, from the top, and a partially internal view. Its most noteworthy characteristics are comparative absence of cerebral convolutions, great capacity of the lateral ventricles, and special thinness of the walls of the cerebral hemispheres. Unfortunately, Prof. Garrod omits reference to Dr. Chapman's previously published description and figure; nor are the brain-figures of the former anatomist at all satisfactory to my mind, despite its being said they were drawn under advantageous circumstances; to the wherefore I shall have occasion again to allude. The blood-corpuscles are very large.

1 Prof. Wilder's specimen measured 3'7 inches in extreme length.
2 I am also indebted to this author for a separate impression of his paper.
According to the dissection made by Prof. E. Ray Lankester, under Prof. Garrod's supervision, my statement (l. c.) as to the number and arrangement of the cervical nerves is not confirmed; and the further evidence of Prof. Edouard Van Beneden, of Liége, who dissected a Manatee in Brazil, is cited against my reading of the number and distribution of the cervical nerves present.

Some of my former observations being thus questioned by such competent authorities as the above-named gentlemen, I naturally felt I should like to have another opportunity of investigating the disputed points. In this way I might be able to ascertain whether variations would explain the discrepancies of statement, while I should also satisfy myself wherein I had failed to interpret nature aright. My wish was gratified sooner than I anticipated.

**History and Observations on Habits of Live Specimen.**—Through the energy and prompt measures of Mr. John T. Carrington, Naturalist and Curator of the Westminster Royal Aquarium, in June 1878 a large adult female Manatee, which had arrived at Greenock in a healthy condition, was purchased and immediately transferred to its final quarters in London. Of its first capture, shipment, and further carriage I learned the following particulars:—The animal was taken in a net on the Dauntless Bank, off the Island of Lequana, near the mouth of the Essiquibo River, British Guiana; and it was said to have been the only one observed in that locality for three years, thus yielding evidence of their growing scarcity. The native fishermen took it across to Demerara; and there it was bought on speculation by Capt. Picott, of the S.S. 'Blenheim,' who, by the same evening's mail, despatched a letter to the Managers of the Aquarium. On the voyage across the Atlantic the large box containing the Manatee was kept about two thirds full of fresh water; and being placed near the "donkey-engine," steam was passed at intervals into the water, so as to keep the latter up to a warm temperature. As the colder latitudes were reached, some trouble was taken to retain the water at a uniform heat. Before starting, a quantity of the fresh so-called "Moca-moca" leaves\(^1\) and fruit was obtained, which the creature devoured in a few days; and then it was supplied with a liberal allowance of hay and a slight amount of bread. There is, however, no very conclusive evidence of its having consumed the latter.\(^2\)

On arriving at Greenock the Manatee was there bought by Mr. Carrington for the sum of £200; and the steamer proceeding onwards, conveyed it to Glasgow. Here the tank was carted to the St.-Enoch's station, Midland Railway, and despatched, in a covered car, to London. Telegrams were sent to six different stations in advance to

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1 I am ignorant what plant the so-called "Moca-moca" is; but Dr. Sclater mentions that the Manatee brought to the Zoological Society's Gardens in 1875 "was fed during the voyage on the leaves of a large aquatic plant resembling the Water-lily (Nymphaea) shipped for the purpose" (P. Z. S. 1875, p. 529).

2 Dr. Chapman (l. c. p. 459), evidently at second hand, says:—"The smaller Manatee ate more than the larger one, which was natural, the large one having eaten heartily of grass and ship-biscuit before leaving Baltimore in the morning."
have a dozen or so buckets of hot water ready at each when the train arrived, which warm water was poured into the tank, and the temperature thus kept up. Mr. Carrington himself sat alongside the tank all the journey by rail; and he mentions that during the night-time the Manatee frequently raised itself and made endeavours to get out of the box. Whether the unusual sensation of railway travelling disturbed it, whether the chilling of the water and colder atmosphere of midnight affected it, or whether, evening being its natural active period, caused the uneasiness, is uncertain. Mr. Carrington certainly suffered temporarily from deafness after the night’s run in the nearly empty railway carriage; so great and incessant was the jumbling jarring noise. Doubtless, then, the strange sensations, unwelcome disturbance, and rude shakings, may have had their influences; for on first introduction into the Aquarium glass tank, and for nearly a week after, the Manatee would not feed; fears therefore were entertained that it would not long survive. Failing to observe cessation of its sulky humour or illness, as the case might be, and justly believing food a necessity, (on Mr. Carrington consulting me) I suggested the introduction of milk into its mouth by a syringe. Accordingly, the water was drained off, and three persons entering the tank, and inserting a cork in the fore part of the mouth, a small quantity of milk was several times given forcibly by a syringe. The Manatee, though ordinarily exceedingly quiet and gentle in its demeanour, evidently seriously objected to being thus unnaturally fed. Obliged to swallow a certain quantity of the milk and castor oil, it nevertheless rejected what it could, while displaying an astonishing muscular force of body, tail, and limbs. So great was its power that the three persons found the greatest difficulty in restraining its movements, and introducing the food. During this rough manipulation, and, indeed, during the whole of its after confinement in the tank, it was never heard to utter any sound indicative of voice; nor did it then, or ever after, attempt to bite or otherwise injure those handling it, though, of course, with floundering, wriggling struggle, endeavouring to free itself from the grasp of its would-be friends. Whether its ailment had passed, the spirit of resistance had overcome the sulks, or it deemed feeding itself preferable to milk diet against its will, a very few days more elapsed when, to Mr. Carrington’s satisfaction, it began spontaneously to munch and swallow the green food floating in the water. Thenceforward its appetite improved; and by degrees it daily devoured astonishing quantities of vegetable stuffs, passed pieces naturally, and in all respects throve amazingly.

On first arrival at the Aquarium, cabbage, lettuce, watercress, pieces of carrot and turnip, loose and bundles of hay, and quantities of pond-weed were put into the tank, both floating and sunk by weights attached. Occasionally it would sniff or examine these by snout and lips without chewing or swallowing, until its appetite returned as above mentioned. It then showed preference to watercress, though often taking

1 The castor oil was given along with the milk to obviate or relieve supposed constipation; for, according to Dr. Chapman (I. c. p. 460), the Philadelphia specimens were supposed by him to have suffered therefrom.
cabbage; but afterwards it chose lettuce, and entirely eschewed the others. When in the height of health it consumed, according to Mr. Carrington, from 90 to 112 lb. of green food daily. As lettuce became scarce and dear, it cost 10s. a day to supply it with the French sort; and although cabbage &c. was then cheap and abundant, it daintily chose the former, and as steadily avoided and refused the latter.

For six months all went well, and numerous were the visitors that came and went without disturbing the equanimity or destroying the appetite of this Sirenian. The tank-water was kept at about 70° to 74° Fahr. by steam being introduced at regular intervals or whenever the thermometer showed a depression. But just at Christmas time, during very cold weather, by accident the keeper one night in the dark unskilfully left the waste-plug loose or obliquely placed it in the hole; consequently the water slowly drained away, and Manatee was left high and dry to suffer from a serious chill of the cold atmosphere. Next morning when the water was run into the tank it showed signs of depression and illness, and thenceforth, apparently refusing all food, it daily became thinner and thinner, but lingered on until the 15th of March, 1879, when it died of sheer exhaustion.

1 According to Dr. Sclater (l.c.), the Manatee which lived in the Zoological Society’s Gardens in 1875, was fed there on lettuce and vegetable-marrow. Dr. Chapman states the Philadelphia animals, while under observation, ate and appeared thoroughly to enjoy Valisneria spiralis (as much as twenty-one pounds in twenty-four hours), Ceratophyllum (the Hornwort), and Uleia latissima: but he likewise says, “the Manatee will eat freely of cabbage, spinach, kale, baked apples, celery-tops,” &c. (l.c. pp. 459 & 461).

2 The following extract from the ‘Field’ is a short popular report of the post-mortem examination that I drew out for Mr. Carrington’s use, and which explains the precise nature of the creature’s illness &c.,—

“Agreeably to your wish I herewith supply you with a short report on the cause of death of the Manatee. I need hardly remind you of the sex—a female, adult though not old. As you are well aware, the animal had very sensibly lost flesh, so that, instead of the original barrel-like plump figure, gradual wasting had caused backbone and ribs to acquire exterior prominence most unusual in the Sirenian tribe. All the important organs—to wit, the brain, heart and lungs, stomach, liver, and kidneys—were sound and healthy, though flaccid and fabby in texture. The flesh and fat of the Manatees when killed in their native haunts are well known to be firm, but pale-coloured, and uncommonly good eating, comparable in appearance and flavour to well-fed veal or pork. In this Aquarium specimen, however, it may be assumed that during its late illness and fasting both fat and muscular substance had degenerated and run to waste. Literally, fat, in most limited quantity, was indistinguishable from the cellular and fibrous tissues and flesh, and, excepting the more solid back- and tail-muscles, soft and watery to a degree. Under the tongue was a small watery bladder, or cyst, resembling what, surgically, is called a “ranula.” This cyst may be of parasitic origin; but I have laid it aside for further examination. It certainly was not of a fatal character. The real cause of the animal’s illness and subsequent death lay in another quarter, namely, abdomen and bowels. On opening the belly, about its middle, I found a small piece of the gut adherent to the inner lining of the belly-wall; and further examination showed that a limited area of the intestine had undergone inflammation, ulceration, and peritonitis, the latter accounting for the adhesion above mentioned. The very thick muscular coat of the intestine evidently prevented absolute perforation and rapid death. As far as the structures in question enable me to judge, the illness about Christmas time may be attributed to a sudden colic and inflammation of the intestine (enteritis), or, as likely, sharp peritoneal attack (peritonitis), brought on by the rapid chill in the temperature of the air. All the symptoms you mention point to this. The almost total loss of appetite afterwards, gradual depression, and wasting bear out the probable course of the disease, but indicate the local character of the
As regards the general habits of this specimen, they bear out in nearly every particular the observations made by Dr. Chapman and Prof. Garrod on animals kept in limited areas, and with the advantage in this case that the transparency of the glass tank and its accessibility from all sides allowed close inspection at all times. One may class it among animals of crepuscular or nocturnal habit, inasmuch as it chiefly fed at night. To use Mr. Carrington's words, its tank was regularly and literally smothered with green food late at night, and, though eating a little before visitors by gaslight, it was not until after all the people had left the Aquarium that it began to feed in earnest, though by morning it generally managed to have finished an unusually ample meal. As a host of observers have noted, the harmless stupid nature of the Manatee and its uniform quiet stolidity are quite characteristic and manifest in the creature in its native haunts as much as in confinement. During the greater part of the day it dozed in various attitudes, every now and again rising, lazily and apparently without the slightest effort, to the surface to breathe; or occasionally it made a move round the tank in a slow unconcerned manner. It never violently plunged or rolled about, as, for a short time, it seems the specimens at Philadelphia did (l. c. p. 459). Altogether a dull and apathetic creature, even night time and its voracious feeding did not seem to enliven it much. In moving round the tank at times it would poke its nose close up to the glass, remaining stationary there for a few minutes, and without exhibiting fear of the over-curious on-lookers. In the same way it would occasionally carelessly toy with its food, its muzzle being exceedingly movable and tactile. I attentively watched the eye, the small size of which, with its grey or steel-blue iris, bore quite a pig-like expression. There was, however, a cunning leer in the organ of vision; and, what with the dark colour of surrounding skin and its deep-set position, elephantine roguery seemed mingled with porcine obstinacy. The nictitating membrane is comparatively large and very mobile. During life I also observed that the full-sized pupil was round and not slit-shaped or "transverse oval" as I had previously interpreted it in the dead body. I afterwards verified the above remark on the rotund pupil in the fresh carcass, and then made a coloured drawing from nature, which is reproduced in Pl. VIII. fig. 1. Prof. Vrolik's figure quoted below, of a side view of the head, I had criticised as being deceptive in the eye-region, from an outer circular line and presence of a heavy backwardly overlapping orbital fold giving the appearance of a large patent eyeball. Now, in justice to this worthy anatomist and his artist, I may here notice that in this adult live animal there was a distinct skin-elevation or semicircular fold

peritoneal inflammation and reparatory effort of nature, unfortunately at last unsuccessful. From what you state, your treatment seems to me to have been judicious under the circumstances, and specially considering the difficulty of arriving at any true and sure knowledge of the malady in such a thick-skinned phlegmatic creature."

2 Bijdrage tot der Natuur- en onteekundige Kennis van dem *Manatus americanus*, pl. i.
3 Loc. cit. p. 132.
behind and above the eyes. In an old male doubtless this is more prominent; and it therefore may exonerate the Dutch artist from false representation, though certainly the drawing in question is apt to mislead.

Having given attention to the intervals occurring between the times of breathing ("blowing") in the White Whale (Beluga), which range from 10, 17, and 20 seconds to a minute or a minute and a quarter when swimming round in the large tank of the Aquarium, I found on contrast that the respiratory intervals of the Manatee are considerably longer. I give the results of four observations made with watch in hand. The figures represent minutes and seconds of time, and the breathing as noted in succession; the four observations were, however, made on different occasions. Nos. I., II., III. were recorded when the animal was in what I may term a drowsy condition, No. IV. when fully awake and moving about. I omitted taking notes when the Manatee was out of the water.

<table>
<thead>
<tr>
<th></th>
<th>m. s.</th>
<th>m. s.</th>
<th>m. s.</th>
<th>m. s.</th>
<th>m. s.</th>
<th>m. s.</th>
<th>m. s.</th>
<th>m. s.</th>
<th>m. s.</th>
</tr>
</thead>
<tbody>
<tr>
<td>I...</td>
<td>2 15</td>
<td>3 15</td>
<td>3 10</td>
<td>2 45</td>
<td>4 27</td>
<td>3 12</td>
<td>2 13</td>
<td>4 25</td>
<td>2 57</td>
</tr>
<tr>
<td>II...</td>
<td>0 58</td>
<td>2 35</td>
<td>2 16</td>
<td>2 52</td>
<td>0 10, the latter an extremely brief inspiration immediately following one of moderate length.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>III...</td>
<td>2 55</td>
<td>2 25</td>
<td>1 30</td>
<td>2 43</td>
<td>2 15</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IV...</td>
<td>1 15</td>
<td>1 34</td>
<td>1 43</td>
<td>1 0</td>
<td>2 12</td>
<td>1 20</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Taking, then, the average time between the twenty-five inspirations in Manatus, it is 2 minutes 20 seconds, or 2 m. 25 s. if the last of row II. is excluded. In twenty-two successive inspirations in Beluga vigorously swimming, the average in one set of observations made by me was 44 seconds. From the above data it will be seen that the Sirenioid remains three times (3\(\frac{3}{11}\)) longer under water than the above cetacean genus. Dr. Chapman (l. c. p. 461) states of one of the Manatees that "at intervals of about one minute to one minute and a quarter he rose to breathe." He does not say whether the animal was in motion or at rest, which might make a difference. He further truly remarks:—"One can readily understand, after seeing the lungs inflated, how easy it is for the animal to maintain its almost motionless position at variable depths of the water, the lungs acting very much like the air-bladder in fishes, and looking, indeed, more like the lungs of Lepidosteus than those of a mammal."

Before referring to the singular positions in which the Manatee rests in the water, I may take occasion to mention that the figures in the accompanying plates (Pl. V. and, in part, Pls. VI. & VII.), as will be seen on comparison, are not drawn to a uniform scale; nor are they in every case intended to represent accuracy as to detail of skin-texture. They are all, however, sketches from nature by my old friend Mr. Berjeau, and are chiefly designed to show the various attitudes assumed by this specimen when confined in the glass tank of the aquarium. To some extent the drawings are preferable to words, and convey at a glance a fair knowledge of nearly all the positions adopted by the animal both during the day and night.

One was prepared to expect that the somewhat rigid figures represented in Pl. V.
figs. 7 & 9, would occur, and even that the positions in figs. 1, 2, and 3 might obtain, as movement in the water caused flexion and change of outline according to circumstances; but that the peculiar attitudes, with bent body and tail, shown in figs. 5, 6, & 8 (same plate) should be by far the most ordinary ways in which the Manatee rests stationary for hours together, was not to be previously conceived or looked for. The attitudes depicted were, moreover, again and again witnessed by crowds of onlookers. According as the water was higher or lower, so did the animal incline to its relative position in the tank, often preferring to be sufficiently near the surface for a leisurely turn upwards of the bent body to enable the nostrils to reach the air. On occasions, possibly being cramped for want of plenty of room, it would by a slow kind of half-rolling easy turn display a variety of movement, see fig. 4, Pl. V. It certainly was very extraordinary and suggestive of one use of its great broad flat tail to find this latter bent under and resting on the ground, while the body with dependent fore limbs (fig. 8) lay horizontally above. But the highly curved body, head, and tail as the creature floated without evident motion (fig. 5) was quite as remarkable, and, to me, a new and unexpected attitude, and one of very frequent occurrence. At one time it would float, doze, and sleep with body and tail stretched perfectly horizontal (fig. 7); at another, descending to the bottom, it lay full stretched in the more natural slumbering posture of repose (fig. 9).

Again, when feeding, while not unfrequently it would seize with its bristle-clad lips and munch the lettuces near the surface appearing in side view, much as in Pl. V. fig. 1, yet the most common position in feeding was that in Pl. VII. fig. 1. The last-mentioned figure, moreover, shows how it uses its flippers or fore paws to grasp the vegetable substances and convey or hold and steady them while the corners of the upper lip bend in, as shall afterwards be spoken of.

Dr. Chapman (l. c. p. 461) mentions, “When not in motion the Manatee rested by the tip of his tail upon the floor of the aquarium, his head downward, and with the back much arched.” I presume, therefore, he means one or other of the positions (see the present fig. 5 or 8, Pl. V.).

The fore limb, and obviously the manus, has a greater variety of movement than might be thought possible from its stiff skin-gloved character—a circumstance explained by the well-developed hand-muscles; for there is not merely an extensive web of stout aponeurotic fascia, as obtains in the Whales. In the Manatee under consideration I observed that, when at rest, the flippers were usually partially tucked in under the body, but unequally so, the left one having received an injury which, though healed, had left a stiff joint.

There would seem to be little doubt but the attitudes now depicted are the natural ones of *Manatus*, and those quite habitual to the genus. Thus, knowing it frequents lagoons, estuaries, and other shallow waters where herbage is abundant, the conditions (save less reeds and muddy water) of tank to a pool are quite within the bounds of comparison.
Notes on the Dead Specimen, its outward aspects.

Table of Admeasurements.

<table>
<thead>
<tr>
<th>Description</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme length from the snout to the tip of the tail</td>
<td>94.5</td>
</tr>
<tr>
<td>Girth of neck just behind vertex of cranium</td>
<td>31.5</td>
</tr>
<tr>
<td>Girth immediately in front of the pectoral extremities</td>
<td>38.5</td>
</tr>
<tr>
<td>Girth immediately behind the pectoral extremities</td>
<td>41.0</td>
</tr>
<tr>
<td>Girth about 4½ inches in front of the umbilicus</td>
<td>50.5</td>
</tr>
<tr>
<td>Girth at the umbilicus</td>
<td>51.0</td>
</tr>
<tr>
<td>Girth at the opening of the vulva</td>
<td>41.0</td>
</tr>
<tr>
<td>Girth at the anus</td>
<td>31.0</td>
</tr>
</tbody>
</table>

The head.

<table>
<thead>
<tr>
<th>Description</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme length, or distance between the muzzle and occiput</td>
<td>15.0</td>
</tr>
<tr>
<td>Girth at the snout, including the lower lip</td>
<td>18.0</td>
</tr>
<tr>
<td>Girth vertically before the eyes, including the lower lip</td>
<td>12.25</td>
</tr>
<tr>
<td>Girth behind, projecting part of lower lip vertical to eyes</td>
<td>23.6</td>
</tr>
<tr>
<td>Girth middle of head, just anterior to projection of mandible</td>
<td>21.2</td>
</tr>
<tr>
<td>Oral region, or length of the side of the mouth</td>
<td>3.0</td>
</tr>
<tr>
<td>Length of under lip, following tegumentary curve</td>
<td>3.5</td>
</tr>
<tr>
<td>Breadth of chin, following tegumentary curve</td>
<td>3.0</td>
</tr>
<tr>
<td>Breadth of chin at the angles of the mouth</td>
<td>4.5</td>
</tr>
</tbody>
</table>

Muzzle and nostrils.

<table>
<thead>
<tr>
<th>Description</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement of arch over muzzle, covering nostril</td>
<td>11.0</td>
</tr>
<tr>
<td>Nasal orifices, distance behind free end of muzzle</td>
<td>3.5</td>
</tr>
<tr>
<td>Nasal orifices, diameters across and vertically when dilated, about</td>
<td>0.8</td>
</tr>
<tr>
<td>Nasal orifices, distance apart at outer angles</td>
<td>2.0</td>
</tr>
</tbody>
</table>

The eye.

<table>
<thead>
<tr>
<th>Description</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter</td>
<td>0.4</td>
</tr>
<tr>
<td>Distance from front of muzzle (outside)</td>
<td>5.7</td>
</tr>
<tr>
<td>Distance from front of muzzle (mesially)</td>
<td>6.0</td>
</tr>
<tr>
<td>Distance from the inner angle of nostril</td>
<td>5.0</td>
</tr>
<tr>
<td>Distance between the eyes at their centres</td>
<td>6.5</td>
</tr>
<tr>
<td>Distant from the angle of the mouth</td>
<td>3.5</td>
</tr>
</tbody>
</table>

The ear.

<table>
<thead>
<tr>
<th>Description</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Auditory orifice, distant from posterior angle of eye</td>
<td>6.3</td>
</tr>
<tr>
<td>Auditory orifices, apart from each other, in diameter</td>
<td>11.0</td>
</tr>
<tr>
<td>Auditory orifices, apart from each other, following curve</td>
<td>12.0</td>
</tr>
</tbody>
</table>

Pectoral extremity.

<table>
<thead>
<tr>
<th>Description</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distant from the muzzle</td>
<td>16.0</td>
</tr>
<tr>
<td>Distant from the end of the tail (measured from axilla)</td>
<td>73.0</td>
</tr>
<tr>
<td>Roots apart from each other, following curve of back</td>
<td>18.25</td>
</tr>
<tr>
<td>Extreme length of free portion</td>
<td>13.1</td>
</tr>
<tr>
<td>Extreme breadth of free portion</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Vol. XI.—Part II. No. 2.—August, 1880.
At the narrowest portion its transverse diameter is............. 2-0
Girth at the root.................. 9-5
Girth at about the middle............. 10-5
Girth at about the outer distal third ............. 10-75

Tail or caudal extremity.

Extreme length, or from the loin-wrinkle backwards, measured on the ventral surface ............. 28-5
Extreme length, measured on the dorsal surface ............. 27-5
Distance between first wrinkle and angle of terminal border ............. 18-5
Breadth, following curvature of terminal border ............. 15-0
Extreme breadth, following superior curvature of skin ............. 18-5
Girth about four inches from the tip ............. 25-0
Girth about ten inches from the tip ............. 37-0
Girth at the root or hindermost loin-wrinkle ............. 28-0

Generative organs &c.

Rectum distant from end of tail ............. 32-5
Distance from middle of anus to opening of vagina ............. 5-2
The umbilicus is distant from muzzle ............. 34-5
The umbilicus is distant from end of tail ............. 58-3
The umbilicus is distant from middle of vaginal opening ............. 20-5

Allowing for difference of age and other conditions, these measurements, if compared with those formerly given by myself, will be seen to present a general correspondence, saving that the present animal has relatively less girth, doubtless accounted for by wasting of body. While, on the whole, there appear to be equal increments of growth corresponding with age, it moreover comes out, when Prof. Wilder's foetus (in paper cited) is taken into consideration, that the head decreases in proportion to the entire length of the animal. Thus from foetal to adult life in Wilder's and my own three examples the decreasing ratio of the head may be taken respectively as 30, 18, 17, 15. The hiatus between 30 and 18 would no doubt be bridged were the new-born or quite young animal examined. The decrement of facial length Wilder regards as indicative of a retrograde metamorphosis.

What admeasurements fail to show, or at least but imperfectly indicate, is the marked difference between the general contour of the head, body, and flippers of this specimen and the younger male Manatee formerly photographed by me. Especially is this the case in the view from above, to appreciate which compare the present fig. 2, Pl. VII., with a corresponding dorsal view, Trans. Zool. Soc. vol. viii. pl. xiv. fig. 3. Moreover the tegument itself varied quite distinctly, though this might in part be due to age, lean condition, and other influences.

As a whole the skin did not exhibit so very markedly the deep cracks, wrinkles, and minor furrows so characteristic of the younger male. Besides, whether from age,
the rubbing of the body in transport, or other unknown causes, there was a notable absence of the long sparse scattered hairs. What could be detected were chiefly short and stumpy, and only visible on close inspection, and best seen on looking at the skin sideways. The character of the hairs themselves was quite identical with the younger creature's.

The wasting which had followed the animal's illness, doubtless to a great extent accounted for the fact that at death the outline of the cranium was distinguishable, and the spine prominently visible almost throughout its entire extent. The peculiar bloated bagginess adverted to in the former specimens, consequently, was greatly diminished in this case; hence one could better appreciate the muscular anatomy of the creature.

The tail or caudal expansion was manifestly different-shaped from that previously figured by me. Transcribing my notes thereon taken from the object direct, I observed that the tail was almost flat below, except at the central spinal line. Above it was only very slightly arched, and that, of course, most towards the root and spinal central line—this latter being about an inch broad, but more faintly marked towards the posterior half. A notable feature was the total absence of a terminal median upper incision; on the contrary, there was rather an extension or bulging at this part. The shape of the caudal expansion, again, was decidedly tapering and pointed, in contradistinction therefore to most museum specimens and to the abruptly truncate broad outline of the male and female already examined by me¹. The caudal root-constriction, as seen dorsally, so well marked in these animals preserved in spirit, was nothing like so distinct in this Westminster Aquarium specimen, although a special skin-fold did obtain and was situate 28.5 inches from the point of the tail. On the upper surface of the caudal expansion, but not at all on the under surface, were indications rather than well-marked patches of the small button-like scales which formed so prominently a tegumentary feature in the previous young male. I noted also in the present instance that the secondary and tertiary tail skin-creases were very minute, shallow, and wholly transverse in direction; but quite at the margin they followed somewhat radially the direction of the edge.

Of the fore limbs or flippers the skin-markings on their upper surface in this adult were simpler in appearance than in the figure from the photograph of natural size shown in Trans. Zool. Soc. vol. viii. pl. 18. By this it will be understood there were less transverse wrinklings and very few, indeed scarcely any, of the button-shaped scaly skin-warts formerly reported in the young animal. These could, however, be distinguished towards the thumb side of the flipper and near to the nails. As to the shape of the entire fore limb, it was decidedly more elongated and taper-pointed than in the illustration referred to of the younger animal.

¹ In the absence of caudal notch and shape of tail this specimen resembles the foetus described and figured by Prof. Wilder l. c.
I carefully searched for, but failed to find traces of, more than three nails, the usual number recorded; these were, in this case, clearly defined and well formed.

What has been said of the outline of the dorsal region applies equally to the abdominal surface, viz. the caudal contour, foot-shape, and muzzle constituting the main differences between the young male and this adult female. The transverse constriction at the root of the tail and the other less marked furrows of the body were present in this female, though each and all were by no means so pronounced as shown (l. c. pl. xvii.) in the copy from the photograph of the young male’s body. In this Aquarium example, from the great loss of flesh and contraction of the parts, the abdominal walls were pinched in even below the level of the ribs. The recti abdominis muscles stood out prominently, each fully 2\(\frac{1}{2}\) inches broad. There was a deep median furrow extending from the vagina forwards to within a few inches of the limbs; the indent, shallowing to a narrow line in front, was deepest posteriorly, and behind the vulva it bifurcated slightly. Round the anus traces of linear grooving were slight. I have, in Pl. VII. fig. 4, reproduced an old drawing lying by me of the perineal region of the first female dissected by me; it agrees well with this Westminster Aquarium specimen, and may be of use for comparison with the same region in the male (l. c. pl. xvii. fig. 2.).

In my former Memoir on *Manatus* I referred to Sir Everard Home’s figure\(^1\), copied by Frédéric Cuvier\(^2\) and others, wherein a prominent teat is represented, whereas in the animals formerly examined by me the female showed only a very rudimentary trace of nipples and no subjacent gland. The examination of the present adult female, however, has enabled me to substantiate Sir E. Home’s observations; only in a side view of the body the teats would not be so conspicuously visible as he has represented the left one, especially as his was a young animal. In this Aquarium specimen the teat in each axilla was on a line with the elbow (Pl. VII. fig. 3), and fully an inch long and about as much broad. A small but easily distinguishable central orifice existed among the surrounding punctated skin, which latter is glandular in appearance. The mammary gland itself was readily traced, and in the position and with the relations of parts I have already described\(^3\).

Regarding the head, as I have already hinted, the outline of the skull in its upper contour was more visible, and there appeared to be a greater proportional breadth between the eyes and a less transverse expansion of snout, than in the carcasses formerly examined; but in this and other points the unusual laxity of the tissues must be taken into account for variations. In certain aspects the profile, and even the fore-shortened view, of muzzle resembled a young Hippopotamus or Walrus, minus stout bristles of latter (Pl. VI. fig. 7). At times, however, when alive, the animal would raise and shorten its muzzle so as to have an uncommonly pig-like expression.

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\(^1\) Phil. Trans. 1826, pl. 26 &c.; Lectures on Comparative Anatomy, vol. iv, pl. 55.
\(^2\) De l’Histoire Nat. des Cétacés (1835), pl. i.
so have; viz. leaf regard 2 concert. caterpillar “fanning, But I while Undoubtedly and minute hensile ence self of question, averring Manatee’s Vrolik’s1 view, he so far modifies this as to admit, with me, that the levatores labii proprii muscles act strongly in concert. I myself had only taken exception to Vrolik’s averting the upper lip to be solely (or, as I had translated from the Dutch text, “plainly”) erectile, in contradistinction to its manifest and peculiarly fleshy character. Neither Garrod nor Vrolik seem to me to have examined minutely the parts and structures in question, nor allowed sufficiently for the muscular efficacy of the action, irrespective of purely vascular erection. Remembering that the lower lip of Manatus is relatively little used in the aforesaid lateral grasping action, and trying the experiment on one’s self, viz. fixing the lower lip, it is not difficult by muscular force alone to imitate the Manatee’s labial habit—of course in a minor degree and with due allowance for difference in oral construction. To take another example, the delicately tactile and prehensile tip of the Elephant’s proboscis all allow are under control of the innumerable minute muscular fibres, the nerves and blood-vessels rather intensifying tactile power than solely conducing to mobility. Similarly I regard the Manatee’s muzzle as to all intents and purposes a true curtailed trunk or proboscis, but differing in preponderance

4 Bijdrage tot der Natuur- en Omtrekkundige Kennis van den Manatus Americanus, 1852, p. 59.
5 I was induced to this trial from having observed a French peasant with an almost malformed mouth, i.e. a projecting nipple on each side and underlying lower lip, faintly recalling the Manatee’s oral region. Every time the man spoke, these lateral projections approached and Sirenean peculiarity was manifest.
of lateral instead of vertical action in prehension. The rete mirabile is the rule, and not the exception, in the vascular system of this creature, and, with the minute nerves, supply to the bristle-clad area of the lips that concentration of touch needful to discriminate in the mechanical act of seizure. But, beside the levator muscle above spoken of, I have already shown that an extension of the great panniculus, the levator labii superioris alæque nasi, and others all commingle by fibres around the upper lip and muzzle, and doubtless tend to consentaneous action of the region in question. Moreover, in the dead animal, when I pressed my finger against the upper front part of the flaccid muzzle, directing it backwards, the otherwise truncate organ became horseshoe-shaped, medianly depressed, and the two bristle-clad spots of themselves naturally approached each other (see sketch, Pl. VI. fig. 6), though partially, as would be the case in the act of grasping during life.

Lastly, I may refer to Prof. Garrod's expression of the nostrils possessing a "flap-valve" (l. c. p. 189, pl. xxviii.), by which is to be understood merely floor-pad, which by the muscular circular contraction of the nasal orifice is partly raised and completes occlusion at will: but there is no free valve such as the above term would signify.

Memoranda on the Muscular System.—It is not my intention critically to examine and compare throughout my former researches on the myology of this Sireenian; but as in my present dissection I observed several varieties of parts structurally, I deem it fair to myself to call attention to a few of these, chiefly of the fore limb, for which consult Pl. VIII. figs. 3 & 4.

I searched for but found no representative of the coracobrachialis, thus agreeing with previous dissections. The vessels of the brachial rete near the elbow, I remarked, partially overlie the distal portion of the second tendon of insertion of the double-bellied biceps humeri.

As regards brachialis anticus and supinator brevis, my previous statement (l. c. p. 158) is here applicable. In the right arm of this animal the pronator radii teres and flexor carpi radialis were indivisibly united, but their combined origins and insertions agreed with my former descriptions.

What I have previously stated with regard to the flexor sublimis, profundus, and longus pollicis does not apply in this case; nor is the relation of the palmar fascia and the palmaris longus identical. Here the strong broad aponeurosis of the forearm covers superficially and entirely the whole of the flexores, the breadth of the bones, excepting over the outer, ulnar, disputed muscles (infrâ). Just above the wrist the fascia forms a well-defined arch, and embraces the common flexores; and higher up between combined pronator radii teres and flexor carpi radialis; and on the opposite side, but inner border, of the flexor carpi ulnaris &c. it is firmly fixed to the radius and ulnar lower shaft, and, partially, the deep wrist-fascia.

Above the wrist-joint on the ulnar border a long fusiform muscle springs, which lower
down, in part lying upon and in part commingling with the flexor carpi ulnaris, runs on to the outside of the fifth digit, and is inserted by tendon on the distal outer margin of the fifth metacarpal. The muscle in question is apparently supplied by a branch of the ulnar nerve; at least I traced the nerve under its belly, though an awkward slip of the scalpel prevented my assurance of its entrance into the muscle. To all intents and purposes the muscle now described is representative of a palmaris longus or of an unusually developed flexor brevis minimi digit. If it is the latter, then what may be combined palmaris longus and flexor carpi ulnaris obtain in this example, as has been hitherto described.

As to the sublimis and profundus flexors in common, their muscular origin reaches quite and even beyond the wrist. Distally, but superficially, it is tendinous, viz. from the lower third of the arm-bones. As freshly examined, the digital tendons go to the ends of the second, third, and fourth proximal phalanges, beyond which they form uniform, stout, aponeurotic coverings to the fingers. Between the wrist and ends of metacarpals tendons representing perforans and perforatus are easily distinguishable. Moreover the subjacent longest-continued fleshy belly has its fibres slightly athwart, and minute tendons underneath, chiefly distributed to the third and fourth digits. A longus pollicis is not distinct, unless that tendon, going to the second digit, represents it.

There is a single distinct lumbral muscle (/, fig. 4) which arises from the wrist-fascia, and, with a comparatively long fleshy cord, is inserted into the tendon of the fourth digit. In its course it passes but slightly from the radial towards the ulnar side of the palm.

As to the remarkable interossei, clearly in this example the superficial fleshy layer cannot be considered lumbricales, as suggested by me in my former paper, a single lumbral muscle existing superficially as just described. Again, it is very questionable if the superficial layer is an anomalous flexor brevis manus, as also formerly hinted. The flexor brevis manus, as originally described by Prof. Mivart and myself in the myology of Hyrax, had a position superficial to the flexor sublimis and profundus, instead of deeply to those muscles, as in this case; and both origin from the palmar fascia and tendons of insertion differ.

I may describe the interosseal arrangement in this Manatee, as it varies from that of the previous occasion. Of the superficial set from the inner radial tuberosity and the carpus there arises a strong mass of fleshy and tendinous substance, which thereafter divides into three somewhat fusiform divisions, inserted respectively on the sides and proximal ends of the proximal phalanges. One division goes to the ulnar side of the second digit and to the radial side of the third; another division, the middle one, ends on the sides of the third and fourth digits; and the third division is fixed respectively to the neighbouring sides of the fourth and fifth digits. The deep interossei are relatively powerful and almost altogether fleshy. They agree with what I obtained on the former

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occasion, excepting that there is an additional single belly to the radial side of the fifth digit.

To the ulnar side of the superficial interossei there is another pair of muscles, which spring together from the cuneiform bone (ulna?), and pass on to the fifth digit, being inserted palmarly respectively on the radial and ulnar edges. These may represent an opponens minimi digiti and abductor minimi digiti. I have already recorded the presence of a flexor brevis and abductor minimi digiti in the Manatee; but these muscular aponeurotic bands were not nearly so clear and well defined as in this Aquarium specimen.

Absent entirely in the former instance, there is in this only one short muscle to the thumb. This arises from the fascia covering the end of the tendon of the pronator radii teres and flexor carpi radialis muscles, and it occupies the metacarpal bone its whole length. The muscle may either be a flexor brevis pollicis or representative of adductor pollicis.

Of the short deep muscles of the neck (see dissection, Pl. VIII. fig. 5) the rectus capitis anticus major has the usual cranial origin; and the two muscles of opposite sides thence diverge backwards, each with a thick fleshy belly flattened gradually posteriorly. A tendon of insertion is fixed to the transverse process of the fifth cervical vertebra, and partly to the sixth. Another middle-placed tendon goes on to the head of the first rib; and still another, innermost and broadest, is fastened to the body of the first dorsal vertebra, there mingling with the periosteal fascia covering the bodies of that and the succeeding vertebrae. The insertions met with in the former specimen were three dorsal vertebrae and head of second rib. In this animal the rectus anticus minor offers no variation worthy of mention.

The longus colli I again found well developed, flat, tolerably muscular, and divisible into three portions. The first division, taken in the order formerly described, comprises fibres chiefly directed from without inwards, which pass between the transverse processes of the fourth, fifth, and sixth cervicals, some odd tendinous slips going to the first dorsal. The second division partly overlaps the third, and is inserted by short tendons into the extremities of the third and fourth vertebrae and root of the fifth. Division third of the two sides arises in proximity from the atlas; but they afterwards leave a fusiform space between them. Each moiety covers the body and transverse processes of the cervical vertebrae; and a flat broad tendon is continued over the body of the first to the anterior edge of the second dorsal. This multiple-bellied neck-muscle only shows variety in slightly more extensive attachment than formerly noted.

I here find the rectus lateralis separate as a broad strong fleshy band extending from the occiput and root of stylo-hyoid to the transverse process of the atlas. The obliquus superior?, lying within the last and deeper, is a small muscle which passes from the

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inside of the root of the stylo-hyoid to the hollow on the ventral side of the ring of the atlas. The first cervical nerve-trunk issues between this obliquus and the rectus lateralis; and the posterior nerve-branches run behind the lateralis, while the anterior branch is that numbered 1st cervical in the woodcut, p. 37, and in the dissection (Pl. VIII. fig. 5).

Notwithstanding Rapp's assertion to the contrary, a well-defined scalenus was again met with—in this case a thick fleshy muscle covering partially the 1st rib, and extending to the 2nd and 3rd. Tendons cover the surface of the muscles; and these are inserted successively into the tips of the transverse processes of the 6th, 5th, 4th, 3rd, and 2nd cervicals. A continuation of the muscle goes up broadly to the transverse process of the atlas, a narrow tendon also lying superficially. On the left side I did not perceive an accessory tendon proceeding to the axis; but it was quite evident on the right side (t*, fig. 5), and divided the roots of the 3rd and 4th cervical nerves, though, as I had anticipated, exceedingly delicate and requiring most careful manipulation to demonstrate.

On the Cervical Nerves (consult Pl. VIII. fig. 5, and diagram woodcut, p. 37).

I. This nerve issues from the groove in front of the pedicle of the atlas, and, as described in the myological notes, proceeds between the rectus lateralis and obliquus superior muscles. It possesses small branching twigs, which supply the aforesaid muscles and the rectus anticus major. The main trunk, however, crosses the belly of the rectus lateralis, and coursing outwards divides into branches which pass beneath the levator claviculae and the trapezius muscles (?). These nerve-branches furthermore appear to be distributed to the sterno-mastoid portion of the panniculus carnosus muscle, and to the region behind the auditory part of the skull.

II. The second cervical nerve, slightly thicker than the preceding, issues from the vertebral foramen between the atlas and axis. It may have had in this case a connexion with the root of the first nerve; but if this existed, it unfortunately was accidentally severed in my dissection. The second nerve passes across the scalenus or muscle which is fixed to transverse process of the atlas. Immediately thereafter it sends a branch or loop which communicates with the third nerve. It, the second nerve's main division, proceeds outwards parallel with the first cervical nerve, and, passing beneath the levator scapulae and the trapezius &c., supplies these muscles and the panniculus carnosus, nerve-branches moreover being also distributed to the posterior part of the neck. Besides the loop of connexion with the third nerve, the second nerve splits up into several twigs, which penetrate the deep fascia of the neck and the parts thereunder.

III. Before describing the third nerve, I may draw attention to the fact that whilst on the right side of this Manatee, as alluded to above in the description of the scalenus muscle, there was evidence of the noteworthy small tendon (referred to in my previous

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1 'Cetacea,' p. 86.
memoir\(^1\)) dividing the nerves issuing from the one foramen. On the contrary, on the left side I did not observe the presence of such a minute tendon. But though to appearance absent, there was nevertheless a band of fascia, evidently belonging to the deep cervical fascia, which took the position of the minute tendon in question.

The third cervical nerve, then, distinctly issues from the foramen between the axis and the succeeding vertebra. It passes thereafter outwards and over the scalene, joins, as aforesaid, the loop of the second nerve, and courses somewhat parallel with the branches of the latter. Its main trunk subdivides terminally into branchlets, which are distributed to the trapezius and other parts of the neck above and around the scapula.

IV. From the same foramen as the last, viz. between the axis and the succeeding vertebra, is another nerve-trunk, which within the vertebral foramen unites with the preceding by fascia or, it may be, nervous tissue. This I ascertained after I had made the dissection and had the drawing done represented in Pl. VIII, fig. 5, when I followed the nerves right into the vertebral canal and through the theca of the spinal cord. But inasmuch as the dissection was a laborious proceeding, taking some days to finish, likewise from the animal having died after an exhausting illness with the nervous tissue tender in some places, and particularly from the great difficulty of cleaning the parts around the intervertebral foramen and within the spinal canal, owing to the presence of the rete mirabile, I could not trace the nerves distinctly as separately arising from the spinal cord itself.

However this may be, it is certain that immediately exterior to the intervertebral foramen the fourth and the third cervical nerves are quite distinct and trend in different directions. The third takes an upward and forward, the fourth a downward and backward course. These two nervous cords are nearly of equal calibre, and barely as thick as is the second nerve. Tracing the course of this fourth nerve outwards, I found that fully one inch beyond its exit from the intervertebral foramen it forms a union with a division of the fifth nerve. At this junction the phrenic nerve is given off; and it descends (is directed rearwards) as usual into the chest, lying superficially to the brachial plexus. Beyond the junction just mentioned the calibre of the compound nerve is considerably increased, and it splits up into three divisions.

One proceeds above the shoulder-joint, passes over the suprascapularis muscle, and supplies the parts on the upper and outer side of the shoulder, including the trapezius &c. The second division goes to the outer head of the humerus, being chiefly distributed to the pectoralis major and the deltoid, in a manner therefore equivalent to a supraclavicular branch. The third, deepest nerve-division pierces the tissues betwixt the subscapularis and the supraspinatus, and it goes to the fleshy parts at the back of the scapula, twigs penetrating the supraspinatus &c., and another proceeding through the suprascapular notch.

Comparing what has now been said with the general distribution of the cervical

\(^1\) Op. cit. pp. 137, 152, & 184, pl. xxiv. fig. 29.
Fig. 1.

Diagram of the Cervical Nerves of the left side of the neck in the Westminster-Aquarium Manatee.

1. First nerve. R.a, Twigs to rectus ant. major and rectus ant. minor; R. la, rectus lateralis; S.t.m and Pa, to sterno-mastoid and panniculus; Reg. Ear, to region of ear; and Pa, panniculus carnosus &c.


3. Third nerve, issuing along with the fourth. * loop of communication with second nerve; Tz &c., efferents supplying the trapezius and other parts of the neck.

4. Fourth nerve, after separation from third trunk. Ph, phrenic nerve, derived near loop of junction with fifth; Sh. j, Tz, d.c., division terminating around shoulder-joint, the trapezius, &c.; P.m., D. & Sh. j, second division to pectoralis major, deltoid, shoulder-joint, &c.; S.s. n. s. d.c., the nerve which passes through suprascapular notch and is distributed to fleshy parts back of scapula &c.

5. Fifth nerve. Loop to fourth, afterwards dividing into branches: Sb to subscapularis, C the circumflex nerve, and Sb, te, d.c., nerves to subscapularis, the teres muscle, &c. Communicating branches proceed from the fifth to the sixth and to a division of seventh cervical nerve.

6. Sixth nerve, with cords of union with fifth, seventh, and eighth. C, circumflex nerve; Sb, te d.c., subscapular and teres branches; La. d, to latissimus dorsi; B, to biceps; Pa, to pectoralis.

7. Seventh nerve, with union to eighth. M.s., musculo-spiral; M, median.

8. Eighth cervical. Int., union with first intercostal nerve; U, ulnar; I. c, internal cutaneous; Wr, nerve of Wrishberg; Ch & pe, chest and pectoralis branches; La. d, latissimus dorsi branches.
nerves of man and some of the higher mammalia, it would seem that the two first-mentioned of these three nerve-divisions in the main corresponds with the distribution of the fourth cervical nerve, while the third division rather appertains to the fifth.

V. The fifth nerve is thicker at its origin than is the fourth nerve. It leaves the spinal canal through the foramen between the third and fourth cervical vertebrae present; and while one portion of it joins the fourth nerve where the phrenic is given off as aforesaid, the other, its main trunk, is sent down and outwards to join the sixth nerve, at the same time about its middle transmitting a branch deeply to the subscapularis muscle.

VI. The sixth cervical nerve has a still thicker trunk than the last (5th), and it comes out from the foramen between the fourth and fifth cervical vertebrae. Its first offshoot, a cord of considerable calibre, is that uniting it with the fifth, and which runs outwards towards the subscapularis muscle near the shoulder-joint; thence it passes round the head of the humerus, and ultimately becomes the circumflex nerve of the fore limb.

Other nerve-branches supply the subscapularis, the teres, and rhomboid muscles; and still another passes apparently to the latissimus dorsi or neighbouring muscles. Previous to where these separate, there is a union with the cord forming the musculospiral. What appears as a main trunk of the sixth, or after its junction with the fifth, proceeds towards the seventh, and forms with it a broad nervous expansion at the root of the median. From this expansion fibres either of the sixth or the seventh branch off to the biceps humeri. Another nerve, either derived as a continuation of the sixth or, it may be, seventh cervical, supplies the pectoral muscles. From the same point two other nerves strike off divergingly—one, namely, joining on to the branch of the eighth supplying the thoracic region, and the other forming a communication with the upper part of the ulnar.

VII. The seventh cervical trunk emerges between the fifth and sixth vertebrae. As a thick cord it first sends a union to the eighth nerve; then its main continuation goes onwards, becoming the median nerve of the arm; but at the commencement of this (that is, from the nervous expansion above spoken of as derivative from the sixth) a nerve is sent to the larger belly of the biceps muscle. In close proximity to its junction with the trunk of the eighth nerve a cord is derived which passes over the insertion of the latissimus dorsi, sends a long filament to that muscle, and, winding round the neck of the humerus, becomes the musculospiral nerve of the arm. Its (the seventh’s) connexion with the sixth cervical nerve has already been mentioned.

VIII. The eighth cervical nerve comes out above the first rib. Its great thick trunk sends a branch which unites with the first intercostal nerve, and gives twigs of supply to the scalenus muscle and to the vascular plexus around and just within the chest-cavity. The main cord immediately thereafter receives an accession of fibre from the bridge of union with the seventh nerve aforementioned, and just beyond expands or takes the
form of a great flat nervous band lying on the scalenus. Here it sends off a strong cord, which is joined moreover by a branch from the median division of the seventh or sixth nerve already alluded to—the cord in question constituting a large thoracic nerve with ultimate divisions and twigs supplying the parts on the front of the chest, pectoral and partially abdominal muscles. The main continuation of the eighth nerve pursues a course down the fore limb as the ulnar; but two much thinner branches with terminal divisions derived immediately beyond its (8 trunk) expansion appear to represent the internal cutaneous and nerve of Wrisberg. Moreover the thoracic branch of the eighth nerve is joined by another from the seventh nerve, while at the origin of the ulnar there is a communicating branch also derived from the seventh.

On the Brain.—Both Dr. Chapman and Prof. Garrod in their papers (already quoted) have taken exception to the description of the brain given in my former paper, and no doubt justly correct me in attributing to it too many convolutions. In other particulars also they do not concur with my reading of the parts. Each, moreover, has given his own illustration, said to be from the fresh specimen shortly after the animal’s death, and therefore under advantageous conditions as compared with my own. Taking these circumstances into consideration, it would be expected there should be a certain harmony between the figures particularly of these two observers, granting their better opportunities for examination of the brain. But, on the contrary, their individual representations are totally diverse. Which author, therefore, is the more reliable? or, rather, to put it gracefully, wherein lies the incongruity, and in what respects does one or other, or both, dissent from that heretofore given by myself?

There are two aspects for consideration, text and illustration. Dealing with the descriptive text, a careful analysis of statements as compared with my own, irrespective of paucity of convolutions already mentioned, elicits Dr. Chapman to assume:—1, greater relative height of cerebellum; 2, less differentiation of corpora albicantia; 3, posterior shortening of corpus callosum; and, 4, a different interpretation of what constitutes the sixth, seventh, and eighth pair of nerves. Number 1 may be accounted for by my specimen of brain having been preserved in spirit; number 2 I make no special mention of; and to numbers 3 and 4 I shall again refer. In all other points, allowing for variation of verbal expression, he substantiates my description of the parts. Prof. Garrod mentions that:—1, there is no septum lucidum; 2, the anterior commissure of the third ventricle is small; 3, the pineal gland is small; 4, as also are the

1 With regard to the Dugong’s brain mentioned by me without reference, and inquired after by Dr. Chapman (i.e., p. 454), it was to the cast of the brain-cavity in the College of Surgeons Museum, and not to the brain itself, that I meant allusion.

2 I may here take note of an awkward error in lettering in my former memoir (p. 199, 5th line from bottom), where ps is spoken of as pineal gland, parts of base, instead of pituitary body; while in pl. xxy. figs. 33, 34, ps is placed both on the pituitary body and also on the pineal gland, thus leading to confusion of these parts.
corpora quadrigemina; and, 5, there is no posterior horn to the lateral ventricle. Neither Chapman nor I take notice of No. 1 or 2, or call special attention to No. 3; but we agree in contradistinction to Garrod (No. 4 and 5) as to the relatively fair size of the somewhat united corpora quadrigemina and indication of a posterior cornu.

As regards illustration, Chapman gives a top view and profile outline, but no sections or base with the disputed nerve-origins. Fewer convolutions, size of cerebellum, and less vertical height of cerebrum distinguish his delineations from my own; but, notwithstanding, the likeness to the corresponding figures of mine are within passing limits of comparison. Not so, however, with the four views given by Garrod (l. c. pl. xxx.), which are as unlike Chapman's as my own, and indeed cannot surely be true to nature; for, on the face of it, the outlines &c. of his lateral aspect (fig. 1) and median section (fig. 2) neither correspond with top and base (figs. 3 and 4), nor does the last in nerves &c. bear evidence of accurate drawing from the object itself. With all his advantage, then, of fresh extraction of the brain, I hold he has singularly failed in the lithographic representation of its conformation.

In support of these words I appeal to my present plate (Pl. IX.), where fig. 2 was drawn from the brain of the Westminster specimen in situ; and so far therefore the contour may be deemed tolerably exact. But what the authors who have criticised me, and whose work I in turn criticise, omit to mention is the fact that the Manatee's brain, from its peculiar shape, lofty lateral ventricles, and want of firmness, is exceedingly liable to distortion on being handled, even immediately after extraction. This well accounts for the want of uniformity in the different observers' delineations, while at the same time it does not depreciate, but the reverse, my rendering under adverse conditions explicitly stated in the text (l. c. p. 180).

With the fresh material now before me, and as Pl. IX. demonstrates, there can be no doubt the brain may be regarded as relatively smooth-surfaced, and convolutions or their traces are fewer than I had formerly attributed. Still, in testing my own shortcomings, I could observe slight depressions on the surface, giving indications in some parts of what in the shrunk spirit-preserved specimen I had construed into shallow sulci and convolutions. Thus the sylvian fissure, as my commentators admit, is not only deep, but so divides superiorly as to furnish faint outline tracings of fissure of Rolando and parietal gyrus, as also of what I had formerly denominated lobule and angular gyrus. Posteriorly is a mere superficial indication of what might be deemed to represent supraoccipital furrow and fold. Inferior and superior frontal gyri and sulci could not be distinguished other than the faintest lines wherein the blood-vessels run; and gyri of the outer frontal region, as formerly interpreted by me, did not exist. Callosomarginal and hippocampal sulci (met with by Chapman and Garrod) again obtained, though corresponding gyri were indistinct. To enable me to make a careful examination of the nerves and their origins, and drawings thereof, with the view of ascertaining the wherefore of Dr. Chapman's interpretation of the four posterior pairs, on
removal of the brain I did not immediately make sections to look at the anterior parts, reserving this for later on, and consequently had to immerse it in spirit. Afterwards, however, I found that my previous drawings (l. c. pl. xxv. figs. 34, 35) were by no means seriously inaccurate; for I could distinguish a trace of posterior cornu, and neither pineal gland, corpora quadrigemina, nor interior commissure could be said to be small, as Garrod asserts; indeed the commissure proportionally, and as compared with that of the Porpoise, is large. The white matter of the corpus callosum might not be absolutely so thick as I had represented in fig. 34 (l. c.); but decidedly its length from before backwards agreed, its splenial end reaching beyond the thalamus and in part overlying the corpora quadrigemina. The walls of the lateral ventricles, in a sense, are not absolutely thin, though the cavities are relatively capacious; I could not satisfy myself as to absence or presence of a septum lucidum.

A further examination of the nerves convinces me I had not mistaken these in my former memoir. Dr. Chapman (l. c. p. 454) says:—"If Dr. Murie has correctly described the sixth, its origin, direction, and size are very peculiar. It is possible, however, that the sixth is absent in the Manatee, as I found no trace of it at its usual origin. If such is the case, I should regard Murie's sixth nerve as the seventh, and his eighth as the pars intermedia: his seventh would then be the eighth. I was unable to trace out these nerves, being anxious to take out the brain as soon as possible. The glossopharyngeal, pneumogastric, and spinal accessory were readily recognized. The hypoglossal came off internally, and above the position represented by Dr. Murie in fig. 33, plate xxv." My fresh view of the base of the brain (Pl. IX. fig. 3) shows the cranial nerves as existing in the Westminster-Aquarium Manatee. Olfactory tracts and bulbs are pronounced; optics and third nerves fair-sized, and between, partially hiding their deep origins, a nipple-shaped elevation, shown opened, representing pituitary body and tuber cinereum, and apparently hiding the corpora albicantia. The delicate filaments of fourth nerve, only observed in a fragmentary condition, are not exhibited in the drawing. The enormous fifth nerve, commencement of its divisions, and Casserian ganglion, besides the nerve's lesser root winding round the front border are conspicuous, the root springing from the side of the pons. What can be no other than a good-sized sixth appears superficially to come from the pons Varolii; but in reality its fibres can be traced towards the pyramidal body of the medulla oblongata. To wherefore its considerable calibre in such a small-eyed Mammal, and as to its terminal distribution within the orbit, which circumstances in this case prevented me dissecting, I can only add that, piercing and ensheathed by the thick dura mater of the cranial base, it passes through the great vacuity immediately behind the alisphenoid adjoining the root of the fifth, and proceeds forward towards the orbital space, thus somewhat militating against the notion of its being a division of the seventh nerve. Moreover, what represents portio dura and portio mollis with the pars intermedia are also present; and although appearing as derivative from the pons immediately behind
the sixth, their origin can be traced towards the medulla oblongata outside the latter. As regards the compound eighth nerve, funiculi respectively constituting glossopharyngeal, pneumogastric, and spinal accessory are clearly distinguishable. The ninth nerve (hypoglossal) is equally manifest, and derives its filaments from a more median line than the divisions of the eighth. In short, the cranial nerves, as a whole, are derived from nearly their normal situation, as obtains in the Mammalia generally.

Lastly, in connexion with the brain, I have in Plate IX. given the vascular distribution. The circle of Willis is complete; but the internal carotid and basilar artery seem relatively small, while the other cerebral branches take on somewhat a retial character.

Concluding Remarks.—The present communication of necessity has led to a few items of controversy; but while supporting my own former observations and views, I have no wish to detract from the really useful papers of my fellow anatomists.

The most important points are those in connexion with the brain and the cranial and cervical nerves. As to the brain, I with pleasure acquiesce in the emendation of its comparatively smooth surface; but I am dubious as to Garrod’s figures giving its natural contour and details correctly, sine qua non. I moreover think the minor differences of special parts mean nothing more than variety in expression rather than established facts; for with separate specimens to work on, and under dissimilar conditions and aspects, each individual has consequently seen from his own point of view. As to the cranial nerves, I could have much wished Dr. Chapman had supplemented his remarks by a good figure of the brain’s base; for in his attributing my lettered eighth nervous funiculi (l. c. pl. xxv. figs. 32, 33) to a pars intermedia considerable ambiguity arises; besides, against his idea there is the weighty fact that the said filaments spring as usual from the side of the medulla oblongata.

1 The accompanying woodcut (fig. 2) is reduced from a rough sketch made now fully ten years ago, previous to extraction of the brain of the female Manatee dissected by me. By accident it and a few notes had got mislaid and lost sight of when preparing my material for the press. Had it been otherwise they might have saved me falling into errors of interpretation of supposed convolutions, magnified by spirit-preparation and surface-scaling. I do not offer this as an apology; for one must be judged by their publication, be it right or wrong. To me, however, Prof. Rolleston’s words have some meaning:—“Persons, however, to whom an inner conviction of their own accuracy may be dear in the face of adverse criticism, may learn from this the advisability of preserving such documentary evidence as that to which I have referred.” (Rolleston versus Lankester, “Blood-corpuscles of the Annelides,” Cambr. Journ. of Anat. and Physiol. vol. xii. p. 404, April 1878.)
As to the reading of the cervical nerves, it seems to me that every thing I had previously advanced in my memoir (l. c. pp. 187, 152, and 184) is borne out in this fresh dissection. Prof. Lankester (in Prof. Garrod's paper, l. c. p. 143) rightly admits that I never insisted that the two nerves issuing between the second and third cervical vertebrae had direct origin in the medulla\(^1\). Moreover, if his inference (certainly not expressed by mine) of the actual separate spinal-cord origin of the two nerves in question be invalidated by this more recent investigation on my own part, the purport of my reasoning nevertheless remains unshaken. I distinctly based my argument of the absent cervical vertebra in *Manatus* being most probably the third (and not the seventh as Prof. Brandt had maintained, or sixth as suggested by Prof. Flower), on the analogy of Cetaceans' ankylosed cervicals, and on the number and disposition of the scalene tendons, besides the presence and issue of double nerve-trunk from between the second and third neck-vertebrae. I confess it would have been more satisfactory had I hertofo...
valuable researches of Dr. Herman von Jhering, on the subject of the interdependence of nerves and vertebrae in the different regions and in several groups of the Vertebrata, strongly tend to sustain the view I have offered. Therefore, until more weighty contrary evidence is forthcoming, I am inclined to reiterate my belief in the third vertebra being that absent in the neck of Manatus.

Regarding the present illustration of the sternum (Pl. VIII. fig. 2), I have introduced this, with its attached cartilages, as showing variation in shape and development from that already given by Prof. W. K. Parker and myself. The muscular variations of the manus extant are not so very peculiar in themselves; but in the bearing of such a question as has been raised by Dr. D. J. Cunningham they possess increased interest. Dr. Chapman (l. c. p. 455) has evidently mistaken the conventional flesh-colour, given in my former lithographs, as the natural one; indeed the flesh was rather the tint of veal or pork, as was Garrod’s specimen.

I did not measure the blood-corpuscles, leaving this to Dr. George Gulliver, to whom I supplied material for examination, and who found the corpuscles even of greater diameter than stated by Garrod. Gulliver gives the average size as 21.50 of an inch, and as compared with 20.50 inch in the White Whale (Belauga). The Manatee’s choice of food when in confinement is singular; but as yet data are too scanty to judge of what may be the likes and dislikes of the tribe. The utter silence of this Westminster-Aquarium example seems to denote that the Manatees seldom use their vocal organs; but among the males and during rutting-season I have no doubt it is otherwise. Hearing, according to Chapman and what I have observed, is acute enough. The difference in shape of tail in this and former examples, taken along with Prof. Wilder’s facial specimen (l. c.), shows a want of constancy in outline, especially as regards tapering and tip-incision. It is satisfactory for me to find my opinion of the possibility of specimens surviving transport and living in England confirmed. I think there can be no doubt of a diminution of the species in their old haunts and, like the northern Rhytinae, extinction near: hence the importance of anatomical work and study of their habits while yet possible; for as a link to the study of strange palæontological forms, we have in Manatus and Halicore only the remnants of a chance in the elucidation of a group strange and interesting to a degree, so far as ancestorship is concerned. This

1 Das peripherische Nervensystem der Wirbelthiere als Grundlage für die Kenntniss der Regionbildung der Wirbelsäule, p. 11 et seq.; Leipzig, 1878.

2 The Structure and Development of the Shoulder-girdle and Sternum in the Vertebrata, p. 219, pl. xxix. fig. 21.

3 Memoir, l. c. pl. xxiv. fig. 30.

4 "The Intrinsic Muscles of the Hand of the Thylacine and Phascogale," Camb. Journ. of Anat. and Physiol. vol. xii. p. 434 (Pt. 3, April 1878). Quite recently, and while this was in the printer’s hands, there appears in the same journal Dr. Alf. H. Young’s paper on "The Intrinsic Muscles of the Marsupial Hand (vol. xiv. p. 149, Jan. 1880), where Cunningham’s generalizations are further discussed.

article being already stretched beyond my original intention leads me to forego speaking of the affinities, which, as already mentioned, have attracted considerable attention, the more so from the recent discoveries of fossil Sirenia by Professors Owen\(^1\), Van Beneden\(^2\), and Flower\(^3\). On this subject I hope, in another memoir now in hand, to have more to say\(^4\).

DESCRIPTION OF THE PLATES.

PLATE V.

*Attitudes of Manatee when in Tank of Aquarium.*

Fig. 1. Contour which the Manatee assumes as it rises to the surface of the water, and just before breathing.

Fig. 2. Muzzle and part of the head in three-quarter view, in the act of dilating the nostrils, the after portion of the body sinking.

Fig. 3. Appearance as descending after respiratory effort, the body in this instance slightly rolled to the right.

Fig. 4. A view more from behind as the creature lazily turns over or affects a semi-rolling movement.

Fig. 5. A very common attitude assumed—the body bent in complete arch, and the animal resting thus perfectly quiescent for a long while at a stretch.

Fig. 6. The body less arched by shoulders and head being higher, but tail bent acutely. View three quarters from behind. It rests in this position frequently, and quietly remains long so.

Fig. 7. The Manatee in mid-water perfectly motionless and dozing or sleeping.

Fig. 8. A very common attitude taken, viz. with body and head nearly horizontal, and the curved tail resting on the bottom of the tank; such position adopted both when awake and dozing.

Fig. 9. Outstretched in sound slumber at the bottom of its tank.

\(^1\) Quart. Journ. Geol. Soc. 1875, p. 100, pl. iii.


\(^3\) Quart. Journ. Geol. Soc. 1874, p. 1, pl. i.

\(^4\) Quite at the last moment, while this sheet is passing through my hands, I find that Mr. Alston (vol. i. part 4, p. 92, Mammals, of Salvin and Godman's 'Biologia Centrali-Americana') refers to Prof. Flower as stating that the Brighton-Aquarium specimens never rest on their tail. Chapman's (*I. c.*) and the present specimens certainly did; and I myself feel satisfied, from a consideration of the animal's habit of frequenting and dozing in shallow lagoons, along with a study of its tail-construction, that the curving-under (see Pl. V. fig. 8) is a natural and not abnormal condition, though I am not prepared to state that every animal will revert to it when in confinement. Has the tank at Brighton with constant current of water not something to do with difference of attitude?
PLATE VI.

Different Aspects of the Head, Muzzle, and Tail of the Manatee alive and dead.

The figures are mostly about \( \frac{1}{4} \) natural size.

Fig. 1. Head of Manatee in profile, sketched when alive, and to be compared with figs. 7 and 8 of drawings when dead.

Fig. 2. A three-quarter view of head, showing muzzle under one kind of contraction.

Fig. 3. Profile of head, with mouth slightly open, wherein the muzzle is still contracted but much upraised.

Fig. 4. A front and foreshortened view of the muzzle when contracted as in fig. 3, the parts being so withdrawn as to expose the upper jaw-pad (up).

Fig. 5. Part of the muzzle and open nostril as seen in one instance of its breathing.

Fig. 6. A foreshortened aspect of the muzzle, showing the manner of apposition of the bristle-clad portions of upper lip, as seen, however, in the dead creature.

Fig. 7. Head and shoulders of Manatee in side view, sketched from the animal as it lay on the table when dead. (Compare flaccidity of muzzle with that of the living creature, fig. 1.)

Fig. 8. The same as fig. 7, with the lower jaw relaxed as the head was pulled over the edge of the table.

Fig. 9. A sketch from in front of head of the dead animal, and showing the great relaxation downwards of the upper lip.

Fig. 10. Another view of the flaccid muzzle, from in front, the upper lip presenting a median fold beneath the dilated nostrils.

Fig. 11. A view of the mouth taken when dead, the muzzle being forcibly dragged back so as to expose the upper and lower jaw-pads (up, lp) &c. In this case the circumscribed bristle-clad portions (be) of the upper lip have a tendency to become prominent and turn inwards.

Fig. 12. Sketch of tail, side view taken when in the act of swimming, and showing undulations.

PLATE VII.

Manatee feeding, and Views of Dorsum, Mamma, and Perineum.

Fig. 1. Manner in which a lettuce was grasped, and the muzzle and lips used in the act of feeding. From a sketch of the creature in the tank when alive.

Fig. 2. Outline of the carcass from above as it lay extended on the table; and for difference in contour and figure generally, compare with a similar figure given in my former memoir on the Manatee, 'Trans. Zool. Soc.' vol. viii. pl. xviii, fig. 3.
Fig. 3. Reduced sketch from nature of the right axillary region, showing position of the mamma; t, teat.

Fig. 4. The female external genitalia, of nat. size:—a, anus; r, perineal raphe; l, labium; s, vaginal orifice. Drawn from the specimen dissected by me in 1870.

PLATE VIII.

Eye, Sternum, Limb-muscles, and Dissections of the Chest for Cervical Nerves.

Fig. 1. The left eye, of natural size and colour.

Fig. 2. Front view of the sternum and part of the ribs and intercostals (i) of the right side, reduced; sc, sterno-costal muscle, and f f* fascia.

Fig. 3. A dissection of the palmar surface of the right fore limb from the elbow-joint onwards, for comparison with fig. 13, pl. xxii. Trans. Zool. Soc. vol. viii. B², biceps, second head; Ba, brachialis anticus; T³, triceps, third belly; Ul, ulnar nerve; B. ret, brachial rete; Pr, Pr, pronator radii teres and flexor carpi ulnaris; a, aponeurosis; F. com, flexor communis digitorum; F. cu & c, flexor carpi ulnaris &c.; Fbp, adp, flexor brevis and adductor pollicis; Pl, Pl, palmaris longus and flexor brevis minimi digitii; Abmd, adductor minimi digitii; Opmd, opponens minimi digitii; int, superficial interossei; I, II, III, IV, V, digits respectively.

Fig. 4. The palm further dissected. F. com, flexor communis cut and reflected; I to V, digits; l, the single delicate lumbricalis muscle; S. int, superficial interossei; D. int and D. int², deep interossei; Fbp, adp, flexor brevis and adductor pollicis; abmd, abductor minimi digitii; opmd, opponens minimi digitii.

Fig. 5. Deep dissection of back part of skull, neck, and thorax, chiefly to show the cervical nervous distribution. St, sternum thrown back; 1, 2, 3, 4, 5, 6, 7, 8, the eight pairs of anterior cervical nerves issuing from the intervertebral foramina, and relations of other parts; r*, minute tendon (only on right side) between third and fourth nerves; pn, pneumogastric nerve; ph, phrenic nerve; Sy, Sy*, sympathetic nerves and ganglia; T³, third intercostal nerve; Pn, posterior nares; Bo, basioccipital; c, condyle; a, atlas; c, c, c, bodies of fifth and sixth cervical vertebrae; d₁, d², d³, d⁴, dorsal vertebrae; Rama, rectus anticus major; Rami, rectus anticus minor; Obₘ, obliquus superior; Rl, rectus lateralis; Lc₁, Lc₂, longus colli (three bellies); Sca, scalenus; Di, digastric; Stm, sterno-mastoid, and Pa & c., panniculus carnosus &c. of left side reflected; Mm, angle of left mandible; Sh, stylohyoid bone severed; I. ret, intercostal rete of vessels; Jw, jugular vein, and ca carotid artery: the rete mirabile covering these being removed, the former vein and artery are given as contracted, the better to show the cervical nervous distribution.

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PLATE IX.

The Brain, Nerves, and Blood-vessels, of natural size.

Fig. 1. Side view. Drawn after preservation in alcohol, but modified from the cast and from a hasty outline of the object when fresh.

Fig. 2. Top view, in situ within the skull. The accurate and finished drawing of this was made before the brain was removed, the bones only being worked up from the dried skull.

Fig. 3. Basal view, with cranial and three pairs of cervical nerves. This was drawn from the specimen after preservation in alcohol, but guided by a drawing taken immediately after extraction, when fresh, along with cast of the cranial cavity.

The lettering applicable to these three figures is as follows:—1, 2, 3, 5, 6, 7, 8, 9, corresponding cranial nerves, the fourth not being shown, and 5* being lesser root of fifth; C1, C2, C3, first, second, and third cervical nerves; ga, ganglion of same; Ca, Casserian ganglion; d2, the three divisions of the fifth nerve; pd, portio dura, and pm, portio mollis of seventh nerve; gph, glossopharyngeal, pn, pneumogastric, and spa, spinal accessory divisions of eighth nerve; hy, hypoglossal or ninth nerve; ga, ganglion of first spinal nerve; r, rete mirabile, and th, theca of spinal cord; ac, anterior cerebral, mc, middle cerebral, pc, posterior cerebral arteries; ic, position of internal carotid artery cut short; W, circle of Willis; b, basilar artery; Fr, frontal bone cut through; co, condyle of occipital bone.
DIFFERENT ASPECTS, HEAD, MUZZLE & TAIL OF MANATEE ALIVE & DEAD
MANATEE FEEDING AND VIEWS OF DORSUM, MAMMA & PERINEUM.
MANATEE
EYE, STERNUM, LIMB-MUSCLES, & DISSECTION NECK & CHEST, FOR CERVICAL NERVES, &c.
V. On the Intestinal Spiral Valve in the genus Raia. By T. Jeffery Parker, B.Sc.,
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in the Royal School of Mines. (Communicated by Prof. T. H. Huxley, F.R.S.)

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I have not judged it necessary to give a special abstract of the paper, as all the results of my observations
are to be found in a condensed form in §§ 4, 6, 10, 13, and 21.

§ 1. For the last few years I have had the opportunity of examining a large number
of intestines of various species of Raia, and have been greatly struck with the astonishing
amount of variability exhibited by the spiral valve—a variability most surprising
when one considers the great physiological importance of the structure in question,
and the extent of the probable lapse of time since it first came into existence.

The best accounts of the spiral valve are to be found in the works of Claude
Perrault¹, Müller², and Duméril³, the two latter giving a general description of the
valve, with the main differences it presents in the chief genera of Elasmobranchs, while
Perrault has an excellent figure and description of the very typical form of valve
discovered by him in the "Renard marin." I have been able to find none but the most
general description of the valve of Raia; and the only figure of it I have met with is
that in Monro's 'Structure and Physiology of Fishes,' where, being drawn in its flabby
fresh condition, it is impossible to get any correct idea of its form and relations.

¹ 'Mém. pour servir à l'Hist. nat. des Animaux,' 1071. (Republished 1786.)
² Anatomie der Myxinoiden.
³ Ichthyologie Générale.
§ 2. The most convenient method of preparing the intestine for examination is to distend it, after washing out the contents with a stream of water, with a 0.5-per-cent. solution of chromic acid, and then to place it in a vessel of the same fluid for a few days. By this method the walls become thoroughly hardened, so that windows can be cut in them to any extent without danger of collapse, and the whole extent of the valve examined in a perfectly natural position. At first I adopted the plan of distending the washed intestine with air, and then drying it; but experience proved that this method was almost worse than useless.

§ 3. The oesophagus of Reia enters the abdominal cavity in its antero-dorsal region, and almost immediately passes, with slight increase of diameter, into the stomach. This passes backwards, and slightly to the left, towards the posterior end of its cavity, and then, turning sharply round to the right, and undergoing a marked decrease of diameter, passes forwards to within a short distance of the anterior end of the abdomen, where it becomes constricted to form the pylorus. Beyond this point the alimentary canal immediately widens, forming the intestine; and this, becoming at once bent round to the right, passes at first directly backwards along the right wall of the abdominal cavity, and finally downwards, forming the rectum, until it reaches the middle line and dilates into the cloaca. Thus the intestine, or at any rate that part of it in which the spiral valve is contained (the valve-gut, Klappendarm), is practically a straight tube, and may be described as having an anterior and a posterior extremity, and dorsal, ventral, right, and left sides.

The superior mesenteric artery passing to the right and somewhat ventralwards from the dorsal aorta, reaches the left side of the intestine a short distance posterior to the pylorus, and immediately passes straight backwards along the left or inner side to the rectum, the superior mesenteric vein running parallel with it. Both artery and vein send off, on each side, a set of branches nearly at right angles, in such a way that of each pair of branches one runs almost transversely along the dorsal side of the gut, the other in the same direction along its ventral side. The dorsal branch is, in every case, given off at a slightly more anterior line than the corresponding ventral branch; and the two branches, passing to the right, form an incomplete slightly oblique hoop round the intestine. The hoops thus formed, usually ten or eleven in number, correspond with the attachments to the parietes of the intestine of the successive turns of the spiral valves, with the single strange exception of the second, counting from the anterior end; this is seen, on opening the gut, to correspond to the middle of the space between the first and second turns of the valve.

The portion of intestine anterior to the first branch of the mesenteric artery and vein is usually distinguished as the duodenal portion, or bursa entiana; it receives the bile and pancreatic ducts, and is supplied by a special (duodenal) branch of the celiac artery; it differs, however, in no other respect from the remainder of the valve-gut.

The portion of intestine posterior to the last branch of the superior mesenteric
artery is distinguished as the rectum; it is supplied by a special branch of the aorta, the small inferior mesenteric artery; its mucous membrane is smoother than that of the rest of the intestine; and the spiral valve does not extend into it. With its dorsal wall is connected the characteristic rectal gland.

The pylorus is usually much contracted, and is very often produced into the cavity of the intestine as a short, thick-walled tube (Pl. X. fig. 8, and Pl. XI. fig. 3), thus forming a very perfect pyloric valve.

§ 4. A comparison of a large number of intestines of Raia shows that the spiral valve exhibits certain features of great constancy, and others, again, which vary almost indefinitely. The constant features are:—

1. The position of the anterior end of the valve.
2. The course of its outer or attached edge.

The variable features are:—

1. The length, in relation to the width of the intestine, of the attached edge, upon which depend:—
   a. The number of turns.
   b. The position of the posterior end of the valve.

2. The course and the length of the inner or free edge, upon which depend:—
   a. The direction of the successive turns of the valve.
   b. The width of the valve.
   c. The area.
   d. The resistance offered to the passage of food.

3. The character of the mucous membrane.

§ 5. The spiral valve commences immediately posterior to the pylorus, on the left (inner) and slightly towards the dorsal side of the bursa entiana. From this point its attached edge, represented in the diagrams (Pl. X. figs. 2 & 5, and Pl. XI. figs. 2, 4, 7, & 9) by the thick line, sweeps sharply backwards and ventralwards for about a quarter of a turn, along the left side of the bursa. It then, almost suddenly, changes its direction, passing into a slight backward inclination, from left to right, across the ventral side of the intestine, curving round the right side, and finally passing, more obliquely, from right to left across its dorsal side, thus completing the first turn.

With the second turn the “pitch” of the spiral line becomes again less steep, and continues to be tolerably uniform as far as the last turn but one, when it once more becomes slightly steeper.

In consequence of this the compartments or vertical spaces between successive turns, from the second to the last but one, are approximately equal, while the space between
the last but one and the last is somewhat greater, and that between the first and second is, as a rule, although not invariably, about twice as great. The second branch of the mesenteric artery and vein (mentioned above) runs across the middle of this large space between the ventral portion of the first and second turns.

A comparison of the figures will show how uniform in this respect the attached edge is; the almost isolated cases represented by figs. 1 & 4, Pl. X., are the only ones showing any marked deviation from the arrangement described.

The proportion between the length of the attached edge of the valve and the diameter of the gut is best judged of by a consideration of the number of turns of the former. This is seen in fig. 8, Pl. X., to be only 7½, while in fig. 4, Pl. X., it amounts to 9½. In some cases, not figured, I have found it to be considerably lower, and in others higher.

The proportional length of the attached edge is thus extremely inconstant; and, in consequence, the position of the posterior end of the valve varies indefinitely. It may be dorsal (Pl. XI. fig. 1), ventral (Pl. X. fig. 4), right or left (Pl. X. fig. 6), or may occupy any intermediate position.

§ 6. The free edge of the valve (represented in the diagrams by the thin line) starts at the same place as the attached edge. It passes at first directly inwards or to the right, nearly at right angles to the wall of the intestine, and then sweeps more or less sharply backwards. In consequence of this, as will be seen by an examination of the figure, and especially of the transverse section (Pl. X. fig. 3), the first half-turn of the valve, namely that part contained in the bursa entiana, is rolled upon itself, and forms a sort of hollow cone open along its dorsal side and having its apex directed forwards. This disposition of the first half-turn of the spiral valve is very constant, occurring, with but slight modification, in every specimen examined.

Beyond this point the free edge begins to acquire more or less of a spiral twist. Its simplest course would be to form a spiral line parallel with that constituted by the attached edge, in which case the whole of the valve, with the exception of the first half-turn, would be a regular screw surface. The nearest approach to this is shown in fig. 4, Pl. X., in which it will be seen that from its second turn to the last but one the valve forms a regular spiral inclined plane, the width of which is very nearly equal to the semidiameter of the intestine. For the last turn the width gradually diminishes, so that at the posterior extremity of the valve it does not exceed half the semidiameter.

The specimen from which fig. 4, Pl. X., is taken, as well as that containing the only other perfectly regular valve I have met with, was unfortunately dried, the effect of which treatment has been to make the valve shrink somewhat, and so appear narrower than it really is. If the specimen had been preserved in chromic acid, there can be no doubt that the thickened inner edge would have approached more nearly the axis of the intestine than it is seen to do in the figure; it would then have tended to coincide with
the axis, and become a straight line, thus giving a sort of columella to the spiral, and effectually preventing the passage of food in any but a spiral direction.

It is evident that, retaining the same general character as that described, a much simpler and less efficacious form of valve would be produced if the free edge, still remaining parallel to the attached edge, formed a more open spiral. This condition of things is well shown in the last four turns of the valve in fig. 1, Pl. X. (the anterior turns have undergone a modification presently to be described), the width of which is not greater than half the semidiameter of the intestine; and, in consequence, a wide passage is left down the axis of the latter, along which its contents could pass directly, or without taking a spiral direction at all. It is a valve of this sort which Perrault figures in his "Renard marin" (Alopechias vulpes), and which he aptly compares to "un escalier tournant sans noyau."

But in this valve (fig. 1)—the simplest I have met with, except one unreliable dried specimen—the anterior turns do not retain the simple character described. They have, in fact, undergone a notable increase in width, the second turn becoming as wide as the intestine itself, and, being now prevented from taking a transverse direction, have become more or less folded and deflected, the direction of the deflection being, on the whole, a backward one. Thus the inner edge of any given turn of the valve, instead of being in the same plane as its attached edge, comes to be in the same plane as the attached edge of the turn next behind, or even as that of the next but one. In fig. 1, for instance, the free edge of the fourth turn is on the same level as the attached edge of the sixth.

This state of things is carried to an extreme in the cases shown in fig. 8, Pl. X., and fig. 1, Pl. XI. In these the width of the second turn is so great that its free edges come to be on about the same level as the attached edge of the seventh; and the width of the valve gradually diminishing from the third to the seventh turns, the free edges of these also are brought approximately into the same plane. This is well shown in the cross section, fig. 9, Pl. X. The successive turns therefore form, as it were, a "nest" of imperfect truncated cones, placed, with their apices directed backwards, one inside the other, and gradually diminishing in height from the innermost to the outermost. Moreover the successive "cones" adhere so closely to one another that there is practically produced a central conical chamber, with a peripheral spiral cavity wound round it. This condition is, in fact, actually produced if such an intestine be dried; for then the successive turns become completely fused together wherever they are in contact. In the diagram of this type of valve the free edge is seen to form a very curious and complicated figure (fig. 2, Pl. XI.).

In fig. 1, Pl. X., it will be seen that the first two turns, although on the whole deflected backwards, turn at first forwards or towards the pylorus. If this anterior deflection were persevered in, and took place in every turn, we should have such a
valve as that shown in fig. 8, Pl. XI., in which there is again a "nest" of cones, but with their apices directed forwards instead of backwards, and with their altitudes approximately equal. All the turns have, indeed, the form and direction which is normal to the first, and which it retains even in extreme cases of backward deflection.

§ 7. There are thus four chief forms assumed by the spiral valve of *Raia*, the characters of which may be recapitulated as follows:

*Type A.* Simplest form: free edge in all the turns, but the first on the same level as the attached edge; width of valve not greater than half the semidiameter of the intestine. This form is more or less hypothetical, the nearest undoubted approach to it being that shown in fig. 1, Pl. X.

*Type B.* Regular spiral: the free edge is again on the same level as the corresponding portion of the attached edge; but the width of the valve is equal to the semidiameter of the intestine, so that its thickened free edge forms a columella (fig. 4, Pl. X.).

*Type C.* All the turns but the first are deflected backwards, the width of the valve becoming much greater than the semidiameter of the intestine (fig. 8, Pl. X., and fig. 1, Pl. XI.).

*Type D.* All the turns deflected forwards, the width of the valve again being considerably greater than the semidiameter of the intestine (fig. 3, Pl. XI.).

It will be seen that, of these four types, *A* forms a starting-point or stem form, from which the other three may be supposed to have diverged by the turns of the valve growing either directly inwards (*B*), or backwards (*C*), or forwards (*D*) during their increase in width. And this view is borne out by the occurrence of intermediate stages. I have found one or two undoubted transition-forms between *A* and *B*; and by far the greater number of the valves examined are intermediate either between *A* and *C* or between *A* and *D*.

§ 8. I have figured two of these intermediate forms, figs. 6 & 7, Pl. X., which show in a very striking manner that the variations in the valve are quite independent of species or sex. Both these specimens, in fact, were taken from adult male examples of *R. maculata* of as nearly as possible the same size.

To show that the variations are wholly independent of the age of the animal, I may mention that although the simplest form (fig. 1, Pl. X.) is from a small specimen, yet one of the most complicated (fig. 8, Pl. X.) is from one very little larger, while a far simpler form is often seen in full-grown animals. Moreover I have examined two or three specimens of *Ray* not more than three inches long, excluding the tail, and found that in them the valve exhibited all the variations occurring in the adult, one approaching very closely to type *C*, another to *D*.

§ 9. It will at once be perceived that the variations just described in the form of the spiral valve will produce a corresponding difference in the amount of absorption-surface
SPIRAL VALVE IN THE GENUS RAIA.

possessed by the intestine. I am enabled to express these differences numerically, through the kindness of my friend Mr. Ambrose R. Willis, B.Sc., who has taken the trouble to make for me the necessary calculations.

Taking the intestine represented in fig. 1, Pl. X., as the nearest approach to type A, and for B, C, and D, figs. 4 (Pl. X.), 1 & 3 (Pl. XI.) respectively, we have the following dimensions:—

<table>
<thead>
<tr>
<th>Type</th>
<th>Length of intestine, measured from pylorus to commencement of rectum</th>
<th>Internal area of intestine, = a.</th>
<th>Length of attached edge of spiral valve</th>
<th>Area of one side of valve, = b.</th>
<th>Total absorption-area, = a + 2b.</th>
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<tbody>
<tr>
<td>A</td>
<td>cm.</td>
<td>7</td>
<td>sq. cm.</td>
<td>44.3</td>
<td>cm.</td>
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<tr>
<td>B</td>
<td>9.5</td>
<td>92.5</td>
<td>83.9</td>
<td>69.16</td>
<td>230.82</td>
</tr>
<tr>
<td>C</td>
<td>12.5</td>
<td>145.3</td>
<td>102.1</td>
<td>183</td>
<td>511.3</td>
</tr>
<tr>
<td>D</td>
<td>10.3</td>
<td>97.1</td>
<td>82.5</td>
<td>163.68</td>
<td>434.46</td>
</tr>
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</table>

In this form, however, the areas, which it must be understood are only approximately correct, are not readily comparable, owing to the different sizes of the four specimens; and it is convenient to take a common length both for the intestine itself and for the attached edge of the valve. Taking as a standard these dimensions as they occur in A, in the above Table, we have, for all four types, the internal area of the intestine equal to 44.3 sq. cm., and the other areas as follow:—

<table>
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<tr>
<th>Type</th>
<th>Area of one side of valve</th>
<th>Total absorption-surface</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>sq. cm. 46.17</td>
<td>sq. cm. 136.64</td>
</tr>
<tr>
<td>B</td>
<td>48.26</td>
<td>143.82</td>
</tr>
<tr>
<td>C</td>
<td>105.0</td>
<td>254.3</td>
</tr>
<tr>
<td>D</td>
<td>116.2</td>
<td>276.7</td>
</tr>
</tbody>
</table>

Thus, in intestines of the same size, a valve of the type D will have about two and a half times the area of one of the type A, while the entire absorption-surface (i.e. area of both sides of valve plus internal area of intestine) will be as nearly as possible twice as great in the former as in the latter—a fact as remarkable as if (the average length of the human intestine being 25 feet) subjects were occasionally found with only 20 feet, and others with as much as 40 feet.

§ 10. The relation, in respect of absorption-surface, between the four types is stri-
ingly shown in the annexed diagram, in which the areas given above are expressed as squares. The square $ab\,cd$ represents the internal area of the intestine itself, or, in other words, the absorption-surface of a valveless gut; $ab'^1\,c'^1\,d'^1$ is the entire absorption-surface of $A$, $ab'^2\,c'^2\,d'^2$ of $B$, $ab'^3\,c'^3\,d'^3$ of $C$, and $ab'^4\,c'^4\,d'^4$ of $D$. By taking away the square $ab\,cd$ we have the gnomons $dc'b$, $d\,c'b$, $d\,c'b$, $d\,c'b$ representing the entire areas of the spiral valves of $A$, $B$, $C$, and $D$ respectively, and, of course, the trapezia $dc'\,d'\,c'$, $d\,c'\,d'\,c'$, $d\,c'\,d'\,c'$, $d\,c'\,d'\,c'$ representing the areas of one side of those valves.

§ 11. But these numbers by no means adequately express the full advantage accruing to the possessor of a perfect form of spiral valve; for, in the complicated forms, not only is the absorption-surface greater than in the less complicated, but the resistance offered to the passage of food is immensely increased, and, consequently, the time to which it is exposed to the action of the digestive fluids. For instance, in fig. 1, Pl. X., there is a clear central passage from one end of the intestine to the other nearly as wide, posteriorly, as the corresponding space in a rabbit's cæcum; in fig. 4 the whole of the food is compelled to take a spiral course, the columnelliform arrangement of the free edge of the valve quite preventing any direct passage; in fig. 1, Pl. XI., although there is a central passage, yet it is so constricted at one part of its course, namely at the apex of the conical cavity formed by the third turn, that a very small aperture is left, so small, indeed, that a dried specimen of it often becomes entirely closed; moreover a good deal of food, taking a spiral course, will become wedged in between the closely adhering turns of the valve, and very considerably delayed; finally, in fig. 3, Pl. XI., a
very perfect "columella" exists, and, owing to the peculiar form of the turns, the food must be continually forced into the narrow ends of the "cones" (that is, in a retrograde direction), the obstruction to its rapid passage being far greater than even in the last case.

§ 12. The last of the variable features mentioned in the Table on p. 51 is the character of the mucous membrane. How this differs in different individuals will be seen from the enlarged surface-views given in Pl. X. figs. 10–13. The membrane may be raised into a strong network of ridges, both ridges and intervening spaces being covered with papillæ; or there may be a very open network with a fine hexagonal reticulation in the intervals; or the fine reticulation only may be present, and no well-marked ridges developed.

It is also a fact worth mentioning, that when the mucous membrane exhibits strong papillose ridges it is usually, in chromic-acid specimens, hard and rough to the touch, almost like the rumen or reticulum of a ruminant; the whole wall also is very thick and resistant. On the other hand when the membrane appears finely pitted owing to the delicate reticulations on its surface, it feels soft, and the whole wall is usually more or less flabby.

§ 13. All these things taken together—the variation in the extent of the absorption-surface, in the resistance to the passage of food, and in the characters of the mucous membrane—make the individual differences in the intestine very great indeed. Altogether I am inclined to think that this is the most remarkable case on record of spontaneous variation in nature, since the variable structure is neither a rudimentary, nor a comparatively useless, nor a merely ornamental one, but is one the perfection of which is of the highest importance to the animal's well-being. It is quite true that, as Professor Huxley suggested to me, the Skate with the improperly developed valve has nothing to do but to eat more; but eating more means catching more; and catching more entails a greater expenditure of energy; so that, in any case, the animal in question must be rather heavily handicapped in the struggle for existence.

§ 14. I have examined the intestines of a few other Elasmobranch genera, and now give the result of my observations. These must be taken for what they are worth, which is, perhaps, not much; for with the case of the Skate before us, it seems of little use to record any but an extensive series of observations.

In a large specimen of Scyllium canicula I find an especially interesting form of valve, one, in fact, which showed a far higher development of the type D than any I had found in the Ray. This intestine is shown in fig. 5, Pl. XI: there are twelve turns to the valve, all but the last of which are strongly deflected forwards, producing a struc-

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1 The specimens brought from the market are rarely in a sufficiently fresh condition to repay microscopical examination; but if a large number of fresh specimens could be obtained, I am convinced that the histology of the Ray's intestine would be well worth careful study.
ture which must offer an immense amount of resistance to the passage of the intestinal contents, and, of course, making a decidedly greater proportional increase of surface than in any of the cases recorded of the Ray. The difficulty of cleaning out the intestine afforded a good criterion of the forms of these points; the finely divided contents stuck so tightly between the successive "cones," that a stream of water was often quite insufficient to dislodge them. In fact the chyle (if one may apply the term to what rather resembled fine mud) completely filled up the whole available space in the intestine, so that, although the animal was preserved entire in spirit, the gut and its valve were in as good a condition for examination as if the former had been carefully emptied and distended with spirit while fresh. The pyloric valve was very perfect, having the form of a short conical tube projecting into the bursa entiana, with a very small aperture at its apex. This, of course, brought about the result referred to, that only finely divided matter could find its way into the intestine.

Another point I may mention about this specimen is the great thickness of its walls at the posterior end; the thickness was actually greater than the diameter of the lumen at that part. This may have been a mere individual abnormality; but it seems not impossible that this increase of muscular substance had relation to the great force necessary to drive on the contents in a gut with so peculiar a spiral valve.

In a smaller specimen of the same species there were eight turns to the valve, of which the first five had a forward, the last three a backward direction; so that the valve was intermediate in character between C and D.

§ 15. In Notidanus I found the valve to have twenty turns, and to be very much what fig. 1, Pl. X., would be if its posterior turns reached the centre—that is, intermediate between B and C, and approaching more nearly to the former. The pylorus is like that of Scyllium, projecting into the cavity of the intestine as a short tube with a narrow aperture, and forming a highly perfect valve.

§ 16. In Cestration philippi there were eight turns to the valve; these, again, were intermediate between B and C, but approached more nearly to the latter type than in Notidanus. The pylorus was remarkable, being very wide and quite devoid of any well-marked valvular arrangement. In correspondence with this, entire Cephalopods, partially digested, were found in the intestine.

§ 17. In Chimara monstrosa (Pl. XI. fig. 6) I found a valve of only three and a half turns, remarkable from the fact that the attached edge did not form a regular spiral, but for a part of its course (namely, during the first turn) formed a slightly sinuous antero-posterior line. In consequence of this, the second compartment of the intestine was fully half as long again as the bursa entiana.

§ 18. The only other Elasmobranchs which I have been able to examine are Zygaena malleus and Carcharias lumensis, two of the genera which, instead of a spiral valve,

1 Duméril ("Ichthyologie générale") found the same number in this species.
possess what may be called a scroll valve—that is, a fold of the intestinal wall, the fixed edge of which is usually stated to "run straight and parallel with the axis of the intestine," while the fold is "rolled up upon itself into a cylindrical spiral."

This description is not strictly correct. On opening the gut along its ventral wall by a longitudinal incision (Pl. XI. fig. 8), the valve appears quite like a second intestine within and nearly filling the first. It may be unrolled from right to left; and it is thus seen that the attached edge is not in a straight line, but is slightly (though distinctly) curved, beginning just posterior to the pylorus on the right side, curving gently outwards until it actually passes to the left of the median ventral line of the intestine, and then back again to the right, to end on the dorsal side at the commencement of the rectum. The free edge is very strongly curved—the width of the valve, in the middle being equal to two thirds of its length, while at either end it gradually diminishes until the free and attached edges meet. Thus the form of the unrolled valve may be compared to that of a vertical section of a biconvex lens one surface of which has a very slight, the other a very strong curvature.

The valve thus constituted is rolled upon itself from left to right, the successive turns being comparable to a series of cylinders placed one within the other and becoming gradually larger, in length as well as in diameter, from within outwards. This is well shown in fig. 8, in which the ventral portion of each turn is cut away.

I give this description and the accompanying figures of the scroll valve of Zygaena for the sake of comparison with the spiral valve; my account adds nothing to Duvernoy's excellent description of the similar valve in Thalassorhinus vulpecula.

§ 19. In Lepidosiren I have found the spiral valve to be a well-marked, that of Ceratodus a less perfect, example of type D. To the latter Dr. Günther's description applied perfectly well:

§ 20. Lastly, in the Lamprey there is, as is well known, a ridge of mucous membrane projecting into the intestine, round the inner surface of which it takes a spiral course, the spiral being a very open one, the whole width of the valve not more than half the diameter of the gut. The valve is therefore an extremely simple example of type A.

A valve of this sort is, of course, to all intents and purposes, a typhlosole, only differing from the structure of that name in worms from the fact that its course is spiral instead of straight—just as the papillose ridges of the hind gut are spiral in Astacus, while they are straight in Homarus. Such a valve also bears a close resemblance to the embryonic condition of the spiral valve in the Elasmobranch.

§ 21. Thus the spiral valve, reduced to its simplest expression, becomes a typhlosole; and the scroll valve, indefinitely reduced in width, becomes the same thing. Even in the fully developed structures we get a sort of hint of a connexion between the two;

1 Ann. des Sci. Nat. 2e série, 1835, t. iii.
2 Phil. Trans. 1871, part ii. p. 511.
3 Balfour, 'Elasmobranch Fishes,' pl. xvii. fig. 2.
the first quarter-turn of the attached edge in \textit{Raja} is hardly more curved than the homologous portion of the valve of \textit{Zygæna}, while the greater part of the first turn in \textit{Chimæra} is almost straight, so that the portion of the valve enclosed in the second compartment in that genus is, practically, a scroll valve. The same may be said of the portion contained in the first compartment (the bursa) in \textit{Raja}, as will be seen by comparing a transverse section of that part of the gut (fig. 3, Pl. X.) with a section of the valve of \textit{Zygæna} (Pl. XI. fig. 10). These facts may be expressed in a tabular form, thus:

\begin{table}[h]
\centering
\begin{tabular}{|c|c|}
\hline
Type & Description  \\
\hline
A & Spiral valve  \\
B & Scroll valve  \\
C &  \\
D &  \\
\hline
\end{tabular}
\end{table}

This Table is intended to express that both spiral and scroll valves are derivable from the typhlosole, that the then culminating forms of the spiral valve \textit{B}, \textit{C}, and \textit{D} are derivable from the simple form \textit{A}, and that, of the three, \textit{D} is the most differentiated, in virtue of possessing the greatest extent of surface, and offering the greatest resistance to the passage of the intestinal contents.

\textsection{22.} In conclusion, I have to express my thanks to Professor Huxley for placing at my disposal specimens of \textit{Chimæra}, \textit{Cestracion}, \textit{Notidanus}, and \textit{Ceratodus}, to Dr. Günther for allowing me to examine specimens of \textit{Zygæna} and \textit{Carcharias} in the British-Museum collection, and, chiefly, to Mr. Willis for devoting much time and trouble to the estimation of the surface in the chief forms of spiral valve.
DESCRIPTION OF THE PLATES.

PLATE X.

Fig. 1. Longitudinal section of the intestine of Raia, sp., made by removing the whole ventral half of both gut and spiral valve (an example of type A).

Fig. 2. Diagram of spiral valve corresponding to fig. 1, constructed by representing the course of the attached edge by a thick line, and that of the free edge by a thin line.

Fig. 3. Transverse section through the bursa entiana of another specimen, showing the way the valve is rolled upon itself in the first part of its course.

Fig. 4. Longitudinal section of another (dried) specimen (an example of type B).

Fig. 5. Diagram corresponding to fig. 4.

Fig. 6. Intestine of R. maculata (male), with the ventral portion of each turn of the valve cut away.

Fig. 7. Intestine of another specimen of R. maculata (male), dissected in the same manner as fig. 6.

Fig. 8. Intestine of Raia, sp., with the ventral wall of each compartment removed, the valve being left intact (type C).

Fig. 9. Obtained by cutting the same intestine across the line $ab$, and viewing the upper moiety from below.

Fig. 10. Mucous membrane of the first turn of the spiral valve of a specimen of Raia maculata $\delta$ ($\times 6$).

Fig. 11. The same in R. batis $\delta$ ($\times 6$).

Fig. 12. The same in R. maculata $\delta$ ($\times 6$).

Fig. 13. The same in R. batis $\delta$ ($\times 6$).

PLATE XI.

Fig. 1. Intestine of Raia, sp., in longitudinal section (type C).

Fig. 2. Diagram corresponding to fig. 1.

Fig. 3. Intestine of Raia, sp., dissected similarly to fig. 7, Pl. X. (type D).

Fig. 4. Diagram corresponding to fig. 3.

Fig. 5. Intestine of Scyllium canicula $\delta$ (half nat. size). Dissected similarly to fig. 8.

Fig. 6. Intestine of Chimæra monstrosa, dissected similarly to fig. 8, Pl. X.

Fig. 7. Diagram corresponding to fig. 6.

Fig. 8. Intestine of Zygæna malleus, opened along the middle ventral line, and reflected to right and left (in consequence of this the intestine appears much wider than it really is); the ventral portion of each turn of the scroll-valve cut away.

Fig. 9. Diagram corresponding to fig. 8.

Fig. 10. Transverse section through the middle of the same intestine ($\times 2$).
INTESTINAL SPIRAL VALVES OF RAIA
INTESTINAL SPIRAL VALVES OF RAIA
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 Continued on page 3 of Wrapper. ]
VI. On the Genera and Species of the Lepidopterous Subfamily Ophiderinæ inhabiting the Indian Region. By F. Moore, F.Z.S. etc.

Received January 19th, read January 20th, 1880.

[Plates XII.-XIV.]

The genus Ophideres was first characterized in 1832, in the 'Voyage de l'Astrolabe' ("Entom." p. 245), by Dr. Boisduval, who described a single species from Brazil under the name of O. princeps. In Guérin's 'Iconogr. Règn. Anim.' ("Ins." pl. lxxxix. f. 1), he further figured a Madagascar species as O. imperator, which he redescribed and figured (the male) in 1833, in the 'Faune Entom. Madagasc. Bourb. et Maur.' p. 99, pl. xiv. fig. 3.

In 1852 M. Guenée, in the 'Spec. Gén. des Lép. Noctuelites;' iii. p. 109, recharacterized the genus, including in it and describing all the then known species of the group. This arrangement was followed by Mr. Walker in 1857, in the British-Museum 'Catalogue of Lepidoptera Heterocera,' and has been continued by all subsequent writers.

Having made a recent examination of the several species of this interesting group of Moths, I submit the result in the following pages, treating therein, however, only of the species of the Indian Region. The species being much diversified in the form of the external outline of the fore wings, and also in the shape of the terminal joint of the palpi, as well as exhibiting a dissimilarity in the pattern of markings in the sexes, I have found it necessary to group them under various genera, and to restrict the genus Ophideres to its type, namely O. princeps. Of six of the species described, figures are here given of the larva and pupa, copied from original drawings made in India by Mr. A. Grote, Sir W. Elliot, and Mr. S. N. Ward, and from others made in Java by the late Dr. Horsfield.

This group of Moths has hitherto been placed by entomologists between the families Catocalidæ and Erebidæ; they have, however, closer affinity to the Ophiusidæ, their larva also agreeing better with those of the latter in form. The genus Lagoptera is very closely allied to them. I therefore place them, together with the subfamily Phyllodinae, between the Bendidæ (of which family Hulodes caranea is a well-known insect) and the Ophiusidæ.
Genus Othreis, Hübner.

*Corycia*, Hübner, ib. p. 265.
*Ophideres* (part), Guenée, Walker.

Fore wing elongated; costa nearly straight, slightly arched near the end, apex acute; exterior margin oblique and slightly convex hindward, even in the male, scalloped in the female; posterior margin short, with a fringed lobe near base, and slight excavation beyond; costal vein extending to near apex; first and second branches of subcostal at equal distances before end of cell, third starting from the second at a short distance beyond the cell and forked near the apex, fifth anastomosed to third near its juncture with the second, sixth from angle below end of the cell; discocellular very slender, recurved; two upper median branches from angles above lower end of the cell, third from its end, and fourth at one third; submedian bent near the base. Hind wing broad, anterior margin extending beyond angle of fore wing; exterior margin convex, with a slight subanal angle, abdominal margin short; costal vein recurved, extending to apex; subcostal with two branches from end of the cell; discocellular very slender, deeply concave; upper median branches from pointed angles at end of the cell, lower contiguous; three submedians. Body robust, densely clothed above; fore femora and tibiae thickly pilose beneath, the latter furnished beneath with an elongated, ciliated, glandular spur; middle and hind legs less pilose, with spurred tibiae and spined tarsi; palpi large, long, ascending, second joint clothed with short adpressed hairy scales, third joint slender, long, and with a slight hairy tuft above. Antennae filiform, long, thickened towards the base.

Larva semilooped, cylindrical, sparsely covered with minute hairs; with sixteen feet, but the first pair of ventrals rudimentary; eleventh segment thickened at the dorsal extremity and surrounded by a tubercular spot. When at rest holds the head up and also the last segments; frequently curling the anterior segments up in front. Changes to pupa in a canopy of growing leaves fixed together and lined with a net-like web; pupa fastened by the tail.

**Othreis fullonica.** (Plate XII. figs. 1, 1a, larva and pupa; Plate XIII. figs. 1, 1a, imago, ♂♀.)

*Phalaena B. fullonica*, Linn. Syst. Nat. ii. p. 812 (1767); Clerck, Icones, pl. xlvi. figs. 1–4 (Seba, Ins. t. 42. f. 13, 14?).
Male. Fore wing dark ferruginous-brown or vinous-brown, numerously covered with either ochreous, dark green, or greyish stripes, which on the exterior border form irregular fasciae and terminate in a straight streak to the apex; an ante- and a postmedian oblique transverse darker brown line, the interspace glossy and suffused generally with purple-brown, the reniform mark being more or less unglossed. Hind wing orange-yellow, with a broad black apical marginal band and row of pale yellow cilia spots; a large broad curved black discal band. Thorax, head, palpi, and legs above dark brown; abdomen orange-yellow; legs and abdomen beneath paler; a yellow spot on tibia and tarsal joints; palpi black-tipped.

Female. Fore wing brighter-coloured, mottled grey and brown, stripes paler grey; discal area and fasciae on exterior border chalybeous-grey; postmedian line irregularly sinuous, with a prominent white dentate spot on its middle end narrow lunules below it; reniform mark triangular, and more or less black; a minute black orbicular spot. Hind wing and body as in male.

Expanse 3 to 4½ inches.

Hab. India, N.W. Himalayas (Masuri, Kussowlie), Lucknow, Umballa, E. Himalayas (Darjiling), Cachar, Allipore, W. and E. Ghauts (Bombay, Malabar, Madras); Ceylon; Andamans; Malay peninsula; Penang; Sumatra; Java; Formosa; Shanghai.

From the above-cited localities (specimens from which have been examined) it will be seen that this species has a very extended range of habitat. Specimens have been also occasionally recorded as having been taken on board ship in the eastern seas, many miles from land. It also occurs at Moreton Bay, Australia; and an allied (or probably the same) species, was taken by Mr. Wallace on Ké Island. Other closely allied species from New Hebrides and Navigators' Islands, and another from Sierra Leone, are in the British-Museum Collection.

This insect is stated to be dreaded by the Australian colonists on account of the mischief the image causes to the orange plantations—perforating the ripening fruit with its proboscis, and thus causing them to soon fall to the ground and rot.

This insect has been reared by Mr. A. Grote at Allipore, near Calcutta, from larve feeding on Menispermum glabrum. Sir W. Elliot reared it at Vizagapatam on Cocculus acuminatus and C. cordifolius; and in Java it was frequently reared by Dr. Horsfield from larve feeding on the Tayungan (Epibatherium, sp.) and on the Buntia Silit (Leschenaultia, sp.) from November to April, being most abundant in the latter month.

Major A. M. Lang, in his Entomological Note-book, gives the following account of the rearing of the larva of this species at Lucknow in 1866:

"September 8th. Took from the middle of the underside of a leaf of (? Menispermum) a solitary, spherical, smooth, unsculptured, translucent, light-yellowish egg, about 3"" in diameter. Four or five more found on the 18th, all on the underside. On the 11th a
minute Geometriform larva was hatched; it was very active, dropping itself by a silken thread when disturbed; transparent, yellow and blackish in alternate belts, sparsely covered with hairs; fourteen legs (those on 6th segment wanting); head disproportionately large, holding the head up and also the two last segments.

“On the 13th it changed to a shining, translucent green, the anterior and posterior segments very much more pale and yellow, 4" long; head now the smallest segment, dull pale testaceous, the rest of the segments a pale translucent yellow, which, however, in segments 2 to 9 inclusive, look green—a light bright grass-green—the colour seeming to come from the inside; on the 4th, 5th, 6th, 7th, and 10th segments are pale brown lateral patches; every segment has apparently ten black tubercular spots, each carrying a hair; legs black.

“On the 14th it changed to a velvety black, of the same form and attitude as before; a vermilion spot on each side of the 5th and 6th segments, on the 5th each spot accompanied by an anterior white speck; white lateral markings on 10th and 11th segments.

“On the 17th it changed to a black, with rufous and white ocelli where the vermillion spots were in preceding stage, and several rufous and white specks.

“On the 20th it changed to a most handsome variegated rufous and black, with innumerable lilac, white, and rufous scattered specks.

“On the 25th it spun a leaf loosely across itself, on a bush above ground, and turned into pupa.

“On October 8th the perfect insect (*O. fullonica*) emerged.”

This insect has also been reared at Canara by Mr. S. N. Ward, from whose MS. is the following extract:—“Larva with sixteen feet, but the first pair of ventrals almost obsolete and retractile. Body cylindrical, smooth, and velvety to the touch, but with scattered minute hairs over all the body; 11th segment much thickened at the extremity, falling off abruptly behind, and surmounted by a red currant-like spot. The colour of the larva changes considerably, but is always either pinkish or brownish-purple, or a rich yellow-brown, with dark stripe down the back, a double one on top, and near the bottom of sides; another quite at bottom, and another down middle of belly. On 5th and 6th segments are eye-spots, white, with a tinge of rich yellow above, brown below, and surrounded by a black ring; on 9th and 10th segments is a saddle-like white mark. Head moderate-sized, rather oblong and reddish brown. Changes to pupa between growing leaves, which it knits together with a very tough net-like web, and lines it with one much finer and softer; pupa fastened by the tail, which is furnished with a treble forked bristle in middle with hooks turned outwards, and small bristle on each side hooked inward. Pupa conical, front part rather flattened, and upper part of thorax rather sharper than usual, but not carinated; it is engine-turned all over except articulations, which are soft; they are red; but all the rest is fine shining bronze-colour. Feeds on the Hordee suppoo. September and October. Changes in twenty-two days.”
Othreis cajeta. (Plate XIII. figs. 2, 2a, ♂♀.)

Ophideres cajeta, Guenée, Noct. iiii. p. 112, ♂♀.

Male. Fore wing dark umber-brown, suffused with greyish fawn-colour externally, greyest at the posterior angle; a few grey strigæ disposed on basal and costal areas, and a basal and subapical cluster of green or cream and dark brown scales; veins alternate pale and black-speckled; an equidistant curved antemedian and a postmedian transverse blackish double line, prominent and pale-centred in some, indistinct in others; a small pale-circled dark orbicular spot, and pale-bordered, dark, elongated, lunular, reniform mark. Hind wing orange-yellow; a black apical marginal band, with row of yellow cilia spots, and a short, black, curved, discal band. Thorax, head, palpi, and legs above brown, legs with white spots.

Female. Fore wing brownish fawn-colour, numerous covered with black, pale-grey-bordered, speckled strigæ, which are thickly disposed along the costa, and form irregular fascie across the disk; posterior angle broadly greyish, above which is a small dentate whitish spot; reniform mark prominent, angled hindward and black-lined; a minute black, pale-circled, orbicular spot. Hind wing and body as in male.

Expanse 3 to 3 ½ inches.

Hub. S. India (Malabar and Madras); Ceylon.

This species has a limited range, the specimens under examination having been either from South India or Ceylon. It is very rare. A single specimen is in the Banksian Cabinet in the British Museum; but there are none in the General Cabinet.

"Larva feeds on the Muttee (Terminalia, sp.). Found in September. Makes a slight web within a canopy of living leaves. Pupa plum-colour, with a thick bloom or powder which comes off when touched; front part smooth, top of thorax rounded; the three first segments of thorax very much humped, the succeeding ones decreasing in size like steps; extremity blunt and rounded, with several hooked bristles disposed like a bow-string." (S. N. Ward, MS. Notes.)

Othreis ancilla. (Plate XII. figs. 2, 2a, larva and pupa; Plate XIII. figs. 3, 3a, imago ♂♀.)

Phalena striigata, Donovan, Ins. Ind. pl. liv. (1800), ♀.
Male. Fore wing deep ferruginous-brown, with numerous darker brown strigæ; crossed by indistinct greenish-brown fasciae, which are bordered with glaucous-grey or purple; a subbasal, an antemedian, and a postmedian transverse oblique black line; a brown-bordered reniform mark. Hind wing orange-yellow; marginal black band attenuated hindward, ciliar spots yellow; a short black bilobed discal band. Thorax, head, palpi, fore and middle legs deep ferruginous-brown; abdomen and hind legs orange-yellow.

Female. Fore wing dark purple-brown, strigæ darker, transverse fasciae glaucous-purple, postmedian transverse oblique black line sinuous hindward, a broad longitudinal irregular green band extending below the cell from near base to beyond postmedian line; reniform mark partly green. Other parts as in male.

Expanse $2\frac{1}{4}$ to 3 inches.

Hab. India (Allahabad, Bombay, Canara, Nilgiris, Darjiling); Ceylon.

"Larva half-looper; sixteen legs, the first ventral pair being so slightly developed as to be useless for the purpose of progression; cylindrical, the 11th segment raised, and the apex surmounted by a single blunt red tubercle raised above the skin, behind which the body slopes abruptly down towards the anal legs; spiracles oval and black. General colour dusky purplish-brown, dotted with numerous minute cobalt-blue spots regularly arranged, and with large yellow oval patches on the 4th, 5th, and 6th segments, those on the sides of the 5th and 6th being in the shape of ocelli, the iris yellow, pupil azure blue, surrounded by black; the 9th and 10th segments also patched with yellow irregularly more or less. Changes to pupa beneath a canopy of living leaves fastened firmly together and thinly lined with a bed of silk; pupa fastened by the tail; of an orange-colour, beautifully burnished and rough like shagreen; the lower part of the thorax is much compressed, in fact quite sharp. Found during June, July, and August and sparingly in October and November below the Ghats, and in July and August above the Ghats." (S. N. Ward, MS. Notes.)

Has been reared by Dr. Thwaites, in Ceylon, from larva feeding on Menispermum; Mr. S. N. Ward reared the larva, in Canara, upon Cocculus villosus.

Othreis smaragdipicta.


Female. Fore wing deep ferruginous-brown, with a purplish tinge, varied with black strigæ, which are darkest and thickly confluent on the costa and disk; an irregular-shaped longitudinal bright green band extending from the base below the cell, its broad basal centre being brown; some green strigæ along the costa, and a thick cluster below the apex and along exterior border. Hind wing orange-yellow, marginal black band broad, extending paler along the costa and suffusing the base; a short black bilobed
disca band. Thorax, head, palpi, fore legs in front, and tarsi beneath dark ferruginous-brown, thorax grey-speckled; abdomen above orange-yellow, beneath blackish.

Expanse 3 inches.


**Khadira, n. gen.**

Differs from *Othreis* in the fore wing having a decided falcate apex, the hind margin with shorter and more deeply excavated space between the angles; the hind wing also shorter; the palpi having the third joint slender and not tufted at the apex, the second joint also being more slender; fore tibiae less tufted, and tarsi more spinous.

**Khadira aurantia.** (Plate XIII. fig. 4.)


**Male.** Fore wing dark ochre-red, with numerous short transverse grey strigae, veins alternate grey- and black-speckled; a narrow black oblique band from apex to middle of excavation on hind margin; the oblique band, two inner and two outer transverse dusky fasciae bordered inwardly with purple-grey: hind wing pale orange-yellow, with a black, short, curved, narrow submarginal band, and broader, short, constricted discal band. Thorax, head, palpi, fore legs in front, and antennae ochre-red; abdomen pale orange-yellow. Underside orange-yellow; fore wing with a dusky patch at the apex, and two blackish short curved oblique discal streaks above posterior angle; hind wing with a short black discal spot and an indistinct dusky outer fascia.

Expanse 4 inches.


**Adris, n. gen.**

Fore wing: costa arched beyond the middle, convex at the end, the apex being produced into a lengthened point; exterior margin very oblique, convex, the angle very acute; posterior margin very short in the male, lobe much produced, excavation beyond short. Hind wing prolonged anteriorly, the exterior margin slightly concave below the apex; veins similar to those in *Othreis*. Palpi larger and stouter than in the other genus, more laxly clothed, the third joint with a large, flattened, dense tuft above. Fore tibia in male more densely clothed with longer lateral hairs.

Type *A. tyrannus*.

**Adris tyrannus.** (Plate XIII. fig. 5, 6.)


**Male.** Fore wing dark ochreous-brown, with indistinct darker transverse sinuous fasciae bordered with chalybeous purple; sparsely covered with dark red-brown delicate
transverse strigae; veins black-speckled; a narrow blackish antemedian line and an oblique postmedian line from the apex, each with paler inner border, the latter also bordered externally at the apical end with green speckles; a small black orbicular spot, and distinct green-speckled reniform mark; a small black subbasal spot and cluster of green speckles. Hind wing ochreous-yellow, the base tinged with brown; a narrow curved black submarginal band (entirely separated from the outer margin), and a short broader bilobed discal band. Thorax, head, palpi, and legs above dark ochreous-brown, abdomen ochreous-yellow.

Female. Fore wing ochreous-green, numerously covered with red-brown delicate strigae, transverse lines red-brown; some greyish-speckled spots towards the apex and on the disk, and a similarly coloured marginal patch from posterior angle. Hind wing and body as in male.

Expanse 4 inches.

Hab. India (Simla, Darjiling, Bombay); China (Shanghai); Japan.

"Taken in forests at Simla; disturbed from the thickets in broad daylight it dashes off very suddenly and swiftly with a blind headlong flight, like a frightened owl." (Major A. M. Lang, MS. Notes.)

Adris eutilus, n. sp.

Male. Fore wing ferruginous, crossed by darker wavy greyish-bordered fasciae; an indistinct antemedian transverse line and a prominent postmedian oblique black line; a cluster of green speckles near the base, another on reniform mark, and a few along outer border of the oblique line. Hind wing orange-yellow, an elongated narrow curved black submarginal band, and a small short black lobate discal spot. Thorax, head, palpi, and fore legs in front ferruginous; abdomen above and beneath, and legs yellow.

Expanse 3½ inches.


"Larva feeds on Menispermaceae." (Dr. Thwaites, MS. Note.)

Purbia, n. gen.

Both sexes with shorter wings; fore wings broad, the exterior margin straight below the apex, oblique, even, lobe of hind margin very broad, more so than in any other of the group, the excavation being also very concave. Palpi similar to those in A. tyrannus, but the second joint broad at its apex; fore tibiae very densely tufted.
Purpia discrepans. (Plate XIV. fig. 1, c.)


Ophideres archon, Felder, Reise der Novara, Lep. pl. exii. f. 3 (1873–4), ᵇ.

Male. Fore wing pale purplish-brown or fawn-colour, with a few black speckles along the costa and on the veins; crossed by three very indistinct and incomplete narrow brown bands, the outer sinuously recurved and bordered externally by clusters of greenish scales; an indistinct greenish subbasal spot and a green-speckled reiform mark. Hind wing orange-yellow, with broad black apical marginal band, the row of cilia spots and apical angle being white; a short broad curved black discal band. Thorax, head, palpi, and legs purplish brown; abdomen orange-yellow.

Female. Differs in having a narrow white reiform mark, and two short linear white spots on middle of the disk.

Expanse 3 to $3\frac{1}{2}$ inches.

Hab. India (Malabar); Siam; Singapore; Java.

Menas, Hübner.


Ophideres (part), Guenée, Walker.

Fore wing elongated, trigonal; costa slightly arched towards the end, apex acute; exterior margin oblique, straight; posterior margin long, with a tufted angle near base; slightly curved to the end. Palpi short, compactly clothed with short scales; apical joint small, very short, and conical. Larva similar in form to that of Othreis.

Menas salaminia. (Plate XII. figs. 3, 3 a, 3 b, larva and pupa; Plate XIV. fig. 2, imago.)


Noctua salaminia, Fabr. Ent. Syst. iii. 2, p. 17 (1793).


Male and Female. Fore wing dark green with golden reflections; a broad purplish-grey costal band extending from near base of hind margin to the apex, and a narrow similar band on exterior border, the costal band with numerous short green and ochreous transverse stigae, which are confluent along the costal border, the exterior band with paler purplish-green inner border; a distinct red line along the discal portion of the lower median vein. Hind wing orange-yellow, with a black apical marginal band and yellow cilia spots, and a short black bilobed discal band. Thorax, head, palpi, and front of fore legs ochreous-green; abdomen and legs orange-yellow.

Expanse 3 to $3\frac{1}{2}$ inches.

Vol. xi.—Part III. No. 2.—March, 1881.
Hab. India (Kussowlie, Darjiling, Khasias, Calcutta, Nilgiris, Madras); Ceylon; Singapore; Java; Formosa; Shanghai; Japan.

A widely distributed species, which has also been taken at sea in north of Bay of Bengal in October. A specimen from Australia is in the British-Museum collection.

Larva reared on Menispermum glabrum at Allipore, by Mr. A. Grote. In Ceylon the larva is also found on the same plant. Dr. Horsfield reared it in Java during February and March from larva feeding on a species of Cissus.

VANDANA, n. gen.

Fore wing less angular in form than in Manas salaminia, the costal border more arched, and the hind wing with a greater width of lobe at the base; second joint of the palpi longer, and the third joint very long and slender.

VANDANA dividens.


Female. Fore wing pale fawn-colour, greenish and darkest along the costa, and with a slight rosy tinge, base tinged with pale olive-green; crossed by a dark sap-green oblique band, which is attenuated at the apex and dilating in width to posterior margin, the inner border of the band even, and the outer border irregular hindward; reniform mark black, elongated longitudinally, angled at the lower end of the cell, and divided by a pale line along the discocellular vein; a pale sap-green narrow fascia outside the oblique band. Hind wing orange-yellow, marginal black band broad, with small yellow ciliary spots; short black bilobed discal band also broad. Thorax, head, palpi, legs, and body beneath brownish fawn-colour; abdomen above orange-yellow. Underside: fore wing brown, with an oblique medial band, and base of hind margin only yellow; hind wing with the marginal brown band extending broadly along the costa to the base.

Expanse 3½ inches.


RHYTIA, Hübner.

Ophideres (part), Gueneé, Walker.

Fore wing in male and female with the exterior margin even, and angled outward in the middle; palpi very long, the third joint with broad clavate tufted tip. Larva similar in form to that of Othreis, but with slight dorsal protuberance on the 5th, 6th, 7th and 11th segments.
**RHYTIA COCALE.** (Plate XII. figs. 5, 5a, larva and pupa; Plate XIV. figs. 5, 5a, imago ♂♀.)


_Ophideres cocalus_, Guenée, Noct. iii. p. 115, ♂.


**Male.** Fore wing ochrous green, numerous with slender black transverse striae, those across the disk and on exterior margin grey-bordered; crossed by a curved antemedial and an oblique postmedial black line, both with chalybeous-grey inner border; reniform mark indistinct: hind wing orange-yellow, with broad black marginal bands and small white ciliial spots and narrow streak at apex. Thorax, head, palpi, and legs in front ochrous-green, palpi with a lateral linear grey streak; abdomen and legs above orange-yellow, beneath greyish.

**Female.** Darker ochrous green, with a cluster of creamy-white spots on the discocellular area, another series below the cell, a large patch at the posterior angle, and a slender linear broken spot below the apex: hind wing and body as in male.

**Expans** 2½ to 3 inches.

**Hab.** India (Coromandel, Silhet); Java.

This species has a similar pattern of markings to _R. hypermnestra_, but may easily be distinguished from it by the absence in the hind wing, in both sexes, of the two black discal spots, and in the black marginal band extending to the anal angle, the inner border of which is much less irregularly sinuous, and the row of ciliial spots also are much smaller; the fore wing in the male has the two transverse lines more curved, and the clusters of spots in the female are more confluent. It has been reared in Java by Dr. Horsfield from larva feeding on a species of _Epibatherium_.

**RHYTIA HYPERMNESTRA.** (Plate XII. fig. 6, larva; Plate XIV. figs. 4, 4a, imago ♂♀.)


**Male.** Fore wing ochrous-green, numerous with slender blackish transverse striae; crossed by a distinct antemedian and an oblique postmedian brown line; an indistinct dusky brown suffused reniform mark; a curved grey streak below the apex, and grey striae above posterior angle; transverse lines with chalybeous-grey inner border. Hind wing orange-yellow, with broad marginal black band, white ciliial row of spots and apical angle; and two small black discal spots, the upper one oval, the lower recurved. Thorax, head, palpi, and fore legs in front ochrous-green, palpi
with a lateral linear grey streak; abdomen and legs above orange-yellow, beneath grey.

Female. Fore wing darker green, with a series of creamy-white spots on the disco-cellular area, another series below the cell, a large patch at the posterior angle, and two small slender spots below the apex, all partially crossed by slender brown stigiae.

Expanse 3 to 3 3/4 inches.

Hab. India (Bombay, Canara, Nilgiris, Darjiling, Khasia); Burmah (Moulmein); Andamans; Ceylon.

"Larva semilooper, cylindrical, elongated, slightly humped on the 4th, 5th, 6th, and 11th segments. Legs fourteen, with a rudimentary pair on 6th segment. Colour dusky purplish-brown, blotched with very dark brown, and spotted with minute dots of cobalt-blue; on each side of 5th and 6th segments is a large ocellus, the iris bright yellow in front and vermilion behind, pupil purplish-brown, with a crescent of cobalt-blue, and with a centre which is considerably darker than the rest; besides these the body is extensively marked with black and yellow patches of different shapes. Changes occupy twenty-six days." (S. N. Ward, M.S. Notes, Canara.)

Argadesa, n. gen.

Ophideres (part), Guenee, Walker.

Fore wing in male and female with the exterior margin oblique and scalloped throughout its length; palpi shorter, and the third joint slender. Larva similar in form to that of Othreis.

Argadesa materna. (Plate XII. figs. 4, 4 a, b, c, d, larva and pupa; Plate XIV. fig. 5, 3 a, imago, c II.)


Triphaena materna, Westwood, Nat. Libr. xxxvii. Exotic Moths, p. 201, pl. xxv. fig. 2.


Noctua hybrida, Fabricius, Syst. Ent. p. 593.

Male. Fore wing greenish-grey, covered with greenish-brown or purple-brown transverse confluent stigiae; a short curved dark brown antemedian costal line and a distinct oblique postmedian line; between the lines are three purple-glossed, plumbeous, longitudinal streaks, the upper short and near the costa, the next from lower angle of the cell, the third below the cell; reniform mark trilobed, purple-black; a narrow grey streak curving below the apex and spreading irregularly to the posterior angle. Hind
wing orange-yellow, with a narrow black marginal band and prominent white cilia spots; a single small black discal spot. Thorax greenish grey, head and palpi above brown, palpi black-tipped; fore legs brownish above; abdomen and legs orange-yellow.

Female with darker and more prominent stigmas, the three longitudinal discal streaks much larger, broader, contiguous, purple-glossed, and narrowly divided and bordered with white; hind wing and body as in male.

Expanse $2\frac{1}{2}$ to $3\frac{1}{2}$ inches.

Hab. India (Kussowlie, Lucknow, Allahabad, Kutch, Kattywar, Bombay, Canara, Madras, Calcutta, Balasore); Ceylon; Java.

This insect has also been taken in the island of Madagascar. A specimen from Abyssinia, collected by Mr. Jesse, and another from Gambia are in the collection of the British Museum. It has also been taken at sea in the north of the Bay of Bengal.

"Larva, after last change, $2\frac{1}{2}$ inches long; half Geometrous, long, cylindrical, stout, with the penultimate segment much elevated, and the anterior ones strong; ground-colour red-brown, darker at the hinder and foremost segments, more of an olive-brown in the middle; dorsal line well defined and bistre-colour, on either side of which a similar line, bearing on 5th and 6th segments a splendid 'ocellus,' the upper part of which is primrose, with the lower half purplish brown, with a lilac pupil; sides and middle of back variegated irregularly with lilac and yellow spots and yellow fascia; on penultimate segment a coral-coloured protuberance, spotted with lilac here and there, with on either side a broad yellow fascia; abdomen lighter than back, with a dark ventral line; legs all red-brown, tipped with black; anal legs very long; head dark coral-colour; stigmas violet.

"In state of repose it curls the head and 4th and 5th segments right under the body, forming a circle.

"Turned into pupa 28th Sept., between the leaves. Imago came out 7th October. Period on the wing Sept., Oct.; Lucknow." (Capt. H. L. De la Chaumette, MS. note, 1860.)

Mr. S. N. Ward, in his MS. notes on the Lepidoptera of Canara, says the "larva feeds on the Amoordah Beeloo, changing to pupa among the leaves, which are fastened together with coarse yellow threads, the changes occupying fifteen days. Found from September to December."

Larva reared on Menispermum globatum at Allipore, by Mr. A. Grote. Sir W. Elliot reared it on Cocculus cordifolius; and in Java Dr. Horsfield reared the larva on both Leschenaultia and Epibatherium.
DESCRIPTION OF THE PLATES.

PLATE XII.

Fig. 1. *Othreis fullonica*, larva (Allipore, A. Grote), p. 64.
Fig. 1a. " " pupa (Java, Horsfield), p. 64.
Fig. 2, 2a. *Othreis ancilla*, larva and pupa (Canara, Ward), p. 67.
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Fig. 3a, b. " " larva and pupa (Java, Horsfield), p. 71.
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Fig. 4, 4b, c, d. " " larva and pupa (Allipore, A. Grote), p. 74.
Fig. 5, 5a. *Rhytia cocale*, larva and pupa (Java, Horsfield), p. 73.
Fig. 6. " " *hypermnestra*, larva (Canara, Ward), p. 73.

PLATE XIII.

Fig. 1. *Othreis fullonica* ♂; fig. 1a, ♀ : p. 64. Fig. 4. *Khadira aurantia*, p. 69.
Fig. 2. " " *cajeta* ♂; fig. 2a, ♀ : p. 67. Fig. 5. *Adris tyrannus* ♂, p. 69.
Fig. 3. " " *ancilla* ♂ fig. 3a, ♀ : p. 67.

PLATE XIV.

Fig. 1. *Purbia discrepans* ♂, p. 71. Fig. 4. *Rhytia hypermnestra* ♂; fig. 4a, ♀ : p. 73.
Fig. 2. *Menas salaminia*, p. 71. Fig. 5. " " *cocale* ♂; fig. 5a, ♀ : p. 73.
Fig. 3. *Argadesa materna* ♂; fig. 3a, ♀ : p. 74.
TRANSFORMATIONS OF OPHIDERINE.
SPECIES OF OPHIDERINÆ
VII. On the Structure of the Skull in the Chameleons.
By W. K. Parker, F.R.S., F.Z.S.

Received March 15th, 1880.

[Plates XV.–XIX.]

Besides specimens in my collection of full-grown Chameleons of the common kind and one of the dwarf kind (C. pumilus), I received, some years since, a new-born young one of the common species from my friend Mr. T. J. Moore, of Liverpool.

This gave me an opportunity of comparing an early condition of this strangely formed skull with its permanent form; and the comparison of the two stages gave me the most unexpected results: I found that the conception I had formed of the high, posterior part of the skull, by comparison of it with the same parts in other Lizards, was as wrong as could well be, and that my interpretation of these coalesced and highly modified parts was worth as much as all guesswork is worth, viz. worse than nothing.

Having found my "key," I shall use it carefully in opening the meaning of this, the most singular of all skulls. I shall describe the adult skull first, being confident now of its true meaning; and of it I shall take the outworks first and the inner building afterwards. Then the skull of the young will be described, and its conformity and nonconformity to other and more typical kinds of Lacertilian skulls shown.

After that the dwarf kind will yield its less aberrant skull, to show that there is nothing absolutely unchangeable in any type of skull, but that the more striking modifications of structure are mobile as it were, and are always ready to oscillate this way and that towards other morphological types and patterns.

Nothing is easier than to speak glibly of generalized types and of types that are specialized; in practice, however, no such facility is possible. Here is a family of Lizards whose whole construction is special and aberrant to a marvellous and almost unique degree; and yet these very types are the most archaic, the lowest, and the most generalized, in many respects, of all the known Lacertilia.

So much so is this the case, that every zoologist or anatomist describing the Lizards, as a group, and giving their zoological and morphological characters, would have to qualify one half of his description by repeatedly saying, "except in the Chameleons."

I have long ago shown how remarkably this type differs from the other Lizards in its vol. xi.—part iii. No. 4.—March, 1881.
shoulder-girdle and sternum ("Shoulder-girdle and Sternum," plate xi. figs. 4–6, p. 122); and I have no doubt that every part of its organization, if well worked out, would show some very important modifications.

But in the culminating types of any group whatever, some archaic characters are sure to crop up. I find this "survival" in the Frog among the Anura, and in the Nimble and Green Lizards among the Lacertilia: in the former, which is the best pattern-form for the group, there are two or three characters that are exceptional; and in the latter, the most refined and delicate forms in the Lizard group, the whole cranial roof, from snout to occiput, might have been directly, and not remotely, derived from some most ancient Ganoid fish (see "On the Skull of the Lacertilia," Phil. Trans. 1879, part ii. plate 42, p. 597).

Skull of the Adult Chameleon (Chamaeleo vulgaris).

Seen from above, or below, the outline of this skull is a long oval; from the side it is seen to have a short, steep face, almost as steep and short as that of a Tortoise, and to be surmounted behind by an exorbitant three-limbed crest; it has huge eye-sockets, and a steep hinder region.

In this species, and still more in other larger and more bizarre kinds, the marginal bones of the skull-roof are very large, crested, and adorned with knobs and prickles, as though it were showing a Selachian atavism, and had compounded its investing bones out of the shagreen prickles and the ossified skin of some such Placoid forefather.

The roof dips; and the frontal is not seen from the side; and the whole upper outline, looked at from above (Plate XVI. fig. 3), is like the plan of a double arch, with the coronal suture as a common basal line. But the keystone in front, the single premaxillary (px), is wedged in between the fore face below and the fore skull above. The hinder keystone, the interparietal (ip), binds and finishes the arch that springs from the great auditory wings (Plate XVI. fig. 4). The lower edge of the fore part of the skull spreads out into a much broader structure than the upper; its margins are the maxillaries (mx); the upper outline of the fore part is formed by the prefrontals (p.f) (superficial or dermal ethmoids). The middle of the upper margin is formed by the post-orbitals (pt.o); and the form is finished behind by a pair of compound bones, the squamoso-parietals (sq. p.). Thus the single adult frontal (f) is completely enclosed, and forms the centre of the somewhat sunken roof, which is finished behind by the base of the huge crested interparietal (ip).

The lower surface shows a broad latticework, very complex, and very compound; it is composed of subcutaneous plates and of submucous bones (that are ectostoses in lower types), of cartilage, and of cartilage-bones; for in this view we see the basis cranii, the complex palate, and the marginal bones of the face. The side view (fig. 1) shows the steepness of the face, the height of the crest behind, the strength of the flat jaws,
the depth of the mandibular pier, and the size of the eye-sockets, with their mem-
brane-cartilaginous partition.

The end view (fig. 4) shows an almost vertical structure, semioval in shape, which is
the frame of a system of openings or archways. In the centre we see the foramen
magnum (f. m) on each side; above, the huge temporal openings; directly below, the arch-
way under the skull and between the steep pterygoids (pfg); and outside those bones a
steep oblique space, whose outer boundary is the high vertical quadrato mandibular
pier; this outer space, on each side, is again subdivided by the transit of the long
descending columella auris.

A. The Investing Bones.

This remarkable building must now be taken to pieces (ideally), and described part
by part.

The frontals (f) are completely fused together, and form a broad plate over the fore
part of the cranial cavity. The coronal suture is nearly transverse; and in front of it,
contrary to rule, in a hollow surrounded by tubercles, we see the round fontanelle (f0).
Each side of the bone is cut away in a concave manner four times; and the fore part is
a sharp spike wedged in between the nasals.

Those bones (n) are small and falciform, with their sharp ends, behind, binding on the
last shallow pair of notches on the frontal. In front a sharp spike of bone, the nasal
process of the premaxillary (n. px), wedges in between these broad ends, and almost
touches the frontal wedge.

The margins are formed above, half by the prefrontals (p.f) and half by the so-called
postfrontals ("postorbitals" pt.o). Each prefrontal is an irregular plate of bone, high-
crested and arched; it encircles the front third of the huge orbit, and runs inwards as an
anteorbital plate behind the nasal capsule. Above, it articulates by sutures with two of
the shallow notches of the frontal; it is then itself notched in a crescentic manner,
leaving an oval membranous space between it and the narrow part of the corresponding
nasal; its narrowed fore part binds, first upon the broad end of the nasal, and then upon
the nasal process of the premaxillary. In front (fig. 1) it reaches down to articulate
with the maxillary (mx) above the nasal opening (al. n, e. n); and behind it articulates
with the postorbital (pt.o) over the middle of the orbit. The suture at this part is
jagged or dentate; and both the bones being narrowed where they meet, a triangular
part of the frontal (f) appears in the roof of the orbit.

The fenestra between the nasal and prefrontal (n. f) is directly over the continuous
aliseptal roof; here the fenestra is in the bony investment; in Lacerta that roof is
complete, but the cartilaginous capsule is imperfect, there being a nasal fenestra in the
proximal part of the aliseptal cartilage on each side ("Skull of Lacertilia," part i. Phil.
Trans. 1879, pl. xliii. fig. 7, p. 607). The next bone, the postorbital (pt.o), has its fore
half binding against the roof (f, i.p), and its hinder half projecting outside and beyond it,
and reaching round the great temporal space to articulate with the squamosal \( (sq) \). It has a sharp, crested, ornate upper part, which passes, hollow and flat, to the roof; then it descends as a long, subtriangular spike behind the orbit, which spike binds on the front of the upturned malar or jugal bone \( (j) \). Where it articulates with the prefrontal, there it shows an orbital part articulating with the frontal over the eyeball. The squamosal \( (sq) \) is a very sharp bone: but it appears to be larger than it is; for the ascending part, which runs up to the interparietal crest, is half of it due to another bone, and the suture can be faintly seen even in the adult \( (\text{fig. 1, } sq, p) \). That other bone is a subarcuate thickish rod, all that remains of the parietal. From the point of fusion downwards the squamosal enlarges and forks, one fork passing forwards to articulate, by a long sinuous suture, with the postorbital, and the other behind a round arched space; under this archway the anterior canal and its ampulla \( (a. s. c) \) can be seen. The hind fork descends as a straight process to articulate with the "otic process" of the quadrate \( (q, ot. p) \). On the other side of the archway the squamosal sets its fore foot upon the thick top of the jugal \( (j) \). The inner face of the hinder fork does not directly bind upon the parotic wings \( (\text{fig. 4, } op, sq) \), but there is another temporal bone \( (s.t) \) wedged in between those two parts: this is a wedge-shaped bone, sharp above and thick below; it reaches halfway to the parietal above, and nearly down to the quadrate below.

The interparietal \( (i.p) \) forms the broad hinder third of the roof, behind the coronal suture, which is slightly concave in front; the wings of this T-shaped bone articulate obliquely with the broadest part of the huge postorbital \( (pt.o) \); and then each wing of the bone ends by a gently concave margin which overroofs the occipital arch \( (s.o) \). From the tubercular growths that surround the fontanelle \( (fo) \) in the hollow of this hind part of the frontal, the interparietal arises (covered here with tubercles) into a huge, flat, falcate, free crest, whose convex margin is above, and the concave margin of which, at its proximal third, rests directly upon a crest that grows upwards from the supraoccipital \( (\text{figs. 1 and 4, } i.p, s.o) \). At its highest part, behind, it is thickened and knobbed, and is embraced by the top part of the parietals \( (p) \), which expand somewhat to articulate with its double thickening. Below and behind it is a rather thin lamina; and for some depth the supraoccipital \( (s.o) \) is as thin as the plate which rests upon it.

The upper view \( (\text{fig. 3}) \) shows to what an extent the hinder part of the three parietals \( (i.p, p) \) have shot up out of the reach of the cranial cavity, relatively lessened to a tithe of its original bulk \( (\text{see Plate XV.}) \); and now these bones mainly enclose the largely open temporal space right and left; in the young we see them lying down upon the great fontanelle of the tumid cranium. Here the huge temporal space is bounded by the interparietal within, and by the postorbital and combined squamosal and parietal outside.

Seen from below or above, the infero-lateral series of bones are like a Gothic arch; the key-stone of this arch is formed by the premaxillary \( (px) \), which is a wedge
THE SKULL IN THE CHAMELEONS.

with a rounded lower end and a sharp thin upper part—the nasal process (n. px). Only
the broad end is seen in the lower view; for the maxillaries (mx) close under it, as they
close under the paired rudiments in the human embryo! This wedge is thickened again,
above (fig. 3), where it binds together the two prefrontals; it then runs sharp and thin
between the nasals. The maxillaries (mx) are large bones, high in front, and gently
lessened backwards into a sharp jugal process. In front they have a deep round notch,
in which the outer nostril and its enclosing cartilages (e.n, al.n) lie. In front each bone
is not far from its fellow, and is ornate; behind the nostril the bone rises as a strong
rounded process, which props up the prefrontal. Descending thence in a crescentic
manner, it leaves a space for the small oblong lacrimal (fig. 1, l), inside which is seen
the large triangular lacrimal canal (l. c), bounded on its inside by the antorbital
plate of the prefrontal.

Only the maxillary (above) bears teeth; and these are confluent with the jaw.
From the lacrimal the jugal (j) runs back, no larger than it at first; but bending
up behind at more than a right angle, it becomes a broad and thick bar, finishing the
orbit, propping up the fore fork of the squamosal, and is itself clamped in front by the
stylloid lower crus of the postorbital.

The lower surface of the skull (fig. 2) shows the maxillary as having a wide palatine
plate up to its junction with the palatine bone (pa); thence it becomes less than
half its anterior width. Behind the junction of the maxillaries in front, in the semi-
oval space formed by their divergence, we see the single vomer (v); its length is one
half greater than its breadth; its sides are concave; and so is its inferior surface; it
projects into the notch between the maxillaries; and the palatines articulate with
its posterior margin, which is a rounded notch. It is a thick but not very high bone
(Plate XVIII. figs. 2–5).

The ascending processes of the palatine bones (fig. 2, pa) are united together by
suture for a greater length than that of the vomer; together these upper arched
spurs are not equal to the lower flat region of these bones.

The lower part of each palatine grows outwards and forwards, and articulates
obliquely with the palatine plate of the maxillary; behind, the inner margin of each
bone, at the lower plane, approaches the mid line; and thus a grooved space is formed,
into which both the internal nostrils (choææ, i. n) open. These passages are large,
ove, with their long axis parallel to the axis of the skull, and their inner boundary
the notched tract between the lower and upper part of the palatines. In front of and
outside each inner nostril there is a membranous space, bounded on its inside by the
vomer, and on its outside by the palatine process of the maxillary. Above this space,
and above the vomer, there is in most Lizards, as in the Serpents, a thin curled laminar
bone—the "septo-maxillary;" it does not exist in the Chameleon.

Where the broad lower part of each palatine articulates with the pterygoid (py),
behind the co-adapted upper spurs, the base of the cartilaginous orbital septum (p.s, p.e) is seen, with a widening membranous space on each side of it as the pterygoids diverge backwards. These bones (fig. 2, pg) are one half longer than the palatines, and they pass obliquely inside these bones, and then send out a triangular spur close behind the suture. Then they seem to lessen to one half their front width; but this is due to a change in the direction of the expanded part from horizontal to vertical.

Their hinder part is the broader by far, and is a large reniform lobe (fig. 1), which is lowest opposite the ascending jugal bone (j), and then rises to be attached by ligament to the quadrate (q). Instead of passing within that bone, it comes short of it by a definite space. Behind the sinuous inner margin of the flat part, the pterygoid has an oblique facet of cartilage, which lies obliquely over and outside a similar facet on the "basipterygoid" (b.pg.). Attached to the outer spur of the pterygoid, and wedged between it and the jugal process of the maxillary, is a four-cornered oblique plate of bone, one third the size of the palatine; this is the "transpalatine" (t, pa). This bone forms, with the pterygoid, the hind boundary of a large oval palatine fenestra, the outer wall of which is formed by the maxillary and the inner by the palatine.

The investing bones of the lower jaw (Plate XVI. fig. 1, and Plate XVII. fig. 1) are a dense well-compacted series of splints. The dentary (d) is much the largest of these, and occupies nearly all the outer face of the jaw and carries all the teeth; it is seen, above and below, on the inner side. On the outside, within and behind the dentary, the articular (ar) is invested with the angular (ag), a small style; the supraangular (s.ag), is a wider plate, which overlaps the jaw and is seen most on the inner side (Plate XVII. fig. 1). On the inner side, in turn overlapping the supra-angularare, we see the large four-cornered coronoid (cr), whose upper angle forms the crest or coronoid part of the jaw; it bends down upon the supra-angularare behind, the articularare below, and the dentary and splenial in front. The latter bone (Plate XVII. fig. 1, sp) is a thin lath of bone, widest in front, where it reaches the chin, and narrowest behind; it hides the upper edge of Meckel's cartilage (mk).

B. The Endocranium.

The inner part of the skull is composed of membrane, cartilage, and bone; the hind part is largely ossified, but keeps most of the subdividing synchondroses. The fore part is cartilaginous, with subcentral calcifications running in certain lines between the orbits; the ethmoidal and nasal regions are free even from this deposit (Plate XVII. figs. 1-4). In front of the postcranial roof there is a long pyriform fontanelle; and the tract between the eye and ear is largely membranous. This arises from the arrest of the alisphenoid (a.l.s); the orbitosphenoidal tracts are very narrow, and become mere lips to the orbital septum, only spreading again in the cribriform region, where the olfactory
nerves (i) pierce the narrow floor of this shallow part of the skull, where it is closing in above the fore end of the orbital septum.

The rest is a broad, subquadrate, inflated, double pouch, forming the paired nasal capsules (Plate XVII. figs. 3 & 4).

The occipital condyle (oc. e) is semicircular, and receives into its substance the exoccipitals and basioccipital; the notochordal "dimple" is obsolete; its upper edge (Plate XVI. fig. 4) is straight, and its lower more than half a circle. This condyle is nearly twice as large as the foramen magnum (f. m) above it—a small gothic archway. The basioccipital (b.o) is a large bony wedge, convex behind, at its narrow part, but hollowed in front, where it joins the basisphenoid (Plate XVI. figs. 2–4, b.o); its cranial surface is slightly concave.

Standing on this bone, right and left, we see the exoccipitals (e.o): but these are not simple now (Plate XVI. fig. 4, e.o, op, & Plate XVII. fig. 4); they have coalesced with the extended opisthotics. Hence they seem not only to give exit to the 9th, 10th, and 12th nerves (ix, x, xii), but also to contain the lower and hinder part of the posterior and horizontal canals, and to form the large solid parotic wings (op).

The supraoccipital (s.o) is also compound; for it has gained two additional bones, the epiotics, and therefore encloses the anterior and posterior canals (a. s. c, p. s. c) at their junction. It forms the upper half of the foramen magnum (f. m), rises high up above that passage, and then, suddenly narrowing, forms a crest—that, at its narrow top, on which the interparietal (i.p) rests. This occipital "tegmen" runs as far forward as to the alisphenoid (Plate XVII. figs. 1, 3, 4, a.l.s); it is wedge-shaped laterally, and emarginate above (Plate XVII. fig. 1 & 4, s.o). In front (Plate XVII. fig. 4, s.o, ep) this epitoico-supraoccipital ends in five tooth-like projections, the middle of which is the crest, whilst the outer two are part of the original epiotic. On account of the curious manner in which the hind roof is, so to speak, tilted forwards, the epiotic rides obliquely over the top of the prootic (Plate XVII. figs. 1, 3, ep, pro).

The prootics (Plate XVI. fig. 1, and Plate XVII. figs. 1, 3–6, pro) contain most of the anterior and horizontal canals (a. s. c, h. s. c); they lie below the epiotic region of the compound roof-bone (ep, s.o); and the two eminences caused by the ampullæ of those canals are close behind the foramen ovale (Plate XVII. figs. 3, 4, v). On the inside of the skull (Plate XVII. fig. 1, pr. o) the prootic is seen in front of the triradiate synchondrosis, in the fork of which we see the epiotic (ep), and behind the stem the opisthotic (op).

In the upper view (Plate XVII. fig. 4) the anterior and posterior canals (a. s. c, p. s. c) are seen projecting from the prootics and opisthotics, and meeting in the epiotic to unite into one tube; the horizontal canal is beneath the anterior, and is therefore out of sight in this aspect (see fig. 6, h. s. c). In the inner view the prootic is seen to rest, behind, on the basioccipital (b.o), although it mainly lies on the basisphenoid (b.s.; see also the section, Plate XVIII. fig. 12, b.s, pr.o). The meatus internus (Plate XVII. fig. 1, viii)
is seen a little distance behind the foramen ovale (v); the 9th and 10th nerves (ix, x) escape between the opisthotic and exoccipital, the chink between these ankylosed bones being large on the inside; the 12th nerve (Plate XVI. fig. 4, xii) pierces the exoccipital.

The basisphenoid is a large winged bone; below (Plate XVI. fig. 2, bs), it is seen to be split behind, and to have its hind margin somewhat concave to receive the rounded fore edge of the basisoccipital (b.o). It narrows forwards, is hollow both above and below (Plate XVIII. figs. 11 & 12); and in front the part below the pituitary cup (Plate XVII. fig. 1, py, b.s) is no thicker than the base of the orbital septum, the end of which it ossifies. That cup, the "sella turcica" (py), has a thick bottom; and its hinder margin is the oblique forwardly-tilted postcinoid wall (p.ol). On each side of this hollow the bone grows out as a large oblique expanding wing—the basipterygoid process (b.py), the direction of which is forwards, outwards, and downwards (Plate XVI. figs. 2, 4, Plate XVII. fig. 3, and Plate XVIII. figs. 11 & 12, b.py). These wings have a facet on their enlarged free ends; and these articulate with the facets of the pterygoid, the basipterygoid processes lying between and below the pterygoid bones. The alisphenoid (Plate XVII. figs. 1, 3, 4, al.s) arises from the prepituitary part of the basisphenoid; it is a thickish semioseous band, filling up scarcely a quarter of the alisphenoidal region; the rest is membranous. It is free and pointed above, the point looking forwards in the membranous space. We miss here the latticework of cartilage seen in the smaller and more typical Lizards (see Phil. Trans. 1879, pl. 43), both in the alisphenoidal and orboto-sphenoidal region. The Chameleon’s alisphenoid is ossified in its lower half; and at its root and in its upper falciform part it is calcified more or less, as in other Lacertilia.

A large rounded space of membrane intervenes between the orboto-alisphenoid (Plate XVII. figs. 1–3, o.s, al.s). This is not bounded by cartilage, but the roof-bone comes down to this part and rests on these cartilaginous wings. This is where the upper part of the huge postorbital (pt.o) wedges in over the orbit, behind the orbital plate of the frontal (Plate XVI. fig. 1); the latter plate rests on the orboto-sphenoid, and the postorbital on the interparietal, near its junction with the frontal. In old specimens (Plate XVII. fig. 3, p.s, o.s) the presphenoid becomes osseous; this tract leans against the ossified part of the alisphenoid, and descends at a right angle to that bar; the cartilage is continuous between them. In the angle the large round optic fenestra (ii) is seen; and in front of the presphenoid there is an oval fenestra twice the size of the optic passage; this is the interorbital space (i.o.f); it is a long notch in the Lizard (op. cit. pl. 43. fig. 8, i.o.n). Endosteal tracts are to be traced, in old specimens, under the optic passage and under and over the interorbital fenestra, up to the point where the middle wall belongs to the ethmoid (p.e). From the basisphenoid to the anteorbital cartilage the basal line is slightly arched or concave; the upper line is still more concave (Plate XVII. fig. 3).

In the upper view of the endocranium (Plate XVII. fig. 4), the orboto-sphenoidal
wings (o.s) are seen to be only one third as wide behind as the alisphenoids (al.s); they become only half their hinder width, and then expand again as they pass into the ali-ethmoidal laminae (al.e), where the floor of the skull passes into the roof of the nasal pouches.

Near each other, in the middle of this rewidened tract, the small oblique olfactory passages I are seen; and further forwards, under these wings, the orbito-nasal nerves (figs. 3 & 4, v') enter the nasal labyrinth. Where the middle ethmoid passes into the septum nasi (Plate XVII. fig. 1, p.e, s.n), there is no "cranio-facial fenestra," as in Lacerta (op. cit. pl. 43. figs. 1 & 2, c.f.f') and Trachydosaurus, but, as in the Struthionidae among Birds, the orbito-nasal partition is continuous, except in the presphenoidal region.

The valley over the ethmoidal wings has no ascending (tegmina) or cartilage growing over it either here or in Lacerta; but all Birds show a spike-shaped remnant of the front cranial roof of the "Ichthyopsida" mounting over the channel for the olfactory nerves. The endocranial roof, however, is very large behind in the Chameleon, as I have just shown.

The nasal labyrinth, as seen from above (Plate XVII. fig. 4), looks like a quadricellular capsule. It has four nearly equal swellings: the hinder pair are circular; and the front pair have a helicoid appearance. The postero-lateral edge, in front of the ali-ethmoidal laminae (al.e) is sinuously notched; and in the notch are packed, right and left, the nasal glands (n.g). This is the position of these glands in certain birds where they are moderately developed, as the Rhea and Fowl (Phil. Trans. 1866, pl. 9. fig. 5, n.g, and 1869, pl. 86. fig. 9, n.g). In Snakes and most Lizards, where the vomers are distinct, these glands lie in the vomers as in a dish, and are covered by a lid-like bone—the septo-maxillary (Phil. Trans. 1878, pl. 33, and 1879, pl. 42. v, n.g, s.m.x).

Here, in the Chameleon, the high (supero-posterior) position of these glands is the correlate (as in the Fowl), of a single vomer, and of suppression of the septo-maxillaries. There is no more than a broad lip-like prenasal cartilage (Plate XVII. figs. 1, 3, & 4, p.n), slightly bent downwards in front. Outside, in front, the outer nostrils (e.n) are nearly encircled by a confluent labial (al.n) or alinasal cartilage, nearly closed above, and very similar to the cartilaginous "annulus tympanicus" of the Frog. In the anteorbital region the nasal labyrinth is complicated by an ethmo-palatine cartilage (Plate XVII. fig. 3, and Plate XVIII. figs. 6 & 6a, e.pa).

Endocranium as seen in transverse sections.

Here the various sections throw a welcome light upon the structure of the nasal labyrinth (Plate XVII. fig. 2, and Plate XVIII. figs. 2–6a). In the side view of the septum nasi the cartilage is seen to be thickened at the ends and middle of the septum; and the part removed to expose this structure (Plate XVII. fig. 2) shows that the pouch on each side is subdivided into two, and that each of these

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is a double pouch. The front division opens outwards as the outer nostril, and the hinder into the inner nostril, outside the ascending submesial process of the palatine bone (see also Plate XVI. fig. 2, pa, i. n).

In the transverse sections through and in front of the outer nostril (Plate XVIII. figs. 2–5), we see how the cornua trabeculae (c. tr) form the dilated floor, and that to these horns are added the growths of the annular alinasal (al.n).

Directly behind the nostrils (fig. 5) the septum nasi (s. n) is seen to be definitely rounded below, a form which it keeps as it passes backwards as the septum also of the orbits (the perpendicular ethmoid and presphenoid—p.e, p.s).

At the widest part of the nasal pouch, through the middle of the hinder division, we see that the alisepal cartilage (Plate XVIII. figs. 6 & 6a, al.sp) becomes both wall and floor (a. w, n. f) as well as roof. The floor is dilated where it presses against the intruded upper palatine process (pa) on each side; and near this part the cartilage grows inwards so as to form a semicircle (half a coil) with the outer part of the floor; this half-coil is the "inferior turbinal" (i. tb). Where the wall turns inwards, below, to form the floor, there, on the outside, a large pedate process of cartilage grows downwards and inwards; this is the ethmo-palatine cartilage (e.p. pa), which generally becomes confluent with the nasal pouch even in the Urodela; it is very large in the Chameleon.

Behind the nasal pouches and the hinder part of the ethmoidal roof the perpendicular ethmoid (Plate XVIII. fig. 7, al.e, p.e) is still no deeper than the septum nasi (fig. 6, s. n); but it is much thicker, and the top of it is grooved, and in the groove run the olfactory nerves (i). The next section (fig. 8) shows a similar structure; but in front of the interorbital fenestra the cartilage, now presphenoid (fig. 9, p.s), is of considerable depth and is becoming thin in the middle. The next section (fig. 10) is through the common optic foramen (ii.); and now the cranial cavity is suddenly widened to receive the fore part of the hemispheres.

The next two sections (figs. 11 & 12) are through the alisphenoidal region, and where the mid brain lies; the cavity of the skull is here at its widest. The first of them is close in front of, and the next directly behind, the "sella turcica." In the first (fig. 11) the alisphenoids (al.s) are cut through where they are seen to rest on the basisphenoid (b.s), which is deeply scooped above for the pituitary body (p.y), and below shows the beginning of the basipterygoid wings (b.pg).

The partly ossified anterior part of the supraoccipital (s.o) is shown in the next section (fig. 12); here the sides are membranous, and through a hole in this large fenestra, below, the trigeminal nerve (v.) is seen emerging. The prootic (pro) passes forward under the foramen ovale, and articulates with the broader part of the basisphenoid (b.s), which is subconcave above and winged below (b.pg).

In the next section (Plate XVII. fig. 5) the supraoccipital (s.o) is seen as a thickish vertical plate under the interparietal (i.p); the notch between this part and the epiciotic (ep) is cut through (see figs. 1, 3, & 4). Here the arch of the anterior canal (a. s.e)
is cut through in the epiotic, and the arch of the horizontal canal \((h. s.o)\) is cut through in the prootic \((pr. o)\). That bone extends outwards, and flanks the "paroccipital," or wing of the combined opisthotic and exoccipital (fig. 4, \(pr. o, op\)). The vestibule \((vb)\) is laid open in this section, and the passage into it, viz. the fenestra ovalis \((f. o)\), close in front of the columella. Below this opening a wedge of bone is seen: this is the antero-inferior part of the opisthotic \((op)\); see also fig. 1. Here the section of the cranial cavity is hourglass-shaped, the auditory capsule bulging inwards; the stem of the triradiate synchondrosis, between the three periotic elements, is here cut through downwards, and the cartilage of the anterior fork, between the epiotic and prootic, is cut across. The 4-edged wedge of bone belonging to the opisthotic \((op)\) rests obliquely upon the edge of the fore part of the basioccipital \((b.o)\), which is at its broadest here: it is gently concave above, and much more scooped below (see also Plate XVI. fig. 4, \(b.o\)). In the next section (Plate XVII. fig. 6), the epiotic and supraoccipital \((ep, s.o)\) are continuous, and are of great extent (see also figs. 1, 3, 4): the spinous process is thinner, and passes gradually into the roof \((s.o)\), which also passes into the epiotic \((ep)\). This region contains the neck of the anterior canal \((a. s.c)\) where it is passing into that of the posterior canal. The horizontal canal \((h. s.c)\) is seen in section in the prootic \((pr. o)\); and the vestibule \((vb)\) is shown opening out at the fenestra ovalis \((f.o)\). Here the stapediaal end of the columella \((st)\) is seen filling up the opening, and the rest of the columella \((m.st, e.st)\) is shown attached to the inside of the quadrate, which is cut through obliquely, showing the pedicle \((pd)\) and the shoulder of this pier \((q)\). The investing bones over this part are not figured. Here a thin wedge of the opisthotic \((op)\) is cut through; this is the part which in higher Lacertilia divides the \textit{fenestra ovalis} from the \textit{fenestra rotunda}. At this part the opisthotic is distinct from the exoccipital; this latter bone \((e.o)\) is here shown as helping to form the passage for the 9th and 10th nerves \((ix, x)\). The basioccipital \((b.o)\) is here at its narrowest part, close in front of the occipital condyle.

The next section (Plate XVII. fig. 7) is through the root of the condyle, the thickest part of the parotic process \((op)\), and the hind part of the quadrate \((q)\), behind the columella. The posterior canal \((p. s.c)\) is here cut through; and here the ridged roof-piece \((s.o, ep)\) is very solid. The vestibule \((vb)\) is still seen behind the fenestra ovalis: this is the part of the sac which corresponds to the more distinct rudiment of the cochlea, seen in the higher kinds of Reptilia (including most Lizards). The vestibular sac here intervenes between the exoccipital \((e.o)\) and the opisthotic \((op)\), which has here its most solid and outstanding part, forming most of the "parotic process." The basioccipital \((b.o)\) has here widened again somewhat before its end in the substance of the condyle. This section is behind the prootic and the two front canals; the quadrate \((q)\) is cut down from the otic process \((ot. p)\) to its lower condyle \((q. c)\). The cartilage on the inner face of the auditory sac is the hinder fork of the triradiate tract (see fig. 1).
On the Investing Bones displayed in the transversely-vertical sections.

By going over the figures of these sections in detail, we shall recapitulate what has been said of this system of bones; the reader will compare these illustrations with those showing the skull in various aspects.

Section 1 (Plate XVIII. fig. 1).—This is through the fore part of the skull, and shows how the maxillaries (mx) embrace the premaxillary (px), especially below; besides the sharp dentary edges of the former, the upper part of each bone has begun to form the large supracranial valley.

Section 2.—Here (fig. 2), in front of the outer nostrils (e. n), the maxillaries (mx) are scooped in forming the passage, and are two-winged; they are crested above, have a ridge below the crest, and are cultrate at their inturned lower edge. The premaxillary (u. px) is now a small wedge between the upper part, only, of the two bones, above the end of the nasal pouches. Below, an oblique wedge of bone is seen; this is the large left fork of the vomer (v) cut through.

Section 3.—Here (fig. 3) the skull was divided through the nostrils (e. n); and thus the maxillaries (mx) are seen in two parts on each side. The premaxillary (n. px) has thickened again; and the right, or lesser, fork of the vomer (v) is cut through as well as the larger spur.

Section 4.—In this section (fig. 4), which is also through the nostrils (e. n), the nasals (n) are cut through at their foremost pointed end; the other parts are closely like what was shown in the last.

Section 5.—Here (fig. 5), close behind the nostrils, the vomer is cut through behind its notched part; it is hollow both above and below, and much wider in the latter region. There is here a definite space between the vomer and the inner edge of each maxillary bone (mx); and the nasal and intermaxillary wedges (n. n.mx) are larger.

Section 6.—In this section (fig. 6) two pairs of new bones are cut through; it was made through the widest part of the hinder pouches. The cranial trough is now very large and deep; for above the maxillaries (mx) a pair of large, solid, obliquely-crested bones have come into view. These are the prefrontals (p.f). The sharp wedges of the nasals and premaxillaries (n. n. px) only cover the middle part of the nasal roof (al.sp); there is here only a fibrous mat (n. f) over the nasal sacs, right and left. Below, the vomer has given place to the upper processes of the palatines (pa), which are thick styles: the maxillaries are here thick slabs of bone, sharp above, subcultrate below, and having a sharp process running inwards, the rudiment of a palatine plate. Between the wall and this partial floor the ethmo-palatine (epa) is lodged, just as the "pro-ribbon" is lodged between the laminae of the premaxillary in a Batrachian.

Section 7.—This slice (fig. 7) is from behind the nasal pouches, and also behind the nasals and premaxillaries. Here the frontal (f) comes in at the mid line, and it forms the keystone to a low inverted arch, the piers of which are the large, diverging, sinuous prefrontals (p.f); the frontal is here subconvex above and carinate below.
Here the palatines (pa) are cut through both in their upper and lower regions, and the space between the right and left lower laminae is the postnasal channel (i. n). The maxillary (mx) is lowering down towards the lacrimal bone, and is strongly buttressed by the palatines.

Section 8.—A little further back (fig. 8) the frontal (f) is twice as wide, and has acquired a tubercular ridge; its sides turn up and carry the prefrontals (p.f) on them; it is still slightly carinate below; the prefrontals are now one third less. The nasal channel (i. n) is now at its most contracted part, and the palatines (pa) at their steepest and widest middle part. The maxillaries (mx) are of the same shape as in the last section.

Section 9.—The prefrontals have now become still narrower, and the frontal broader (fig. 9, p.f, f); the latter has lost its lower keel; and the crest above is a mass of tubercles. The palatines (pa) are separated both from the orbital septum (presphenoid, p.s) and from the maxillaries (mx).

Section 10.—In this section the jugal and jugal processes of the maxillary are not retained, but the roof-bones are shown in situ. This slice is through the common optic passage (fig. 10, ii) and through the hinder part of the frontal (f), where the tubercles crowd between the fenestra and the coronoid suture (see Plate XVI. fig. 3). The thick-crested frontal (f) is very solid at this part; and at its edges it carries a new pair of bones, viz. the postorbitals (pt.o). As in the last, the valley is shallower and the skull-roof wider. Here the pterygoids (pg) are in section, close in front of the transpalatines (see Plate XVI. fig. 2, t.pa).

Section 11.—This is behind the orbits and through the alisphenoid and basisphenoid (fig. 11, al.s, b.s); and here the second single roof-bone, the “interparietal” (i.p), is cut through, close behind the coronoid suture. Here we see by this and the last sections that the cranial cavity is much foreshortened the last contained the fore end of that space; and this part of the cavity is covered by a production of the parietals. This middle bone is very solid; its sides are now shelving; and it lies directly on the dura mater. The postorbitals (pt.o) also are shelving, are crested at their outer edge, and then run downwards as a thick facial plate.

Section 12.—In this section (fig. 12) the roof-bone (i.p) does not rest on the dura mater, but is separated from it by a considerable space; its crest is higher; and its sides are thin, and do not meet the thin hind part of the postorbital (pt.o), which is cut through close in front of the ascending process of the jugal (Plate XVI. fig. 1, pt.o, j).

Section 13.—This section (Plate XVII. fig. 5) is through the large deep temporal spaces and the fore part of the ear-capsule. The roof is partly membranous; where it is covered in above it is not by investing bone but by the bottom of a high wall growing from the endocranial roof, or supraoccipital (s.o); the roof-bone is another crest on the top of that, a long distance from the cranial cavity. This latter part is thickened
above and below and winged at the middle; it is the high interparietal crest (i.p) (see also fig. 1). Bounding the temporal space, right and left, is the crest of the squamosal (sq), which rests on the supratemporal (s.t), forking over it; the pedicle of the quadrate (pd) is here cut across.

Section 14.—Both crests are now very high (Plate XVII. fig. 6); and the interparietal (i.p) is thickest above, and tuberculate both there and in the middle; the outer bones are not figured.

Section 15.—Here the section of the crest (Plate XVII. fig. 7, i.p) is very similar to the last, and the squamosal (sq) has the form it showed in fig. 5; the supratemporal (s.t) is here cut through in its hinder part.

The Postoral (Visceral) Arches.

A preoral arch, the ethmo-palatine, has already been described (see Plate XVII. fig. 3, and Plate XVIII. figs. 6 and 6a, pa); that is a mere rudiment. Between that cartilage and the quadrate bone there is no endoskeletal structure; for the “epipterygoid” is suppressed. Behind the mouth two large and one lesser arches are found. The pier of the mandibular arch or quadrate (Plates XVI. and XVII., g) is one third the length of the mandibular ramus; its proper pedicle (pd) is free, semiliniptal, and unossified at its end; the outer process (ot. p) is in a line with the shaft of the bone, and is scooped above, where the two temporal bones (sq, s.t) rest upon it; that articulation has considerable mobility. This bone has a narrow waist and widened ends; the lower part ends in a condyle (g. c) like that of the cervical vertebra of a bird; in the axial direction it is convex; crosswise it is hollow or saddle-shaped. The articular surface of the mandible (Plate XVI. fig. 1, and Plate XVII. fig. 1) is concave lengthwise, and convex across. The proximal part of the lower jaw is ossified as the “articulare,” and then runs to the chin as an undiminished Meckelian cartilage, partly hidden by the splenial (Plate XVII. fig. 1, ar, mk, sp).

The hyoid arch is in four parts on each side, roughly answering to the pharyngo-epi-, cerato-, and hypohyal of a normal branchial arch, besides a huge glosso- or basihyal, which itself is subdivided (Plates XVI. and XVII.).

The topmost element, or medio-stapedial (m.st), is confluent with the oval stapedial plate (st); it is a very slender rod, which passes downwards and outwards. Where the bone ceases there the extrastapedial region begins; but any segmentation of the cartilage which may have existed is gone.

The extrastapedial (Plate XVI. fig. 7, e.st) is a large tongue of cartilage attached to the inner side of the quadrate behind, in its normal ichthyic position; for there is no drum-cavity in this type, and therefore the extrastapedial does not ride over the edge of the quadrate, as in those types which have an ear-drum. There is a fenestra (e.st.f) in the proximal part of the cartilage; and above this space the thickened inner edge of the
cartilage passes upwards as a short suprastapedial (s.st); this is finished above by an enlarging ligament, which is inserted in the inner face of the quadrates, close to the top.

The ceratohyals (Plate XVI. fig. 6, c.hy) are long, slender, sigmoid cartilages, end in a point above, and are attached by ligament to the skull; they are scarcely as large as the columella. The hypohyals (b.hy) are segmented off from the ceratohyals, are one third as long, one third thicker, and ossified, except at their extremities. These articulate by their narrow end with the basal piece at the fore part of its cartilaginous end, which grows backwards as an unsegmented basibranchial (b.br). The main rod, or basihyal, is as long as the whole basicranial axis of the same individual—from the end of the snout to the occipital hinge. Its fore end, for one eighth of its length, is unossified and segmented off (b.hy'); the rest is a very even cylinder of bone, nearly as thick as the "waist" of the quadrates; it becomes somewhat slenderer in front. Loosely attached to the basibranchial end of the median piece are two arcuate ossified rods, bulbous at their soft end below, and rounded at their smaller upper end; they are the ceratobranchials (c.br) (thyrohyals); they are as long as, but thicker than, the ceratohyals.

**Skull of a Newly-hatched Chameleon (Chamaeleo vulgaris).**

(Total length 1 1/2 inch, head 1/4 inch, head and body 3/4 inch, tail 3/4 inch.)

This skull is the counterpart of that of Zootoca vivipara, described in my paper on the skull of the "Lacertilia" (Phil. Trans. 1879, plate 41, pp. 630-634); the length of those young lizards was nearly the same as that of the young Chameleon, viz. 1 1/8 inch. I shall throughout this part of my description compare these two skulls together.

That which strikes the eye at first in the skull of the young Chameleon is its likeness to the skull of a young Mammal; for now the cranial cavity is very large and swelling, and contains a relatively large brain.

**The Investing Bones of the Young Chameleon's Skull.**

I know of no skull whatever in which the roof-bones undergo so great a transformation as in this. The single frontal of the adult is seen to have two rudiments in the young (Plate XV. fig. 3, f); these are, even now, mainly in front of the cranial cavity, which becomes very narrow over the orbito-sphenoidal region. Thus only one third of each bone lies over the actual cavity, which contains the fore end of the hemispheres and the olfactory bulbs; the rest is due to the size, at this time, of the orbital rim; this is a large lunate tract, convex above and concave below.

Each frontal bone (fig. 3, f) is notched in front; the inner spike bounding the notch is longer than the outer, and runs up to the nasals and nasal process of the azygous premaxillary (n. n. px). The outer spike of the frontal runs, for a short distance, between the prefrontal and the nasal roof (al.sp). The supracranial part of each bone dips to
form its moiety of the roof, which is concave in its fore part; the frontal suture is irregular; and the hinder edge of the two bones forms a margin to the great fontanelle (\(fo\)). Each bone also is hooked postero-laterally, where the postorbital (\(pt.o\)) clamps it; and the hook turns inwards some distance over the side of the fontanelle; this part is thick; the inner part is thin and scale-like. The remaining three fourths of the large bulging fontanelle is enclosed by a very narrow bar of bone on each side, each bone having both outer and inner outgrowths; these bars are the parietals (\(p\)). Each bar is curved, fitting to the side of the swelling membrano-cranium; in front they are wedged in between the hinder part of the frontals and postorbitals (\(p.to\)); behind, they meet each other at a moderate distance beyond the cranial cavity. Outside, each bone at its middle sends outwards and forwards a small spur; the top of the squamosal (\(sq\)) fits on to the angle thus formed.

The somewhat dense parietal bones are developing a thin ragged tract of bone from their inner edge; behind, they are united by a growth of this kind—a tongue-shaped tract, which runs forwards along two fifths of the sagittal line. Over the hind brain (Plate XV. figs. 1, 3) this tract is already crested; it is the beginning of the huge interparietal of the adult (Plates XVI., XVII., & XVIII., \(i.p\)). Thus this band of new bone conjugates the primary paired parietals (\(p\)) into one tract. Afterwards, when the postorbitals and squamosals meet over the temporal region, the parietals up to the external spike against which the squamosal rests (Plates XV. & XVI. figs. 1 and 3, \(p, sq\)) are absorbed, and the hinder part, becoming distinct from the huge interparietal above, is ankylosed to the top of the squamosal below; a trace, however, of the suture can be seen in the adult (Plate XVI. fig. 1, \(p, sq\)).

Thus the single filial interparietal not only stops the growth of the two parental parietals, but, like a lusty “sucker,” draws half their life out of them, and carries them up to a marvellous distance from their original position on the sides of the hind cranium.

Notwithstanding the rapidly-growing frontals, parietals, and interparietals, the roof is uncovered over four fifths of its extent, as a large subcircular fontanelle split up in its hinder two fifths. The marginal bones of the hind skull are so placed as to enclose a lower temporal space (\(l. t. s\)), which is narrow as seen from above (fig. 3), and suboval, widest above, as seen from the side. Still the width of the skull is considerably increased by this outer basketwork of bones, which is finished above by the parietals and interparietal. The postorbital (\(pt.o\)) is the broadest of these bones, and not only forms a third of the orbital rim, but also sends backwards one broad process from its upper part to bind the fore end of the parietal, and another larger and sharper snag, which overlaps the jugal (zygomatic) process of the squamosal (\(sq\)). Its antero-superior process runs over the orbit, but does not, now, meet the prefrontal (\(p.f\)); a large tract of the frontal intervenes (figs. 1 and 3, \(pt.o, f, p.f\)).
The junction of the postorbital with the frontal and parietal is by a broad foot-shaped expansion (fig. 3), with a sinuous edge growing into the frontal and grown into by it.

The squamosal (sq) forms the hinder and lower boundary of the temporal enclosure; its hinder snag runs up and binds on the outer snag of the parietal; its jugal process runs forwards inside the lower process of the postorbital; its body runs downwards and forwards, and rests upon the otic process of the quadrate, where there is a proper (flat) joint with a cartilaginous facet. This bone stands over the front and outside of the quadrate head; but inside and somewhat behind there is another and smaller bone (figs. 1, 4, and 6, s.t): this is the very constant Lacertilian supratemporal, which is jammed in between the opisthotic (parotic) region and the squamosal. The junction of the postorbital and squamosal, below the lower temporal space, is lost in the adult (Plate XVI, fig. 1), these bones meeting higher up; thus the enclosed space is then between these bones (with the small parietal added) on the outside and the great inter-parietal crest on the inside. In front, over the olfactory sæs, we have the two small nasals (fig. 3, n), separated from each other by the top of the nasal process of the premaxillary (n, px).

Outside and behind these are the large ear-shaped prefrontals (p.f), which are both anteorbital and supraorbital in position; their pointed hind part binds against the narrow end of the frontals, whilst their broad fore end protects the nasal wall.

The infero-lateral bones have their fore part finished into an arch by the club-shaped body of the premaxillary (px): this (fig. 3) is free above; but the maxillaries nearly meet below it (fig. 2). The latter bones (mx) rise high behind the alinalosal ring to meet the prefrontal, and then drop suddenly beneath the small unguiform lacrymal (l) and the styloid fore part of the jugal (j); the latter bone is falciform, and finishes the orbit below and behind, running up to bind over the long arcuate descending process of the postorbital.

The submucous bones of the palate (fig. 2) are in three pairs, with an odd one in front: this is the vomer (v), a lanceolate ossicle, hollow above and below, and broader in the latter region than above; it is wedged in between the fore end of the palatine plates of the maxillaries in front, and behind the ascending submesial spur of the palatines behind. These bones (pa) have a falcate outer region below, with the convexity inside; here each bone rises and is arched, meets its fellow, and sends forwards a sharp ethmo-palatine spur, as in Birds.

The pterygoid and transpalatines (pg, t.pa) have much of their adult shape—the former ending by a point under the palatine, but only reaching to one third of that bone, two thirds of its length from the vomer, and not touching it, as in most "Carinate" birds and Hatteria. The investing bones of the mandible (fig. 6) are quite similar to those of the adult; this part only increases in size after hatching; the relative proportion of its elements remains much the same throughout life.
The Endocranium of the Young Chameleon.

The most striking things in this structure are the large, tumid, membranocranium and the massiveness of the auditory capsules (Plate XV, figs. 1, 3, 4, 7, & 8). In front, up to the optic passages (ii), the chondrocranium is merely an imperfect wall of cartilage, confluent with the twin capsules of the nose.

The occipital arch is well developed both above and below; on its sides it is cramped and narrowed by the ear-capsules; the condyle (oc. c) is suboval transversely; the bony centres (e.o, b.o) barely reach it as yet. The foramen magnum (f. m) is very large, and fairly at the end of the skull. The bones are well bordered by cartilage, all save a space in front of the basal plate (fig. 2), where the floor is membranous; that bone, the basioccipital (b.o) is a large, thin, U-shaped plate, the horns of which enclose all but the fore margin of the large suboval posterior basicranial fontanelle (p. b. c. f). A wide tract of cartilage separates this threshold piece from the side plates—the exoccipitals (e.o) behind, and the opisthotics (op) further forwards.

The exoccipitals (fig. 4, e.o) are narrow above and dilated below. The 9th and 10th nerves (ix, x) pass between them and the opisthotics (op); and the 12th (xii) pierces the bone.

There is a considerable tract of cartilage between the exoccipitals and the crown of the arch, the superoccipital (s.o); this is to a considerable extent filled in by an extension, backwards, of the epiotic (ep), a shell of bone of the form of a quadrant (fig. 7, ep). The supraoccipital has already sent upwards a squarish crest, rugged above; this ends in a rounded tongue of cartilage (fig. 8), which lies directly beneath the tongue-shaped interparietal tract (fig. 4, i.p); afterwards, as I have shown, this will be a high thin crest underpropping the high thin crest of the interparietal (Plates XVI. & XVII.).

The outer view (fig. 7) shows the great triradiate synchondrosis between the three periotic osseous tracts. These are very unequal in size: the prootic (pr.o) is the largest, and is twice the size of the opisthotic (op), which again is twice the size of the epiotic. The ampulla of the anterior and horizontal canals, and part of their arches, are contained in the prootic. The ampulla of the posterior and the end of the horizontal canals lie in the opisthotic; and the meeting part of the anterior and posterior is in the epiotic (Plate XVI. a. s. c, h. s. c, p. s. c, pr.o, op, ep).

Below the arch of the horizontal canal, at the postero-inferior edge of the prootic, there is an oval membranous space, the fenestra ovalis, filled by the stapedial end of the columella (fig. 7, pr.o, f. o, st); the postero-inferior margin of the fenestra ovalis is enclosed by cartilage, which will be ossified by the opisthotic, which constantly forms the binder edge of this space. The basisphenoid (b.s) is separated from the antero-inferior corner of the prootic by a cartilaginous tract, and also, above, from the horns of the basioccipital (fig. 8, b.s, b.o, pr.o). But below (fig. 2) the basisphenoid sends back sharp horns of bone, which fasten on the ends of the broad horns.
of the U-shaped basioccipital. The hinder margin of the basisphenoid is lunate, not semielliptical, like the fore margin of the basioccipital; its axial length is only half as great as that of the hinder bone. The basisphenoid would be a triangular wedge (for it ends in an almost pointed process in front); but it gives off at the middle on each side a wing of bone, dilated and cartilaginous externally. These wings are the basipterygoid processes (h.pg), whose direction is downwards, outwards, and forwards.

The openings for the trigeminal nerves (v) are surrounded by membrane everywhere except a small tract below and behind; for here, in the alisphenoidal region, the membranocranium (al.s.f) extends over the highest part of the head, and down on each side to the base (fig. 7). The alisphenoid (al.s) is a feeble sigmoid bar in front of this space; it is continuous with the basal cartilage, between the optic passage and the foramen ovale (II, v), and with the orbito-sphenoid (o.s) above the common optic passage. The lower half is ossifying, and is arched backwards; the upper half, which only reaches up to the most tumid part of the membranocranium, is soft, and bends forwards. Between this feeble rudiment of the "ala magna" and the orbito-sphenoidal lamina there is a deepish triangular notch.

The chondrocranium in front of the ali- and basisphenoid is quite unossified; in front of the great common optic passage (II) there is an oblique presphenoidal band (p.s) running downwards and forwards to the trabecular base. In front of this there is a large oblong interorbital fenestra (i.o.f), not notch, as in Lacerta.

The thick trabecular base below and the thin lamina above this fenestra are about equal in depth. From the upper part there proceed a pair of narrow orbito-sphenoidal wings (o.s); these soon become almost obsolete, and then widen in the ethmoidal region, where they are pierced by the olfactory nerves (i) and lie over the orbito-nasals (v1). The perpendicular ethmoid becomes a low middle wall, passing into the septum nasi (figs. 7 & 8), which divides the flat, but tumid, 4-celled nasal labyrinth, with its annular outworks (al.sp, al.n). From the postero-inferior face of the capsule there is a small semiroyal cartilage projecting; this is the ethmo-palatine (e.pa)

The Postoral Arches in the Young Chameleon.

The whole articular head (otic process) and the pedicle and the base of the quadrate is still soft (fig 1, ot.p, pd, q. c); and part of the free mandible is unossified nearly to the condyle, not being covered, as yet, by the articular (fig. 6, mk; ar). The long glossos- or basihyal rod, with its small terminal segment (fig. 8, c.br, b.hy, b.hy'), is unossified; also the ceratohyals (c.hy) and hypohyals (h.hy). The thyrohyals, or 1st cerato-branchials (e.br), are well ossified already.

The long azygous rod is not quite so long, relatively, as in the adult; it only reaches, if measured by the basis cranii, from the occipital condyle to the middle of the septum nasi.
The columella (figs. 4 & 7, co, st) has nothing to distinguish it from a feebly developed ichthyic epihial or hyo-mandibular, except its fusion proximally with the fenestral operculum of the auditory sac (stapes).

Its direction is downwards; and it is bent outwards; but it lies in the proper position of an ichthyic epihial, a position soon attained in fishes, where the postoral arches are arranged telescopically; that is, the lesser hinder arches pass within the larger fore arches. The more directly outward direction of the epihial, with a forward curve round the quadrate, first shows itself in the Anura, where the tympanum is well developed; here, in the Chameleon, the closing-up of this cavity is correlated with the retention of an ichthyic position of this element.

I shall compare the skull of the young and adult, and both with the typical Lacertian skull, when I have described the next type—one not so non-typical as the common kind.

_Skull of Chameleo pumilus, Adult Male._

Morphologically, the skull of this species comes in halfway between that of the young and the adult in the last species; indeed, it has supplied exactly the link I wanted between those stages to enable me to interpret the strangely transformed roof-bones in the Common Chameleon.

The supercranial valley (Plate XIX. fig. 3) is not so definite in this dwarf species, nor is the interparietal crest so high; moreover that crest is composed of only one, not three, pieces.

All the exposed parts of the investing bones are covered with a growth of tubercles both really and relatively much larger than in the Common Chameleon. They are large clear beads, or "guttae," of bony substance; and these run in rows along the ridges and in lines parallel with the ridges,—a structure better to be understood by reference to the skull itself, or the figures of it, than by any description.

The modifications seen in this skull as compared with the last are tendencies towards, (or survivals of) what is typical; thus, this is an excellent connecting link between the normal Lizards and the abnormal Chameleon.

_Investing Bones of the Skull of the Dwarf Chameleon._

The frontals (Plate XIX. figs. 1 & 3 (f)) are completely ankylosed together; and the fontanelle (fo) is some distance in front of the coronal suture. This double bone is square (roughly), with a wedge-like prolongation in front; thus its anterior margins are oblique and notched; its posterior margin is emarginate, the parietal wedging in behind. As in the young of the last kind, the frontal has a considerable orbital tract (figs. 1 & 3, f), as the prefrontals and postorbitals (p.f; pt.o) are far apart. The orbital regions of the frontal are raised considerably at their edge; and this is strongly beaded.

The "valley" has a pair of submesial rows of bosses, and an irregular crop along the middle; the sutures all round the bone are strongly but irregularly toothed.
There is only one parietal bone \((p, i.p)\); this is quite distinct from the squamosals \((s q)\), postero-laterally. The temporal vacuity (figs. 1, 3, & 4, *l.t.s*) is a large oval space, with an oblique emargination in front, formed by the hinder edge of the postorbital \((p.t.o)\). But in the adult skull of the Common kind (Plates XVI. and XVII.) the temporal space is between the interparietal within and the postorbital, squamosal, and parietal outside. I question whether the parietals in this species ever had a distinct interparietal; at any rate it only had a temporary existence. This relatively large, knobbed slab of bone has an arched lateral outline, and projects backwards half its length beyond the foramen magnum \((f.m)\); it has a lateral pair and a sublateral pair of rows of tubercles, and a median row more compressed and less distinct from each other.

Only the fore margin of the parietal rests directly upon the membranocranium \((dura mater)\); the main part, even over the skull, sends downwards a median keel, which rests upon the top of the endoskeletal crest \((supraoccipital, fig. 5, s.o)\).

In this species the postorbital \((p.t.o)\) just touches the foremost outer tuberele of the parietal (fig. 3); from the middle of the latter (fig. 1, *p, sq*) a descending process bends down upon the fore part of the top of the squamosal: this is where ankylosis has taken place in the adult of the Common kind; and this outer part corresponds with the aborted lateral parietal of that species, which articulates with the great outer parietal crest behind. Here there is no such joint; it is all one bony tract. The postcranial part of the common parietal bone in this species is hollow and smooth below (figs. 2 & 4, *p*); the keel is continued some distance behind the supraoccipital.

The fore part of the roof is formed of two pairs of bones; and these only partially cover it; they are the nasals and prefrontals (fig. 3, *n, p.f*) The nasals are united by a suture and are narrow behind, where they bind on to the fore spur of the frontal, and broad in front, where they articulate with the ascending part of the maxillaries \((m x)\), not with the nasal process of the premaxillary, which does not ascend so far in this kind. For two thirds of their length they have the supernasal fontanelle \((s.n.f)\) outside them; this is pyriform, and ends narrow behind, between the end of the frontal and the top of the prefrontal.

This latter bone \((p.f)\) is large, and covered above with large crowded bosses; it has a short anterior suture with the nasal, in front of the membranous space, and an oblique crescentic suture with the anterior margin of the frontal. It makes part of the rough ornamentation of the fore face, above the maxillary (fig. 1, *p.f, m x*), and then, ascending, has both an anteorbital and a superorbital position, forming by its inner face the anterior fourth of the eye-socket. The postorbital \((p.t.o)\) is an arcuate bone, margining nearly a fourth of the eye-socket supra-posteriorly, and fixing itself to the contiguous bones by two pairs of snags. The upper two of these form the two rounded teeth of a short suture with the frontal (figs. 1 & 3); the two lower processes are larger, more divaricated, and oblique; the front spur descends, and is fastened inside
the top of the jugal \((j)\); the hinder spur obliquely overlaps the jugal process of the squamosal. The latter bone \((sq)\) finishes the oval temporal space behind and below, and runs upwards to prop the parietal at its outer angle, the angle binding on the front of the squamosal. Below, the squamosal helps the supratemporal \((s.t)\) to form a swinging point to the quadratum \((q)\).

The supratemporal \((s.t)\) is a smaller bone; is nowhere subcutaneous; so it has no bony warts on it like the exposed bones. It is tightly jammed in between the squamosal and the parotic wing \((\text{fig. 4, sq, s.t, op})\).

The bones of the lower margin are strongly verrucose at their upper margin; but the skin of the upper lip thickens lower down, and the bone becomes smooth. The premaxillary is like a short round-headed nail; in its upper aspect it looks twice the size it does in its lower; in that aspect, however, it is seen to separate the right and left maxillaries from each other. It is not half so long, relatively, as in the Common species (Plate XIX, fig. 3, and Plate XVI, fig. 3, \(pa\)) there we find it running up between the maxillaries, prefrontals, and nasals; here it only half separates the maxillaries on their upper face, and these bones keep the prefrontals from the mid line.

The maxillaries \((mx)\) are warty both in front of and behind the nasal aperture \((e, n, al.n)\). They are then notched above, for the small “os unguis” \((l)\), and then narrow steadily as they run back under the jugal.

That bone \((j)\) articulates with the lacrymal in front, with the maxillary below, and then ascends to bind over the descending process of the postorbital \((pt.o)\). The jugal forms more than a fourth of the orbital rim; it is a solid falciform bone, covered outside with a row of bosses that form the ornament of the orbital rim; and it has another boss at the end of the maxillary.

On the whole, the membrane bones of this species are like those of the Common Chameleon; but there is an additional bone, which brings it nearer to the typical Lacertilian: this is the parabasal.

This bone \((\text{fig. 2, pa.s})\) is a small style, confluent behind with the basisphenoid \((b.s)\); it is quite similar to what we find in Lizards generally.

The vomer \((e)\) is notched at both ends, and may have arisen from two centres, as in many Birds; but the azygous vomer of the young of the Common species suggests for this also a single centre.

The palatines \((\text{fig. 2, pa})\) are very similar to those of the last kind; they have a narrow ascending, and a wide horizontal region. The former lies over the nasal groove; and the latter encloses it, right and left.

The pterygoids \((pq)\) and transpalatines \((t.pa)\) are very similar to those of \(C. vulgaris\). The former are still shorter, relatively, and are attached behind to the quadrate by a ligamentous tract.

The splints of the mandible \((\text{fig. 1})\) are also quite similar to those of the Common kind; in the figure the splenial \((sp)\) is indicated in this outer view by dotted lines.
The Endocranium of the Dwarf Chameleon.

The endocranium, on the whole, is quite like that of the last kind. The occipital condyle (oc. c) is large and projecting; it is suboval, with its long diameter transverse. The basioccipital (b.o) is hollow beneath, projects externally, and is widest in front. The exoccipitals (e.o) are confluent with the opisthotics (op); but the nerve-passages (ix, x) are their landmarks. So, also, the supraoccipital (s.o) is confluent with the epiotic; it sends up a much smaller crest to meet the less-modified interparietal region. The foramen magnum (fig. 4, f.m) is pyriform; it is much elongated upwards. The parotic processes (op) are much shorter than in C. vulgaris; the posterior canal (p. s. c) is seen to be largely imbedded in the opisthotic; its upper part, which passes into the tube of the anterior canal (fig. 5, a. s. c, p. s. c), lies in the epiotic (e.p).

The prootic (fig. 5, pr.o) contains most of the anterior and horizontal canals (k. s. c); and the side view shows the whole occipito-otic region to be very limited, and shaped like an hourglass.

A lanceolate space, nearly as large as the combined occipital and periotic regions, lies in front of them, naked of cartilage and of bone (al.s.f). The oblique band of cartilage passing in front of this “fenestra,” and leaning forwards, is the alisphenoid (al.s); two thirds of its lower half is ossified as a shaft-bone; below it is continuous with the basi-sphenoid, and in front, at the middle, with the orbito- and presphenoid. The roof-bone (i.p) rests upon its somewhat dilated top. The basisphenoid (figs. 2, 4, & 5, b.s) is a large two-winged bone, narrowing from before backwards, crescentically emarginate behind, and bifid in front; it has large, dilated, descending basipterygoid wings (b.p.y), and above is scooped for the pituitary body. This bone articulates with the basi-occipital behind, the prootics at its sides, and the small parasphenoid in front.

There is a triangular notch between the ali- and orbito-sphenoids, a large common optic passage (ii), and an oblique pyriform interorbital fenestra (i.o. f), as in the Common kind and in many other of the Lacertiiia. The orbito-sphenoid wings (o.s) are not large; the common orbito-nasal septum (p.s, p.e) rapidly lessens forwards; there is no definite bony tract in front of the optic passage.

The Inferior Arches of the Dwarf Chameleon.

These parts are very similar to what I have described in the Common species. The quadrate (q) has a definite otic process and pedicle (ot. p, pd); the articulare (ar) is well ossified; and the postmandibular arches, like the mandible itself, are a mere miniature of what is to be seen in the Common kind.

Comparison of the Skull of the Chameleon with that of other Lacertilia, especially the typical Lacerta.

Leaving out the Chameleon, the types whose skulls are most unlike are Lacerta and
Hatteria; yet that of the latter (see Günther, Phil. Trans. 1867, pl. 1) is less aberrant in many things than that of the Chameleon. The continuity of the stapes with the hyoid arch is not a unique character; that which is unique is the binding of the cheek to the quadrato-jugal, a character which Hatteria has in common with Chelonians, Crocodilians, and Birds. That type, however, has the vomers large and distinct, and an epipterygoid the largest seen in any Reptile.

The most instructive skull for comparison with that of the Common Chameleon belongs to a Mexican Iguanian Lizard, viz. Lamanactus longipes. Its size is about the same; and it is exquisitely ornate, and possesses a very large interparietal crest. Yet in nearly every thing this remarkable skull is normal, except in the development of the crest. As in the Chameleon, the frontals are ankylosed together; but the fontanelle, although bounded by the frontal, lies on the edge of the parietal. That bone sends outwards and backwards the normal "horns," that are articulated to the paroties, supratemporals, and squamosals in the normal manner; but it has also a large, flat, vertical crest, formed by the gradual narrowing of the parietal bone from before backwards; and this crest, keeping very nearly the line of the general gentle rise of the top of the head, extends far backwards beyond the endocranium. But the supraoccipital does not rise to meet it; so that the height of the head behind is much less than in the Chameleon.

In the young of the Common Chameleon and in the adult Dwarf kind, we saw the parietals as one bone: in the former a median forward outgrowth, belonging to the pair of primary parietals, had yoked them together; in the latter the three elements were seen to be all lost in one large, crested, arched, tuberculate slab of bone.

In Lamanactus, undoubtedly, the primary bands that formed the beginning of the parietal bones rapidly developed a common median outgrowth, that shot up into the large lateral crest; but I question if, at any time, there were three distinct bones.

In comparing the skull of the Chameleon with that of Lacerta (see Phil. Trans. 1879, plate 42), I shall leave out of account the supernumerary bones that are seen over the eyes and temples in that typical form, as well as in some others, such as Mocoa (a "Scincoid").

The Common Chameleon differs from the typical Lizards—

a. In the investing bones:
1. Their highly ornate character.
2. The frontals are fused together* and contain the fontanelle.
3. The parietals are broken up into three bones, two parietals and an interparietal; but the former are abortively developed, articulate with the end of the interparietal crest, and are ankylosed with the squamosals.
4. The prefrontals and postorbitalts are articulated with each other over the orbit, thus excluding the frontal from the outer ring.

* Lizards are very variable as to this character.
5. The prefrontals articulate with the nasal process of the premaxillary, in front of and below the nasals.

6. The nasals are very feebly developed, and fail to cover their own region, leaving a membranous fenestra between themselves and the prefrontal, right and left.

7. The premaxillary is a feeble edentulous wedge of bone, almost excluded from the fore palate.

8. The adult of the Dwarf and the young of the Common Chameleon have a normal temporal space; the postorbital and squamosal unite below, and form the lower boundary, which is enclosed by the parietal above. In Lizards, generally, the parietal forms the upper (inner) boundary of the large temporal space, which is bounded by the postorbital and squamosal below or outside; in many cases the supratemporal helps the parietal "horn" to enclose this space above; but in Iguana tuberculata the supratemporal fits inside the horn. In the adult Common Chameleon the paired parietal, being aborted in front and ankylosed to the top of the squamosal behind, helps to form the lower or outer boundary of the temporal space, each inner being entirely formed by the large individuated interparietal. In Lizards, generally, each parietal "horn," passing outwards and backwards to the postero-external angle of the skull, forms a post-temporal space between the hind skull (occipito-auditory region) and itself. In "Cyclodonts" (Trachydosaurus) the huge, arcuate, parietal horn comes so close, in front, to the dilated postorbital, as almost to obliterate the temporal space; for above there is merely a small tract of membrane, which finishes the temporal roof. Thus there is a great open space behind the horn, and this skull approximates to that of the Green Turtle (Chelone viridis). In the Chameleon the two spaces (temporal and posttemporal) are about equally divided by the parieto-squamosal bar (Plate XVI. figs. 3 & 4), which rises over and spans this great tract, not seeming to divide it into two distinct spaces, as in the Lizards, generally, where the posttemporal space is small and lanceolate.

9. The absence of a parasphenoid in the Common kind is a rare character; I have only missed it, in other Lizards, in Trachydosaurus rugosus.

10. The single vomer is very remarkable; and this condition is not due to fusion of the centres; it is azygous in the embryo, as in the Chelonia.

11. The absence of the septo-maxillaries is a correlate of the singleness of the vomer, and of the peculiar position of the nasal glands, above and behind the nasal roof.

12. I consider the intense fusion of the teeth with the jaw-bone, and the absence of pterygoid teeth, to be worth mentioning, as well as the absence of teeth on the premaxillary.

13. The peculiar depth and great size of the pterygoid behind, and its shortness, ending in front of the quadrate, and united to it by ligament; in the Lizards generally the pterygoid is thin and falcate behind, and binds strongly inside the quadrate.

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b. Endocranial modifications in the Chameleon's skull:

14. The huge high supraoccipital crest.
15. The absence of the rudiment of a cochlea, and of the fenestra rotunda.
16. A very small and simple alisphenoid, instead of the normal basketwork of cartilage and bone.
17. The orbito-nasal septum agrees with many in having the membranous space enclosed (as a fenestra), and not open (as a notch), as in Lacerta.
18. There is no cranio-facial fenestra between the perpendicular ethmoid and the septum nasi.
19. The ali-ethmoidal cartilages are notched for the nasal glands; and there is no fenestra, right and left, in the ali-septal roof.
20. There is no free or confluent labial cartilage running between the snout and the upper surface of the vomer, as in Lacerta; but the ali-nasal annulus is much more evidently a confluent (valvular) labial, corresponding to the outer upper labial of the metamorphosed Frog and Toad.

c. Modifications of visceral arches in the Chameleon:

21. There is no epipterygoid—a part which exists in all other Lacertilia known to me, is largest in Hatteria, and is present in all known Chelonia.
22. The pedicle of the quadrate is a very distinct process from the otic process; it is much broader than in the Chelonia, but, as in them, has the tip unossified.
23. The columella keeps within the quadrate, has not a bifurcated supra-stapedial process, has no infrastapedial, and is not functional; there is no cavum tympani. The hyo-branchial apparatus is very unlike that of the typical Lizard.
24. The hypohyals are quite distinct from the basal bar and from the ceratohyals; the latter are not dilated below; both hypo- and ceratohyals are (normally) unossified.
25. The baso- or glossohyal is as long as the skull, is highly ossified, and has a small unossified segment at its fore end and a non-segmented basibranchial process behind.
26. The ceratobranchials are well ossified; they have no upper or epibranchial segment, as in Lacerta; there are no hypobranchial processes, or thyro-hyals, behind and within them proceeding from the basal bar, which is narrow and rounded at the end.

Comparison of the Chameleon's Skull with that of the Amphibia and the Chelonia.

The skull of the Chameleon, in differing so much from that of the other Lacertilia, does not, at the same time, approximate to that of other types below, aside of, or above its own family.

The Chameleon's skull resembles that of those Anura which have a columella but no "cavum tympani," and also agrees with them in having neither a cochlea nor a fenestra rotunda. It agrees with the Chelonians in having a single vomer and no septo-maxillaries, and in having a crested supraoccipital, and with the Ophidia and Crocodilia in having no epipterygoid.
With many Birds the Chameleon agrees in the position of the nasal glands, which is a correlate of the azygous vomer, and the suppressed septo-maxillaries: yet many Birds have two vomers originally; the Chameleon has only one from the first.

In mere form, the head of the Chameleon resembles that of many high-skulled Teleostean Fishes; but the height is obtained by very different methods in the two types of skull.

In conclusion, it is self-evident that the Chameleons are a very isolated group of Lizards. Like Snakes, they are low in certain respects, and yet in others are specialized to the utmost.

**List of Abbreviations.**

The Roman figures in the Plates indicate the nerves or nerve-foramina.

- *ag.* Angular.
- *al.n.* Alinatal.
- *al.s.* Alisphenoid.
- *al.s. f.* Alisphenoidal fenestra.
- *al.sp.* Aliseptal.
- *ar. c.* Articular condyle.
- *a. s. c.* Anterior semicircular canal.
- *au.* Auditory sac.
- *b. hy.* Basihyal.
- *b. hy'* Additional basihyal.
- *b.o.* Basioccipital.
- *b. pg.* Basipterygoid.
- *b.s.* Basiphenoid.
- *C¹.* Fore brain.
- *C².* Mid brain.
- *C³.* Hind brain.
- *c. br.* Ceratobranchial.
- *c. hy.* Ceratohyal.
- *c.o.* Columella.
- *cr.* Coronoid.
- *c. tr.* Cornu trabeculæ.
- *d.* Dentary.
- *e. n.* External nostril.
- *e.o.* Exoccipital.
- *e.p.* Epiotic.
- *e.pa.* Ethmopalatine.
- *e.st.* Extrastapedial.
- *e.st. f.* Extrastapedial fenestra.
- *f.* Frontal.
- *f. m.* Foramen magnum.
- *f. o.* Fenestra ovalis.
- *h. hy.* Hypohyal.
- *h. s. c.* Horizontal semicircular canal.
- *i. n.* Internal nostril.
- *i.o. f.* Interorbital fenestra.
- *i. p.* Interparietal.
- *i. t.b.* Inferior turbinal.
- *j.* Jugal.
- *l.* Lacrymal.
- *l. c.* Lacrymal canal.
- *m.k.* Meckel's cartilage.
- *m.st.* Mediostapedial.
- *m.v.* Maxillary.
- *n.* Nasal.
- *n. f.* Nasal floor.
- *n. g.* Nasal gland.
- *n. pr.* Nasal process of premaxillary.
oc. c. Occipital condyle.
op. Opisthotic.
o.s. Orbitosphenoid.

ot. p. Otic process.
p. Parietal.
pa. Palatine.
pa.s. Parasphenoid.

p. b.c.f. Posterior basicranial fontanelle.
p. c. Middle ethmoid.
p.f. Prefrontal.
p.q. Pterygoid.
p.r.o. Prootic.
p.s. Presphenoid.

p. s. c. Posterior semicircular canal.
pt.o. Postorbital.

px. Premaxillary.
p.y. Pituitary space.
q. Quadrade.
s.ag. Surangular.
s.n. Septum nasi.
s.o. Superooccipital.
s.p. Splenial.

sq. Squamosal.
s.st. Suprastapedial.

st. Stapes.
s.t. Supratemporal.

t.pa. Transpalatine.
v. Vomer.
v.b. Vestibule.

DESCRIPTION OF THE PLATES.

PLATE XV.

Fig. 1. Chamæleo vulgaris: ripe young, 1 1/2 inch long, head ¼ inch, tail ¾. The skull, side view, ×13 1/3 diameters.
Fig. 2. The same, lower view, ×13 1/3 diam.
Fig. 3. The same, upper view, ×13 1/3 diam.
Fig. 4. The same, end view, ×13 1/3 diam.
Fig. 5. The hyo-branchial arches, upper view, ×13 1/3 diam.
Fig. 6. The mandible, inner view, ×13 1/3 diam.
Fig. 7. The endocranium, side view, ×13 1/3 diam.
Fig. 8. The same, upper view, ×13 1/3 diam.

PLATE XVI.

Fig. 1. Chamæleo vulgaris: adult female. The skull, side view, ×3 3/4 diam.
Fig. 2. The same, lower view, ×3 3/4 diam.
Fig. 3. The same, upper view, ×3 3/4 diam.
Fig. 4. The same, end view, ×3 3/4 diam.
Fig. 5. The same species: large male. The skull and brain in situ, longitudinally vertical section, ×3 3/4 diam.
Fig. 6. The same. Hyo-branchial arches, upper view, ×3 3/4 diam.
Fig. 7. The same. Quadrade bone and columella, ×7 1/3 diam.
PLATE XVII.

Chamaeleo vulgaris.

Fig. 1. Large male: the skull, longitudinally vertical section, right side, ×3 diam.
Fig. 2. Part of left section of the same skull, ×3$\frac{3}{4}$ diam.
Fig. 3. Endocranium of a female, side view, ×3$\frac{1}{4}$ diam.
Fig. 4. The same, upper view, ×3$\frac{3}{4}$ diam.
Fig. 5. A smaller male: transversely vertical section of decalcified skull through fore part of ear-sac (13th section), ×3$\frac{3}{4}$ diam.
Fig. 6. Another section, through middle of ear-sac (14th section), ×3$\frac{3}{4}$ diam.
Fig. 7. Another section, through hind part of ear-sac (15th section), ×3$\frac{3}{4}$ diam.

PLATE XVIII.

Chamaeleo vulgaris.

Fig. 1. Smaller male: decalcified skull (same as in Plate XVII. figs. 5–7), section in front of nose (1st section), ×3$\frac{3}{4}$ diam.
Fig. 2. The same, through nostrils (2nd section), ×3$\frac{1}{4}$ diam.
Fig. 3. The same, through nostrils further back (3rd section), ×3$\frac{3}{4}$ diam.
Fig. 4. The same, through hind part of nostrils (4th section), ×3$\frac{1}{4}$ diam.
Fig. 5. The same, through hind part of nostrils (5th section), ×3$\frac{3}{4}$ diam.
Fig. 6. The same, through middle of nasal sacs (6th section), ×3$\frac{3}{4}$ diam.
Fig. 6a. The same object, with bones removed, ×7$\frac{1}{2}$ diam.
Fig. 7. First interorbital section (7th section), ×3$\frac{3}{4}$ diam.
Fig. 8. Second interorbital section (8th section), ×3$\frac{3}{4}$ diam.
Fig. 9. Third interorbital section (9th section), ×3$\frac{3}{4}$ diam.
Fig. 10. Fourth interorbital section (10th section) through optic nerve, ×3$\frac{3}{4}$ diam.
Fig. 11. Section made between optic and trigeminal nerves (11th section), ×3$\frac{3}{4}$ diam.
Fig. 12. Another, through foramina ovalia (12th section), ×3$\frac{3}{4}$ diam.

PLATE XIX.

Chamaeleo pumilus.

Fig. 1. Adult female: the skull, side view, ×6 diam.
Fig. 2. The same, lower view, ×6 diam.
Fig. 3. The same, upper view, ×6 diam.
Fig. 4. The same, end view, ×6 diam.
Fig. 5. The same, side view of orbital and auditory regions, ×6 diam.
SKULLS OF CHAMELEONS
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Received February 25th, read March 16th, 1880.

[Plate XX.]

ON two occasions the late Prof. Garrod had opportunities of dissecting the Sumatran two-horned Rhinoceros; and his notes on their anatomy will be found duly recorded in the Society’s publications. Both his specimens were females.

On March 20, 1879, the Society received on approval a fully adult male of this animal, being, I believe, the first individual of that sex brought alive to Europe. Unfortunately it died on the 5th of April following, the post-mortem examination showing evidence of dropsy, as well as of tubercle in the lungs and spleen. The skin and skeleton of this specimen are now in the British Museum.

Prof. Owen, in his account of the anatomy of Rhinoceros indicus (Trans. Zool. Soc. iv. pp. 31–58), has described and figured the male organs of that species; and the present account will fill up the corresponding blank that has as yet existed as regards these parts in Ceratorhinus sumatrensis.

As was to be expected, the two genera closely conform with each other in all main points, with some considerable differences in matters of detail.

As in R. indicus, there was no scrotum; each testis measured 4½ inches long by 2 broad at the widest part. The epididymis was of the same length as the testis.

The vasa deferentia were 29½ inches long by ½ inch broad; unlike these ducts in the Indian species, they were not dilated terminally. The vesiculae seminales resembled in shape those described by Owen: they were 7½ inches long, and 1 inch across at the broadest part. The right vesicula had two, the left four, narrow ducts, 1½–2 inches long, which joined the vasa deferentia just before these entered the urethra. The verumontanum is short and rounded, ½ inch long and 1 inch broad. The openings of the ejaculatory ducts were very minute; a larger pore, which was the only representative of a vesicula prostatica, lay close above.

1 Prof. Garrod had the drawings which accompany this paper made by Mr. Smit from the animal whilst still fresh, with the object of laying some notes on the subject before the Society. Unfortunately I have been unable to find any such amongst his numerous MS. papers. He also requested me to make notes and measurements of the male organs for him with the like object; and from these sources I have drawn up the present paper. The glans penis is now preserved in the College of Surgeons.

The prostate was of a roughly triangular shape, 2 inches long by 5 inches across, and had the same structure as in *R. indicus*, the glands opening by numerous pores on each side of the verumontanum in a well-marked sinus prostaticus.

Cowper's glands were large (3½ inches by 2) and oval; their ducts opened by pores 1½ inch in front of those of the ejaculatory ducts.

The urethra measured in all, in the unerected state, about 23½ inches, of which ½ inch was "prostatic," 3 inches "membranous," and the rest "spongy."

The glans penis (Pl. XX. figs. 1, 2) is a long and tapering cylinder, provided at the end with a second, somewhat mushroom- or trumpet-shaped expansion, nearly in the centre of which is the opening of the urethra. It thus conforms closely with the same organ in *R. indicus*. But, as will be seen from the drawings, it is provided, in addition, with two large oblong-oval lobes, of the same colour and substance as the rest of the glans, which are free for the greater part of their length, and only attached to the rest of the glans at their bases. These lobes lie on the sides of the dorsum of the penis, and are closely approximated at their bases, as represented in fig. 2. In fig. 1 they are spread out artificially, so as to show better their extent and attached bases. The total length of the glans, to the reflection of the prepuce, was 7 inches, the trumpet-like terminal part being 1 inch long, and 1 inch transversely. The lobes of the glans measured 2½ inches long by 1½ inch across.

In *R. indicus*, according to Prof. Owen (l. c. p. 51), "on each side of the base of the glans, and rather towards its under part, there is a longitudinal thick oblong ridge or lobe, 3½ inches in length, and 8 lines in basal thickness; the thick rounded free border of each lobe inclines downwards." Prof. Owen's figure is reproduced in outline, of the original size, in fig. 3, to show the differences thus indicated. By the kindness of Prof. Flower I have been enabled to examine the penis of an Indian Rhinoceros preserved in the stores of the College of Surgeons, and which is probably the same specimen as that dissected and described by Prof. Owen, with whose description and figures it closely corresponds. The lobes, however, seem to me to be (as also indicated in his figures) rather on the upper than on the under part of the penis, as they lie, in fact, on each side of the dorsum a little removed from the middle line, as also is the case in *Ceratotherium*. They are about 1½ inch in height at the centre, diminishing towards each end till they become indistinguishable from the rest of the glans. *Ceratotherium* therefore differs from restricted *Rhinoceros* in the greater size and development of the lobes, which have now ceased to be mere elevations or ridges attached throughout their length to the body of the glans, but have become freely projecting lobes attached only by their bases1. In *R. indicus*, too, the terminal part of the glans is more slender.

1 I may mention that Prof. Flower also found for me in the stores of the College of Surgeons a detached glans penis of a Rhinoceros exactly like that now described. Its history is somewhat uncertain; but it was probably sent over, along with other viscera of animals, by Sir Stamford Raffles when Governor of Java. There can be no doubt that it belongs to a species of *Ceratotherium*.
being longer in proportion to its depth, and its apical expansion narrower across in proportion to its height ($\frac{7}{8} \text{ inch to } 1\frac{1}{4}$), with its margins, moreover, somewhat crinkled.

It is, in conclusion, interesting to observe that the distinctness of the two genera *Rhinoceros* and *Ceratorhinus*, as shown by other characters—external, cranial, and visceral—is confirmed by these differences in the sexual organs.

**DESCRIPTION OF THE PLATE.**

**PLATE XX.**

Fig. 1. Glans penis of *Ceratorhinus sumatrensis*, of about the natural size, viewed from above, with the lobes artificially extended, to show better their form and attachment.

Fig. 2. The same, viewed from the side.

Fig. 3. Outline of glans penis of *Rhinoceros indicus*, after Owen (Trans. Zool. Soc. iv. pl. ix. fig. 6).
IX. On the Anatomy of the Female Organs of the Proboscidea.
By M. Watson, M.D., Professor of Anatomy, Owens College, Manchester.

Received March 30th, read April 20th, 1880.

[Plates XXI., XXII.]

On a previous occasion I laid before this Society an account of the anatomical peculiarities of the male\(^1\) and female\(^2\) organs of the Spotted Hyæna (\textit{H. crocuta}); and whilst engaged in pointing out the homologous parts of the genital organs in the two sexes I used the following words:—"It is evident, therefore, that, in the female \textit{H. crocuta} the vagina being altogether absent, we must conclude that in the male of this species the utriculus represents the uterus alone, and not the uterus and vagina together. The same remark holds good, so far as I can ascertain, of only one other placental mammal—that is, of the Indian Elephant, in the female of which, as Mayer\(^3\) pointed out, the vagina is altogether absent, and the uterus opens directly into the urino-genital canal." At that time I had not myself examined the female organs of the Indian Elephant; and the comparison was made on the strength of Mayer’s description of these. Since then, through the kindness of my friend Dr. Alfred H. Young, I have had an opportunity of thoroughly investigating the female organs of a young specimen of the Indian Elephant\(^4\); and inasmuch as my observations differ materially from those of Mayer\(^5\), whilst for the most part they agree with those of Hunter\(^6\), Miall and Greenwood\(^7\) upon the female organs of the Indian, as well as with those of Perrault\(^8\) and Forbes\(^9\) on those of the African species, I have thought it well to lay them before the Society. It is, moreover, a matter of some importance that a revised description of these organs should be drawn up, not only because of the difference which exists in the descriptions of the writers above named, but also because upon the exactitude of the description depends the just interpretation of the different parts of the female passages, and, following upon this, the determination of correct homologies as between the male and female organs of the same species. As the representations of the female organs of the Proboscidea already published are, for the most part, unsatisfactory, I have had the accompanying drawings of my own dissections made by a competent artist under my direct superintendence, and can therefore vouch for their accuracy.

\(^4\) The specimen was a young one, measuring between 4 and 5 feet in height at the shoulder.
\(^5\) Loc. cit.
\(^6\) Essays and Observations, vol. ii. p. 175.
\(^8\) Mémoires pour servir à l’Histoire Naturelle des Animaux, tom. iii. partie 3, p. 132.

VOL. XI.—PART IV. NO. 2.—April, 1881.
I would here express my indebtedness to Mr. Forbes for permitting me to examine the organs of the African Elephant which he has lately so accurately described in the 'Proceedings' of this Society. This examination has enabled me to confirm in all respects Mr. Forbes's observations, at the same time that it has put me in a position to make a more accurate comparison of the female organs of the two species than would have been possible from the perusal of any description, however perfect, of the organs of one or of both species. I have further to acknowledge with thanks the kindness of Messrs. Miall and Greenwood in affording me an opportunity of comparing their dissections of the female organs of the Indian Elephant with those of my own specimen.

**EXTERNAL ORGANS.**

Unfortunately, before I examined the specimen the skin had been removed; and consequently the appearances of the external genital fissure could not be noted. The urino-genital canal, however, remained intact; and the position of its anterior extremity showed that, as observed by Perrault in the African, and by Houel, Stukeley, Miall and Greenwood in the species now under consideration, the vulva is placed upon the lower aspect of the abdomen, and opens, not backward, as in the majority of mammals, but downwards and forward, the orifice being situated between the thighs.

**INTERNAL ORGANS.**

*Rectum.*—About one foot in length of the posterior extremity of the rectum remained attached to the genital organs. This portion of the gut passes horizontally backward, and terminates at the anus in the usual manner. The peritoneum does not invest this part of the gut, being reflected from the intestine to the uterus below, and to the pelvic wall above, at a point somewhat in front of the part met with in my dissection. The walls of the gut are extremely thick, and consist of four distinct coats. Enumerated from without inwards these are—(a) a very thick layer of connective tissue, (b) an equally strong coat of longitudinally arranged muscular fibres, (c) a layer of circularly arranged muscular fibres, (d) the mucous membrane. The latter is very dense and tough, and is thrown into well-defined longitudinal rugae. These, for the most part, run parallel to the long axis of the gut; but here and there, especially towards the anal orifice, the larger folds are connected together by shorter, obliquely placed, and anastomosing rugae. Scattered over the surface of the mucous membrane, for the most part at intervals of about one fourth of an inch, is a number of apertures of size sufficient to admit the head of a pin. Although for the most part separated from one another by the distance above mentioned, these apertures are at places more closely aggregated together, so as to form irregular patches. These apertures are the mouths of minute intestinal glands.

1 Histoire naturelle des deux éléphants, mâle et femelle, du Muséum de Paris, 1803.
2 On the Spleen, to which is added some Anatomical Observations on the Dissection of an Elephant: Lond. 1723, p. 104.
Sphincter ani externus.—The extremity of the rectum is provided with an enormously powerful external sphincter. The exact origin of this muscle I could not determine, as the parts had been removed from the pelvis. From the appearance of the dissection, however, the muscle appears to have been attached, as in most quadrupeds, to the lower surface of the last sacral or first caudal vertebra. It measures 3 inches in breadth on each side of the rectum, and, passing obliquely downward and forward, so as to encircle the gut, is inserted by a pointed extremity into the strong aponeurosis which closes the pelvic outlet, 3 inches below the anus. The insertion of the external sphincter corresponds exactly to the origin of the bulbo-cavernosus muscle in the male, as well as to that of the homologous muscle (the constrictor vaginae) in the female.

Urinary Organs.

Kidneys and Ureters.—The right kidney was alone examined. It agreed in all respects, excepting the number of its lobes, with the description which I have formerly given1 of that organ in the male. It was distinctly lobulated on the surface, the lobes being seven in number. The ureters are provided with very thick walls, the thickness being chiefly due to an enormous development of the connective-tissue coat. They pass backward and come into contact with the wall of the bladder 3 inches behind the neck of that viscus. After passing (as in the male) very obliquely through the vesical wall, they open into the bladder 1½ inch behind the neck of the organ. Their apertures are valvular in character, and 1 inch apart.

Bladder and Urethra.—The bladder lies in contact with the lower surface of the vagina. It is of small size for so large an animal, measuring, when distended, only 6 inches from base to apex. It ought, however, to be observed that the parts, having been for some months immersed in spirit, may to some extent have suffered contraction in size. The apex of the bladder is the broadest part of the organ; and therefore the viscus does not present the well-marked pear-shape so common among the Mammalia. The bladder merges insensibly into the urethra; so that it is difficult, from an external examination, to say where the one ends and the other begins. An examination of the interior of the viscus, however, shows that the urethra, from the most dependent part of the bladder to its opening into the urino-genital canal, measures 2 inches in length. As the urethra passes backward it rests against the lower wall of the vagina. Its entrance into the urino-genital canal is separated from the ora vaginae by a semiglobular projection of the mucous membrane, which will be more fully described along with the canal just mentioned. Both urethra and bladder are provided with a thick coat of muscular fibres of a reddish colour, arranged parallel to the long axes of these visceræ, and constituting, so far as the bladder is concerned, a powerful detrusor urinæ. The peritoneum, which is thick and leathery, covers the whole of the

upper surface of the bladder as far back as the points of entrance of the ureters, whence it is reflected to the under surface of the corpus uteri. The lateral surfaces of the bladder are also in part invested by peritoneum, whence this membrane passes to the lateral and superior abdominal walls. The whole of the lower surface and base of the bladder are therefore destitute of peritoneum. As in the male, so in the female, the apparent thickness of the vesical walls is due rather to the peritoneum and subperitoneal connective tissue than to that of the muscular coat.

Genital Organs.

Ovaries.—Each ovary is oval in form, and measures 1 ½ inch in length, and 1 ½ inch in greatest breadth, and about ¾ inch in thickness. Each is distinctly lobulated on the surface, that of the right side more so than that of the left. The grooves or fissures which separate the lobules are, however, quite superficial, and do not extend to any great depth into the stroma of the ovary except in the case of that of the right side, in which, close to the superior or attached margin, are two deep fissures, one of which almost completely severs about ¼ inch in breadth of the ovarial substance from the rest of the organ, the detached portion being further subdivided into two parts by a second short but deep fissure. There is no trace of either of these deep fissures in the ovary of the left side; and probably we are therefore justified in regarding their presence as an individual peculiarity. Each ovary is suspended over the mouth of a very complete peritoneal pouch by means of two ligaments, one of which is attached to each end of the organ. The internal ligament measures 1½ inch in length, and passes from the inner end of the ovary to the extremity of the uterine horn of the same side, whilst the external ovarial ligament extends outward and forward from the outer end of the ovary, and can be traced for a distance of 7 inches in the peritoneum, in the substance of which membrane it at length disappears. This ligament, in all probability, corresponds to the external ovarial ligament of Hyæna crocuta; but whether, as in that animal, it was attached to the diaphragm could not be determined, as the viscera had been removed from the cavity of the abdomen. Both ovarial ligaments are in the form of stout fibrous cords. The pouch, at the mouth of which the ovary is placed, is formed of peritoneum continuous with that forming the broad ligament of the uterus. Its opening, in the natural position of the parts, is directed upwards and forwards (toward the spine of the animal); so that the bag hangs vertically below the ovary. The bag itself is of large size, measuring 3 inches from side to side, 3 inches from above downward, and 1½ inch from before backward, and closely resembles the corresponding structure of Hyæna crocuta. Its posterior free margin is formed by the ovary and ovarial ligaments, its anterior by the free edge of the wall of the sac. As pointed out by Mayer, Miall and Greenwood, the ovarial pouch is separated into two compartments by means of a

3 Loc. cit. p. 63.
horizontal peritoneal septum, the posterior margin of which is attached to and continuous with the posterior wall of the sac, whilst its anterior margin is free. The two compartments are of very unequal size, the upper or dorsal being much smaller than the lower or ventral. The former accommodates the ovary, whilst into the upper and internal angle of the latter (as shown in fig. 2, Pl. XXII.) opens the fimbriated extremity of the Fallopian tube. The separation of the ovary by means of this septum from the Fallopian tube would appear to necessitate certain alterations in the form of the sac at the period of ovulation, so as to permit of the passage of the ova from the upper to the mouth of the oviduct in the lower compartment. The means by which this is effected are certainly obscure; but it is possible that the numerous bundles of muscular fibres which form an open meshed reticulum in the walls of the ovarian sac may be adapted to the attainment of this object. The morsus diaboli is completely surrounded by a thick belt of well-developed fimbriae, which, however, are of small size. The aperture is of size sufficient to permit the passage of an ordinary knitting-needle.

The above description of the ovary and ovarian sac agrees closely with that of Mayer and Miall and Greenwood of these parts in the Indian Elephant. Forbes also found a similar arrangement in the African species, but does not refer to any subdivision of the ovarian pouch into two compartments. Observing, however, as he does, that his specimen closely resembled that figured by Mayer in the Indian Elephant, it would appear that these parts do not differ much in the two species of Elephant. The slightly lobulated character of the ovary was also noticed by Forbes in the African Elephant.

**Fallopian Tube.**—This tube measures 3 inches in length, and extends from the morsus diaboli to the extremity of the corresponding uterine horn, with which it is continuous. The morsus diaboli is situated at the upper and internal angle of the lower or larger compartment of the ovarian pouch. From it the Fallopian tube winds upward and inward, lying in relation to the posterior wall of the ovarian sac, as far as the extremity of the cornu uteri. In this course the tube describes a well-marked sigmoid curve, as well as two or three subordinate flexures, as represented in fig. 2, Pl. XXII. Lying in the posterior wall of the ovarian pouch, the Fallopian tube is altogether concealed from the front by the ovary itself, and is only exposed to view when the latter is everted from the sac (fig. 2, Pl. XXII.). The morsus diaboli, as already remarked, is funnel-shaped, and readily admits of the passage of a knitting-needle. Beyond this orifice, however, the Fallopian tube gradually contracts, until, at the second limb of the sigmoid curve (marked with an asterisk in fig. 2), it only admits a very delicate bristle; this calibre it retains as far as its junction with the uterine horn, into which it opens abruptly. From this description it will be observed that the Fallopian tube lies only in contact with the *posterior* wall of the ovarian sac, and does not encircle the anterior and lower walls of that pouch, as in *Hyena crocuta*, in which animal these parts otherwise present the closest resemblance to those of the Elephant.

Exterior of Uterus.—The uterus consists of a central body or corpus and of two cornua. Each cornu, from the point of entrance of the Fallopian tube to the junction with its fellow of the opposite side, measures 6 inches in length, and describes a well-marked curve, the convexity of which is directed forward. Each of the uterine horns is flattened from above downward, and measures \( \frac{3}{4} \) inch in breadth at its junction with its fellow. They diverge at once from one another, so as to leave close to their junction an interval of a triangular form, which is filled up by peritoneum. The corpus uteri, lying between the layers of the broad ligament, measures 7 inches in length from the junction of the cornua to its opening into the vagina. It is somewhat flattened from above downward, and has a uniform diameter of 1 inch. The corpus uteri lies altogether in front of the bladder, and is completely invested by peritoneum. It differs in this respect from the vagina, which, lying between the bladder and rectum posterior to the line of reflection of the peritoneum from the uterus to the neighbouring viscera, is altogether devoid of serous investment. The body of the uterus is thick and muscular. There is no trace in my specimen of the external constriction which, according to Miall and Greenwood, indicates the separation of the uterus from the vagina, this separation being visible on the interior of the organ only.

Interior of Uterus (fig. 1, Pl. XXII.).—Upon slitting open the cornua uteri, these are seen to be lined by a uniformly smooth mucous membrane, which presents no trace of the longitudinal rugae so commonly met with in other mammals. From the point of junction of the uterine horns a well-defined septum uteri extends backward through the whole length of the corpus uteri, as well as through that of the vagina to the opening of the latter into the urino-genital canal. This septum, therefore, separates the body of the uterus into two perfectly distinct compartments. It is thick and opaque so far as it lies within the cavity of the uterus, but becomes thin and translucent within the vagina. This difference in appearance of the septum at different parts is due to the fact that, within the uterus, the mucous membrane covering the septum as well as the uterine walls is thrown into longitudinal rugae, which, few and ill-defined at the junction of the cornua, become more numerous and of larger size further back, but cease entirely at the os uteri. Within the vagina neither the septum nor the vaginal walls present the slightest trace of mucous folds, the membrane being here perfectly smooth and closely adherent to the muscular parietes of the canal. In consequence of the complete development of the septum uteri throughout the whole length of the body of the uterus, this organ communicates with the vagina by means of two distinct apertures or ora uteri—an arrangement which is almost identical with that which occurs in the Leporidae. In the Hares, however, the vagina is simple and presents no trace of the mesial septum which in the Indian Elephant (at least in my specimen) separates that tube into two distinct compartments. The separation of the uterus from the vagina, although not defined externally except by the line of reflection of the peritoneum to the neighbouring viscera, is indicated in the interior of the organ by two well-defined folds of
mucous membrane, which project into the interior of the uterine compartments, and indicate the position of the ora uteri. The fold in connexion with the compartment of the right side is much larger than that met with in the left. Each forms a very incomplete valve attached to the outer wall of its own compartment, and projects inwards towards the mesial septum. The uterine surface of each is convex, whilst the vaginal surface is concave.

Vagina.—The vagina measures 6½ inches in length, and, as already stated, is not separated by any external constriction from the uterus. The junction of the two, however, is sufficiently indicated by the line of reflection of the peritoneum from the uterus to the neighbouring viscera. The vagina is situated between the bladder and rectum, and is altogether destitute of peritoneum. Its walls are thick, and are provided with a thick coat of longitudinally arranged muscular fibres. Upon slitit open the tube it is seen to be of the same calibre as the corpus uteri, and is lined with a smooth mucous membrane, which presents no trace of the rugae met with in the uterus. The vagina is separated from the uterus in front by means of the mucous folds described along with the ora uteri, whilst posteriorly it communicates with the urino-genital canal by means of two apertures, which are separated from one another by the posterior extremity of the septum vaginae. The latter is quite complete, and extends from end to end of the vagina, so as to separate the tube into two distinct channels—a right and left. In front the septum vaginae is continuous with the septum uteri, whilst posteriorly it intervenes between the two openings of the vagina into the urino-genital canal.

If, now, we compare the foregoing description of the uterus with those of other anatomists who have dissected the Indian Elephant, we find that it differs from one and all of these in several respects. John Hunter\(^1\) refers to the presence of a common uterus and of two horns, thus plainly indicating the absence of a complete septum uteri, such as occurs in my specimen. Mayer\(^2\) also describes a "gemeinschaftlicher uterus," two inches in length, as communicating with the "mit der urethra vereinte vagina" (that is, with the urino-genital canal); and the drawing which accompanies his description clearly shows the presence of a unilocular corpus uteri formed in the usual manner by the junction of the two cornua. Miall and Greenwood\(^3\) state that "the cornua uteri unite to form a short tube of about one inch in length and three quarters of an inch in diameter." This, which they regard as the common uterus, "leads into a somewhat larger chamber about three inches long, which represents the cervix uteri." The separation of the cervix from the remaining nine inches of the tube is indicated externally by a slight constriction, and internally by "two considerable and well-marked enlargements which project inwards from the internal wall and almost close the passage." The latter part of the single tube they look upon as representing the vagina, and describe and figure it as opening into the urino-genital canal by a single orifice, which is divided into two lateral halves by a thick rounded cord covered by mucous membrane,

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\(^1\) Loc. cit. p. 175.  
\(^2\) Loc. cit. p. 33.  
\(^3\) Loc. cit. p. 63.
which is apparently a hymen.” I have, through the kindness of Prof. Miall, had an opportunity of examining the organs from which his description was drawn up, and can testify to the accuracy of the latter. In Prof. Miall’s specimen, therefore, as in those dissected by Hunter¹, Mayer², and Stukeley there was a unilocular corpus uteri. Owen³ likewise refers to the presence of a unilocular corpus uteri in the Indian Elephant.

Since writing the above I have received drawings of preparations, numbered 2775 and 2776, of the female organs of the Indian Elephant contained in the Museum of the Royal College of Surgeons of England, together with the descriptions contained in the Catalogue. The preparations from the Museum of the Royal College of Surgeons are probably those from which Hunter and Owen drew up their descriptions, and show the presence of a secondary vagina as distinguished from the uterus, as well as of a uterine septum which does not extend throughout the entire length of the latter. In this specimen, therefore, there is also a unilocular corpus uteri as distinguished from the conjoined portions of the cornua uteri.

The diversity of statement with regard to the extension of the utero-vaginal septum in the Indian Elephant leads to one of two conclusions: either the extent to which the septum uteri is developed varies in different specimens of the same species—
a view which does not appear probable, but one which is nevertheless borne out by a comparison of the observations of Miall and Greenwood and myself on the Indian, as well as of those of Perrault and Forbes on the African Elephant; or it is possible that the difference may be explained in view of the occurrence or non-occurrence of pregnancy in the various specimens examined. On the supposition that any particular specimen had borne young, it appears not improbable that a portion of the septum may have been ruptured, and that thus the uterus, which previous to parturition had been possessed of a complete septum and of two ora uteri, may have been so far altered as to present a unilocular corpus and single os uteri. At the same time it ought to be stated that the result of Miall and Greenwood’s dissection is rather opposed to this view, as it appears unlikely, were the disappearance of the utero-vaginal septum due to changes taking place at the time of parturition, that its posterior extremity should remain in the form of a thick rounded cord (described by Miall and Greenwood as the hymen) when all the rest had disappeared. Further observations are necessary before this point can be regarded as settled, which it can only be by the examination of the female organs of animals at different ages. It appears improbable that a septum vagina should exist in one specimen and not in another, except on the supposition that a utero-vaginal septum is originally present in each individual, and only gradually disappears as the animal approaches sexual maturity.

Miall and Greenwood⁴, the latest writers on the anatomy of the Indian Elephant, find, as already stated, that what I have described as the corpus uteri is divisible into two

parts—an anterior (measuring an inch in length), which they regard as the body of the uterus, and a posterior (measuring 3 inches in length), which they look upon as representing the cervix uteri. These two parts differ from one another in the character of the mucous membrane. No such distinction is recognizable in my dissection, which, moreover, differs from that of Miall and Greenwood in the fact that, whilst in mine a well-developed septum uteri extends from end to end of the organ, in theirs this septum is confined to the anterior extremity of the organ. With regard to the presence of a vagina, their observations coincide with my own, differing, however, in this respect, that the septum vaginae, which extends from end to end of the organ in my specimen, is in theirs reduced to "a thick rounded cord covered by mucous membrane," which separates the otherwise single opening of the vagina into the urino-genital canal into two—a right and a left os vaginae—exactly as the posterior extremity of the septum vaginae does in my specimen. Miall and Greenwood are of opinion that this cord represents the hymen; but a comparison of their specimen with my own leads me to the conclusion that it ought rather to be regarded as the posterior extremity of the utero-vaginal septum, which had apparently atrophied and disappeared in the rest of its extent.

Passing now to the difference of statement with regard to the presence or absence of a secondary vagina, as distinguished from the uterus, in the Indian Elephant, we find, on the one hand, that Stukeley¹, Hunter, Owen, Miall and Greenwood all affirm its presence, whilst, on the other hand, in the specimen examined by Mayer the coalesced Müllerian ducts formed uterus, and uterus alone, and the secondary vagina was altogether wanting. My own observations, together with an accurate examination of the organs dissected by Messrs. Miall and Greenwood, lead me to the conclusion that, without doubt, a secondary vagina, as distinguished from the uterus, is present in the Indian Elephant. Each of these portions of the combined Müllerian ducts is perfectly distinct, and presents characters peculiar to itself. In the uterus we have the mucous membrane presenting a soft, spongy character, and thrown into longitudinal rugae; whereas in the vagina it is thin and semitransparent in character, closely applied to the vaginal parietes, and presents almost no trace of longitudinal rugae. The uterine walls are thickened by a peritoneal investment, whilst those of the vagina are entirely destitute of such. Lastly, we have the two organs clearly separated from one another by well-marked saucer-like folds of mucous membrane which clearly indicate the position of the os uteri. Whilst, however, my own dissections agree so far with those of Messrs. Miall and Greenwood, they differ from the latter, as well as from those of every other anatomist who has examined these organs, inasmuch as they disclose the presence of a perfect vaginal septum. This septum, which in the specimen examined by Messrs. Miall and Greenwood, as already stated, is reduced to the condition of a thick fibrous

¹ In the drawing (plate viii.) appended to Stukeley’s work on the Anatomy of the Elephant, the differentiation of the combined Müllerian ducts into uterus and vagina is distinctly shown, although in the text this differentiation is not particularly referred to.
cord (regarded by them as the hymen), apparently presented a similar appearance in one of the two specimens dissected by Stukeley\(^1\), whilst in those examined by the other anatomists above referred to not a trace of it was present.

The differentiation of a secondary vagina in the Indian Elephant is not a little remarkable, inasmuch as physiologically this organ appears to be unnecessary, the functions of the secondary vagina being performed by the urino-genital canal; for, as long ago pointed out by John Hunter, into "the proper or, rather, uncommon vagina the penis cannot enter." In respect of this differentiation the female organs of the Elephant differ materially from those of *Hyæna crocuta*, which in other respects they so closely resemble; the combined Müllerian ducts in the last-named animal form uterus, and uterus alone, and the vagina is not differentiated from the uterus.

When we compare the female organs of the Indian with those of the African Elephant, we find, taking into consideration the observations of Perrault and of Forbes on those of the latter, that the two species agree in almost every particular. Perrault\(^2\) describes the cornua uteri of the African Elephant as being in contact for a distance of one foot, their lumina, however, being separated by means of a mesial septum much as in the Indian species. The two cornua, according to him, open separately into a common cavity, which, by reason of the relation which it bears to the uterus above and to the urino-genital canal below, we must regard as the secondary vagina. This organ, in his specimen, measured 18 inches in length, and opened below into the urino-genital canal. According to Forbes (and the observations of this anatomist I can in all points confirm), the cornua uteri lay in contact with one another for only 4\(\frac{1}{8}\) inches, and terminated below in a corpus uteri which measured 2\(\frac{3}{4}\) inches in length. The corpus uteri in turn opened into a secondary vagina, which in his specimen measured only 5\(\frac{1}{2}\) inches in length, and terminated posteriorly in the urino-genital canal, the diameter of the aperture of communication being much smaller than that of either of the canals between which it lies. It would appear, therefore, that in the animal dissected by Perrault the cornua uteri communicated directly by means of two separate orifices with the vagina, without the intervention of a unilocular corpus uteri similar to that described by Forbes.

The presence or otherwise of a "corpus uteri," as distinguished from the two cornua, does not appear to be a matter of much importance so far as the function of these parts is concerned, inasmuch as we know that in some animals the young are accommodated within and nourished by contact with the walls of the body, whilst in others they develop within the horns of the uterus. We may therefore regard the uterus and cornua uteri as different portions of the Müllerian ducts similarly modified in structure, in view of the performance of one and the same function. With respect to the vagina the case is widely different. It, like the uterus, is formed by the junction of the Müllerian ducts;

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\(^1\) See plate iii. of Stukeley \(^4\) On the Spleen, to which is added some Anatomical Observations on the Dissection of an Elephant; \(^7\) Lond. 1723.

\(^2\) *Loc. cit.* p. 133.
but in the majority of mammals (though not in the Elephant) it is structurally adapted to a totally different purpose—namely, to receive the male organ. In both species of Elephant this transverse segmentation of an anterior portion of the Müllerian ducts forming the uterus from a posterior portion forming the vagina takes place; but, as already pointed out, the function of the vagina in the Elephant (if function it has) must be different from that which it performs in other animals, inasmuch as into it the penis never enters, the function of the vagina in this respect being delegated to the elongated urino-genital canal.

In neither of the specimens of the African Elephant referred to was there the slightest trace of a vaginal septum such as I have described in the Indian species.

Urino-genital Canal.—The urino-genital canal extends from the mouth of the vagina to the vulva, and measures 13 inches in length. The canal is not straight, but describes a well-marked curve, the convexity of which is directed backward, and corresponds to that of the perineum, against which it rests. For the sake of accuracy of description it may conveniently be divided into two parts:—(a) an intrapelvic portion, extending from its commencement to the root of the clitoris; and (b) an extrapelvic portion, which corresponds in length to that of the clitoris, beneath which it is situated. The intrapelvic portion measures 5 inches in length and \( \frac{3}{4} \) of an inch in diameter, and is situated within the pelvis. It passes horizontally backward below the rectum. Its walls are three times as thick as those of the uterus, or vagina, the increased thickness being chiefly due to the presence of a layer of circularly arranged muscular fibres, which extends from the ora vaginae to the root of the clitoris. On slitting open this portion of the canal its commencement presents the appearance seen in fig. 3, Pl. XXII. In the axis of the cul-de-sac forming the commencement of the urino-genital canal, there is a semiglobose cushion of mucous membrane measuring \( \frac{1}{2} \) an inch in diameter, which projects into the lumen of the tube. Above this cushion, and separated by it from the transversely elongated urethral aperture, which lies directly below it, are the two ora vaginae, which, as in Miall and Greenwood’s specimen, are separated by “a thick rounded cord covered by mucous membrane.” Each of these permits the passage of a knitting-needle; and the septum between them measures \( \frac{1}{3} \) of an inch in thickness. Upon each side of the central cushion is the orifice of a small canal, into which a probe can be passed to the depth of \( \frac{1}{4} \) of an inch. These canals, which are situated on each side of the uterus and open close to the point of entrance of the urethra and Müllerian ducts, the history of development plainly shows are the remains of the Wolffian ducts; in other words, they are the canals of Gaertner. The urino-genital canal is lined by a thick mucous membrane, which, in its intrapelvic portion, is uniformly smooth and presents no trace of longitudinal rugae. The extrapelvic portion of the urino-genital canal extends along the under surface of the clitoris, and opens anteriorly at the vulva. This orifice, according to Perrault, is, in the African

\[ \text{Loc. cit. p. 107.} \]
Elephant, situated 2 feet in front of the pelvic outlet; and in the Indian species it appears to occupy a similar position. This portion of the urino-genital canal measures 8 inches in length, and is of the same diameter as the intrapelvic portion. Its walls, moreover, are of the same thickness, but differ in the arrangement of their muscular coat. The muscular fibres of the intrapelvic portion of the canal are arranged in a circular manner, whilst those of the extrapelvic segment are obliquely disposed, and are of interest inasmuch as they present a very striking resemblance on the part of the female to the homologous muscles met with in the male. The muscular fibres of opposite sides arise from the central point of the perineum, which is situated 3 inches below the anus, as well as from the middle line of the floor of the urino-genital canal for 3 inches in front of that point. The fibres of opposite sides diverge, and, passing obliquely upward and forward, so as to encircle the canal, are inserted into the body of the clitoris for a distance of 2 1/2 inches in front of the junction of the crura clitoridis. The anterior fibres describe a curved course between their origin and insertion, the convexity of the curve being directed backward. A consideration of the origin, insertion, and relation of these fibres to the insertion of the sphincters ani externus shows at once that they correspond to the constrictor vaginae of other mammals, and that they are therefore homologous with the bulbo-cavernosi muscles of the male urethra. The terminal 5 inches of the urino-genital canal is entirely membranous and devoid of muscular investment. The mucous membrane of this portion of the canal is thick and tough, like that of the intrapelvic part, but differs from the latter in being thrown into minute longitudinal ruge.

Cowperian ducts.—Opening into the floor of the extrapelvic portion of the urino-genital canal 1 inch in front of the junction of the crura clitoridis, which point corresponds to about the middle in length of the entire canal, are two ducts, each large enough to admit of the passage of a knitting-needle. The openings are placed, one on either side of a mesial fold of mucous membrane, 1 inch apart, and are valvular in character. The ducts to which they lead are perfectly straight, and can be readily traced obliquely backward and downward through the floor of the urino-genital canal as far as the central point of the perineum, where unfortunately they had been severed in removing the viscera from the pelvis. Opposite this point their cut ends lay between the bulbo- and ischio-cavernosi muscles—that is, at the spot which in the male is occupied by the Cowperian glands. Now, although it is always unsafe to predict any thing where organized structure is concerned, I have little hesitation in stating my belief that, in a perfectly fresh and entire specimen, Cowperian glands will be found to occupy this position in the female, exactly as they do in the male. At the same time it appears probable that in the female these glands, if present, must be of much smaller size than in the opposite sex, seeing that in the female there is not the slightest trace of the powerful muscles

1 Stukeley, p. 104.
which in the male occupy the interval between the bulbo- and ischio-cavernosi muscles, and which act as compressors of the glands in question.

Clitoris.—The clitoris is formed by the junction of two crura, each of which is attached to the corresponding ischial tuberosity, and measures 3 inches in length. Each crus is cylindrical in form, and is covered on its under surface by the fibres of a well-developed ischio-cavernosus muscle. The two crura, by their junction, form the body of the clitoris, which measures 7 inches in length and ⅜ of an inch in diameter. It is almost cylindrical in form, and lies along the upper wall of the extrapelvic portion of the urino-genital canal. It terminates within the vulva in a rounded imperforate glans, surrounded by a prepuce of mucous membrane continuous with that lining the urino-genital canal. The free extremity of the glans, uncovered by the prepuce, measures ¼ inch in diameter. Running along the dorsum of the clitoris are two arteries of large size, external to each of which is a large nerve. Both structures extend as far as the extremity of the clitoris, and in their course give off subordinate twigs to the neighbouring parts. On making a section of the clitoris this organ is seen to be composed of two corpora cavernosa, each of which consists of a mass of erectile tissue enclosed by a stout fibrous capsule. There is no trace of a corpus spongiosum. With regard to this structure, however, it would be of interest to ascertain, from the examination of a perfectly fresh specimen, whether or not it is, as in the human female, represented by two "vaginal bulbs" situated within the tegumentary folds which bound the genital fissure.

Muscles of Clitoris.—Excluding the bulbo-cavernosus muscle, which has already been described along with the urino-genital canal, these are two in number on each side. (a) The ischio-cavernosus or erector clitoridis is well developed, and arises from the tuber ischii. Its fibres pass obliquely forward and inward toward the middle line, and, covering the under surface of the crus clitoridis, are inserted into it as far forward as the junction of the latter with its fellow of the opposite side. This muscle lies to the outer side of the bulbo-cavernosus muscle. (b) The levator clitoridis is arranged exactly as the levator penis in the male. Each is a strong flat muscle, measuring at its origin 1½ inch in breadth, and is attached to the ischial bone immediately in front of the tuberosity, as well as, although to a less degree, to the upper surface of the crus clitoridis. The muscle passes forward, and, resting upon the dorsum of the clitoris, ends in a tendon opposite the junction of the anterior and middle thirds of the clitoris, which unites at once with that of the opposite side, the single tendon thus formed being inserted into the dorsal surface of the glans clitoridis.

Comparing this description of the urino-genital canal with those of other authors who have dissected the Indian Elephant, we find that the principal difference lies in regard to the number of openings which communicate with this canal. Hunter¹ says, "At the termination of the proper vagina, its cavity" (i.e. the cavity of the urino-genital canal) "contracts at once almost into a blind end, in the centre of which there are three small

¹ Loc. cit. p. 175.
openings, neither of them larger than a crow-quill; the two lateral of these lead to two small sacs (canals of Malpighi), which pass a little way along the sides of the common vagina. The urethra opens into the very beginning or fundus of the common vagina. The middle orifice leads into the common vagina, which soon dilates." It appears therefore that in Hunter's specimen the secondary vagina opened by a single orifice into the urino-genital canal, whereas in mine this single orifice is replaced by two orae vaginae separated by the vaginal septum. Otherwise Hunter's description of the urino-genital canal agrees with my own. Mayer¹, again, describes the os uteri externum as opening directly into the urino-genital canal, and does not mention a secondary vagina. He does not describe the canals of Gaertner. The difference between Mayer's description and that given above lies here—that whereas he found a unilocular uterus communicating by a single orifice with the urino-genital canal, in my specimen the bilocular uterus opens into the vagina, and this, again, communicates with the urino-genital canal by means of two orae vaginae. Miall and Greenwood's description of these orifices agrees exactly with my own, except that they do not refer to the canals of Gaertner.

In the African Elephant Perrault² found four openings at the commencement of the urino-genital canal—namely, those of the urethra, of the corpus uteri, and of the two canals of Gaertner. The latter he does not describe, but figures in the central drawing on plate xxi. Forbes³ corroborates Perrault's description, but differs from him in the interpretation of the parts, regarding the os uteri externum of Perrault as the opening of the secondary vagina. This difference of interpretation depends upon the fact that in Forbes's specimen, as already stated, the cornua uteri opened into a single corpus uteri, which in turn communicated with a secondary vagina opening into the urino-genital canal, whereas in Perrault's specimen the cornua uteri did not coalesce to form a corpus uteri, but communicated by distinct orifices with the space which Forbes regards as the secondary vagina. That Mr. Forbes is right in regarding the space in question as a secondary vagina I have no doubt. Having myself examined the specimen, the fact that the mucous membrane of this canal differs essentially in structure from that of both the horns and body of the uterus, and that the space was separated from the latter by a well-defined os uteri, at once convinced me that Mr. Forbes's view is the correct one.

The only difference between the urino-genital canal of the Indian, as compared with that of the African Elephant, lies in the fact that in the latter the urethra opens upon the cushion which occupies the centre of its blind extremity, whereas in the former the urethral orifice is situated above that prominence. In the African Elephant there is therefore a cul-de-sac above the projection referred to, which does not exist in the Indian species, its place being occupied by the orifice of the urethra.

Neither Hunter, Mayer, nor Owen⁴ makes any reference to the presence of Cowperian ducts in the female Indian Elephant. Miall and Greenwood⁵, on the other hand, de-

¹ Loc. cit. p. 38.  
² Loc. cit. p. 133.  
³ Loc. cit. p. 434.  
⁵ Loc. cit. p. 65.
scribe two sinuses as opening on the superior (intestinal) wall of the urino-genital canal about the middle of its course. These are evidently the Cowperian ducts, although, like myself, these anatomists could not discover the glandular bodies with which I have little doubt they were connected. Their statement that these ducts open on the superior wall of the urino-genital canal arises from a misconception as to the course of that canal after it has passed out of the pelvic cavity. As we have seen, the canal curves forward to terminate at the vulva—an arrangement which causes what, in the majority of mammals, is the upper or rectal wall of the canal to become in the Elephant the inferior wall or floor. In their description of the African Elephant neither Perrault nor Forbes makes mention of Cowperian glands or of their ducts.

The muscles above described as the bulbo-cavernosi appear to be present in the female of both the Indian and African Elephants. Messrs. Miall and Greenwood find in the Indian species an arrangement of muscular fibres almost identical with that above described, whilst Perrault\(^1\) describes the urino-genital canal of the African species as “being covered with a large number of fleshy fibres, which were continuous with the muscles of the anus as well as with those of the sphincter of the bladder.” Neither of these authors, strange to say, appears to have recognized that the fibres in question are homologous with the bulbo-cavernosi of the male animal. Miall and Greenwood\(^2\), indeed, observe that the sides of the vulva “are very loose, and do not appear to be provided with a distinct sphincter”—a fact which is easily explained when one considers the great difference in arrangement of the urino-genital canal of the Elephant as compared with that of the majority of mammals\(^3\). In the latter the canal is, so to speak, cut short, and the bulbo-cavernosi muscles are thereby converted into a sphincter vaginae surrounding the genital fissure, whereas in the Elephant the male-like elongation of the urino-genital canal, together with the presence of an enormous clitoris, gives rise to a corresponding modification in the arrangement of the muscular fibres and a resulting similarity of the bulbo-cavernosi muscles in both sexes. The ischio-cavernosi and levatores clitoridis muscles have both been figured by Mayer in the Indian Elephant. They have not been hitherto described in the African species. The clitoris does not differ much in the two species of Elephant. In the Indian species, however, there is a distinct mucous prepuce which has no representative in the African Elephant. It is true that Forbes\(^4\) describes a “well-marked preputial-like reversion of the integuments” as surrounding the glans; but, so far as I could ascertain from an examination of his specimen, this is merely formed by the reflection of the mucous membrane from the urino-genital canal to the clitoris, the line of reflection being situated about 2 inches behind the extremity of the glans clitoridis. The same arrangement of these parts is found in the Indian Elephant; but, in addition, there is a second and more anteriorly placed fold of mucous membrane, which completely surrounds the glans clitoridis, and leaves

\(^1\) Loc. cit. p. 132.
\(^2\) Loc. cit. p. 66.
\(^3\) Loc. cit. p. 495.
\(^4\) It is worthy of note that Stukeley figures the constrictors vaginae muscles.
only the extremity of that organ (p., Pl. XXI.) exposed. This I am inclined to regard as the true prepuce—a structure which is altogether absent in the African Elephant 1.

From the foregoing comparison of the female organs of the Indian with those of the African Elephant we see that, for the most part, the two species closely resemble one another. The extent to which the utero-vaginal septum is developed appears, from the observations of the different anatomists above referred to, to be variable in both species; and, taking into consideration this variety of statement, further research is necessary before we can arrive at any definite conclusion as to the explanation of this fact.

Comparison of the female Organs of the Proboscidea with those of other Mammals.—The most striking peculiarities of the female organs of the two species of Elephant lie (a) in the presence of a non-functional vagina, which closely resembles the uterus in structure, and (b) in the length and peculiar course of the urino-genital canal, which gives rise to an arrangement closely resembling that of the corresponding parts of the opposite sex. With reference to the first of these points, although there are many mammals in which the vagina is functionally useless during sexual congress, its usual function in such being delegated to the urino-genital canal; yet there are few in which the vagina, in respect of anatomical structure, presents so close a resemblance to the uterus as does that of the Elephant. A resemblance of a similar kind, but more pronounced in character, is, so far as I am aware, only met with in the female Hyaena crocuta 2. In this animal all distinction between the uterus and vagina has disappeared, the vagina being so metamorphosed as to be structurally indistinguishable from the uterus. The lower portion of the uterus of this animal must nevertheless be regarded, morphologically and developmentally, as homologous with the vagina of other mammals. As regards the length of the urino-genital canal, Owen 3 states that in one group of mammals, that of the Platyrrhine Monkeys, the urino-genital canal equals in length that of the secondary vagina, but in the majority of mammals the former is much shorter than the latter. In the African Elephant, according to Forbes, the length of the urino-genital canal is to that of the vagina as 3 to 1, whilst in the Indian species the former is to the latter as 2 to 1. In the Indian Elephant, therefore, as in Hyaena crocuta, the female urino-genital canal is immensely elongated, and closely resembles the corresponding structure of the opposite sex. In both it is provided with Cowperian ducts opening at the junction of its intra- and extrapelvic portions; in both the clitoris is of enormous size; and in both the urino-genital canal extends forward in relation to the lower surface of the clitoris, and consequently opens much further forward than in the majority of mammals, the orifice of the urino-genital canal, in fact, occupying a corresponding position in both sexes. These remarks apply equally to the African as to the Indian Elephant.

1 It is worthy of remark that the structure which I consider as representing the true prepuce was also absent in the specimen of the Indian Elephant dissected by Messrs. Miall and Greenwood.
The female urino-genital canal of *Elephas*, however, differs from that of *Hyæna*, inasmuch as in the latter the canal *perforates* the extremity of the clitoris, and terminates exactly as in the opposite sex; whereas in the former the canal does not perforate, but opens externally by an orifice situated *below* the clitoris. If, however, we imagine the urino-genital canal and clitoris of the Elephant, instead of being entirely concealed by the abdominal integuments, to be free for a part of their course, we shall then have a pendulous organ closely resembling the genital member of the opposite sex, an arrangement which actually obtains in *Hyæna crocuta*. Even in the female Elephant the external organs of generation so closely resemble those of the male, that, according to Perrault and Stukeley, the females which they examined were, previous to dissection, believed to be males. In *Hyæna crocuta* the corpora spongiosa of the female are represented by two small pear-shaped masses of erectile tissue which lie below the crura clitoridis; but in the Elephant these bodies have not been discovered, and, if present at all, in all probability take the form of a venous plexus, the so-called vaginal bulbs of the human female. In the female *Hyæna* there is no trace of the bulbo-cavernosi muscles of the opposite sex, whereas in the Indian Elephant they are largely developed.

I have already indicated that the female urino-genital canal of *Elephas* presents a striking resemblance to that of the male. As in my paper on *Hyæna crocuta* these resemblances were fully pointed out, I need not further refer to them, as the remarks there made apply equally to the Elephant, subject to the modifications just pointed out. I shall therefore content myself by referring the reader to that paper, as well as to one in the *Journal of Anatomy*; where the subject of sexual homology is treated at of greater length.

*Physiological Observations.*—The arrangement of the female passages of the Elephant is such as at once explains the diversity of statement with regard to the position of the female during sexual congress. It is evident that, as the vulva is situated so far forward on the abdominal wall, instead of posteriorly as in the majority of mammals, sexual congress could not be accomplished were the female to occupy the position usual among quadrupeds. Passing by the absurd views of the older writers, in accordance with which the female was placed with her back to the ground, we find that Miall and Greenwood state that “In the natural (unexcited) state the urino-genital canal is curved forwards and opens on the under surface of the belly; but by distention of the crura clitoridis it can be so far straightened that the orifice looks almost directly backwards, being then beneath the anus, but separated from it by a considerable interval. Thus

1 Observations made by me since this paper was laid before the Society show that in the female *Hyæna crocuta* which has borne young, although not in the virgin (in which the parts present the appearance referred to in the text), the external orifice of the urino-genital canal comes to bear the same relation to the clitoris as it does in the Elephant; that is, it opens below the latter.


3 Vol. xiv. p. 50.


5 Loc. cit. p. 65.
the urine is ordinarily discharged downwards and forwards; but sexual congress takes place in something like the position ordinary among quadrupeds. This view of the position of the urino-genital canal during sexual congress is hardly satisfactory when the position of the organs in situ is taken into consideration. These authors had apparently examined the organs when removed from the body, when, of course, the urino-genital canal would form a straight tube—leading naturally to the belief that this form could be assumed by the organ when in situ. The arrangement and mode of attachment of the terminal portion of this canal, however, is such that no amount of erection of the clitoris could so far straighten it as to direct its orifice backward so as to receive the male organ from behind, as happens in the Mare or Cow. Under these circumstances there is only one other explanation that appears to carry weight with it; and that is the view long since held by Buffon, supported by the evidence of eye-witnesses, and more recently by Crisp. According to the statements of these authors the female, during sexual congress, rests upon the knees of the fore legs, the hind legs being simultaneously extended to the full. By this means the orifice of the vulva is so far directed backward as to facilitate the performance of the act in question. The accuracy of this view has lately been called in question by Mr. Sanderson, who states that he has "on four different occasions witnessed the act—once by two animals belonging to a wild herd in the jungles, in the others by animals which had just been caught and which were at large within the kheddah enclosures. On each, the female stood to receive the male in the manner common to all quadrupeds."

Mr. Sanderson's view is further supported by an observation recently reported, to the effect that a tame performing Elephant, which subsequently gave birth to a calf, was on two occasions observed to be covered by the male, and that "in the act of copulation no peculiarity was observed that would distinguish Elephants from other animals." In view of so great a difference of statement on the part of eye-witnesses, it is not easy to decide which is the more reliable. At the same time I may be permitted to observe that the anatomical examination of the female organs in situ certainly throws doubt upon, if it does not altogether contradict, the possibility of the completion of the sexual act so long as the female Elephant occupies the position usual among quadrupeds. The views of Buffon, Crisp, and Slym are supported not only by an examination of the female organs, but are further borne out by certain Indian sculptures, photographs of

1 Honel, plate x., figures the external genital orifice as directed backward during sexual excitement; but this, like others of his sketches, is far from being reliable.

2 Natural History by the Count de Buffon, translated into English, vol. vi. p. 89; Edinb. 1780.


4 I am indebted to the kindness of Sir Joseph Fayrer for enabling me to ascertain that Slym, in his work 'Elephants and their Treatment in Health and Disease,' p. 5 (Moulmein, 1878), supports the view of Buffon and Crisp with regard to the position of the female Elephant during sexual congress.

5 "Thirteen Years among the Wild Beasts of India," p. 94.

which I had lately in my possession. In these the animals are represented during coitus as occupying the position described by Buffon, Slym, and Crisp. This I believe to be the true one.

**Position of the Young in utero.**—With regard to this we know little or nothing. Professor Owen's observations on the placenta of the Elephant throw no light on this point. We know, however, that in some animals the foetus is lodged in the corpus uteri, in others in the cornua, and in others in both corpus and cornua uteri. In the Elephant the structure of all of these parts is alike, and apparently equally adapted to the accommodation of the young. At the same time it ought to be remembered that the mucous membrane covering the septum uteri of my specimen did not present to the naked eye the same soft, spongy structure that characterized it in other parts. Nor is its appearance such as to lead one to believe that during the period of gestation it is capable of undergoing those vascular changes which are essential to the formation of a placenta and the nutrition of the embryo. Professor Owen, however, has shown that the placenta of the Indian Elephant is annular in character; and I am therefore inclined to think that either the septum uteri is absorbed and disappears before the parent reaches sexual maturity (a view supported by the observations of several anatomists already referred to), or that the young must be accommodated within one or other of the cornua rather than in the corpus uteri. Otherwise it is difficult to account for the completely annular character of the placenta described and figured by that anatomist.

_P.S., Feb. 1st, 1851._—Since the above was in type, I have, through the courtesy of the author, received a copy of Dr. Chapman's paper "On the Placenta and Generative Apparatus of the Elephant." Dr. Chapman's observations confirm my own with regard to the essential similarity in structure of the female organs of the Indian and African Elephants, but differ with respect to the position of the female during copulation. According to the keeper (Mr. George Arstingstall) of the Elephant the placenta of which forms the subject of the greater number of Dr. Chapman's remarks, the female during coitus assumed the same position as the Cow or Mare under similar circumstances. This statement is corroborated by Corse, who himself was an eye-witness of the copulation of two tame Indian Elephants. It appears, therefore, that on the one hand we have the evidence of two eye-witnesses (Eles, quoted by Buffon, and Crisp) who maintain that copulation takes place whilst the female rests upon the fore knees, and two (Sanderson and Arstingstall) who allege that the act is performed whilst the female occupies the position usual among quadrupeds. Under these circumstances it appears safe to assume that copulation may take place while the female occupies either of these two positions, although, as above remarked, the anatomical disposition of the female organs lends most support to the views of the first-named observers.

Dr. Chapman is of opinion that, with the single instance of Elephants breeding in captivity recorded by Professor Owen, the case reported by himself is the only one on record. This, however, is erroneous, another

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1 Phil. Trans. 1857, p. 347.
6 'Thirteen Years among the Wild Beasts of India,' p. 94.
case having been recorded by Corse, the animal above referred to (of the impregnation of which Corse himself was an eye-witness) having subsequently given birth to a calf. Thus we have authentic information of the birth of three young Elephants, the parents of which bred in a state of captivity:—(1) that reported by Corse, which took place on the 16th March 1795; (2) that reported by Professor Owen, which took place on the 3rd August 1865; and (3) that reported by Chapman, which took place on the 9th March 1880. In the first of these instances the period of gestation, dating from the first copulation, was 595, and from the last 594 days. In the second the duration of pregnancy was 593 days; whilst in the third the period of gestation, dating from the first copulation, extended to 655, and from the last to 629 days. In the latter case, therefore, the period of gestation exceeded that of the first two by a little over one month.

DESCRIPTION OF THE PLATES.

PLATE XXI.

Female Organs of Indian Elephant (Elephas indicus). Half nat. size.

O, Ovary; S, Septum, separating the peritoneal pouch into two compartments—an upper or ovarian, and a lower or tubal; M.D, Bristle passed into the morsus diaboli; C.U, C.U, Cornua uteri; U, Corpus uteri; V, Vagina; B, Bladder; R, Rectum; Ua, Urethra; U.G, U.G, Urino-genital canal; I, Ischial bone; S.A., Sphincter ani externus; Ur, Ureter; L.C, Ischio-cavernosus muscle; C.V, Constrictor vaginæ (Bulbo-cavernosus) muscle; L.C, Levator clitoridis muscle; Cl, Clitoris; P, Preputium clitoridis.

PLATE XXII.

Female Organs of Indian Elephant (Elephas indicus).

Fig. 1. Uterus, vagina, and commencement of urino-genital canal, opened, from above: half nat. size. C.U, C.U, Cornua uteri (a bristle is inserted into the right cornu); U, U, Cavities of uterus, separated by the septum uteri; O, U, O, U, Ora uteri; V, V, Double canal of vagina, with septum vaginæ between them; O.V, O.V, Bristles passed through the ora vaginæ; U.C, Urinogenital canal.

Fig. 2. Ovary and peritoneal pouch of right side: nat. size (the ovary is thrown up to show the Fallopian tube). O, Ovary; C.U, Cornu uteri; F.T, Fallopian tube (the asterisk indicates the point where the calibre of the tube suddenly diminishes); S, Septum, which separates the peritoneal pouch into O.P, the ovarian pouch, and T.P, the tubal pouch; M.D, Morsus diaboli, opening into the tubal pouch.

Fig. 3. Commencement of urino-genital canal: nat. size. U, Orifice of urethra; G.C, G.C, Openings of canals of Gaertner; O.V, O.V, Ora vaginæ.

Fig. 4. Extrapelvic portion of urino-genital canal, nat. size, laid open from above to show the orifices of the Cowperian (Bartholinian) ducts. C.D, C.D, Bristles passed into the ducts of Cowper's glands; C, C, Crura clitoridis, separated from the body of the clitoris.
FEMALE ORGANS OF INDIAN ELEPHANT.
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1st April, 1881.

P. L. SCLATER,
Secretary.
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OF
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Vol. XI.—Part 5.

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Continued on page 3 of Wrapper.
X. Descriptions of some new and rare Cephalopoda. (Part II.)
By Professor Owen, C.B., F.R.S., F.Z.S., &c.

Received 2nd March, read 20th April, 1880.

[PLATES XXIII.—XXXV.]

SINCE the publication of the paper "On some new or rare Cephalopoda," in the second volume of the 'Transactions of the Zoological Society' (1842, p. 103)², I have not omitted any opportunity of acquiring and promoting the acquisition of specimens of that class, and now submit to the Society a selection of such materials as seem worthy of forming a second contribution on the subject.

Class CEPHALOPODA, Cuvier ².
Order DIBRANCHIATA, Owen ³.
Suborder OCTOPDA, Leach ⁴.

Genus TRITAXEOPUS, Owen ⁵.

Species Tritaxeopus cornutus, Owen. (Plate XXIII.)

The 'Poulpes,' or eight-armed Cephalopods, as a rule, bear their suckers in two rows along each arm. But, however numerous and seemingly "opposite" in arrangement, they are "alternate," and this order becomes more obvious as the suckers are fewer in number and further apart on the acetabuliferous surface. There are also species in which the zigzag course becomes so opened out that the suckers appear to be in a single series, at first along the distal half of the arm, as in Octopus lechenaultii; and finally, with a feeble indication of the zigzag at the basal part, the suckers curve in a linear course to the end of the arm, giving the character on which the generic group Eledone ⁶ is founded.

Other genera or subgenera of the Octopoda have been based on marginal extensions of the arm-membranes ('Cistopus, Pinnoctopus, &c.); but I have hitherto failed to find a notice of any Octopod characterized by having the brachial acetabula in three recognizable series along more or less of each arm.

This, however, is the constant character of an Australian species in other respects

¹ Communicated February 23rd, 1836. See 'Proceedings' for that year.
³ Memoir on the Pearly Nautilus, 4to, 1832, p. 56.
⁵ τρίς, three; τρίζας, rank; πτός, foot. ⁶ ἔλεδων, Arist.; Eledone, Cuv.; Eledon, Leach.
pretty closely resembling, in average size and in the extent of the basal interbrachial membrane, the common Poulpe (Octopus vulgaris) of our own shores. As, however, the acetabular character seems to be of equal distinctive value to that of the opposite extreme connective of Eledone\(^1\), I regard the present species as the type of a genus, the character of which has suggested the name above given.

The following are dimensions of my specimen of Tritaxeopus:—

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The arms differ as to length in the order characteristic of the second section of the "Poulpes" in D'Orbigny's monograph\(^2\), and graduate in the special manner seen in Octopus vulgaris: viz., the "third" arm counting from the dorsal (1) to the ventral (4) pair, being the longest, the "second" arm is but little longer than the "fourth," and the "first" is the shortest. The length of the "third" arm in the specimen figured (Pl. XXIII. a) is 1 foot 11 inches, that of the first (ib. 1) being 1 foot 2 inches. The basal thickness of the fleshy part of the third arm is 1 inch; and this dimension does not diminish in the same degree as does the length in the shorter arms. The extent of the basal webs, \(a\), \(a\), uniting the arms from the base to the middle of the free margin, is 2 1/2 inches between the second (2) and third (3) arms, and 1 1/2 inch between the first (1) and second (2) arms. The proportional magnitude of the "cephalic crown," formed by the arms and their webs, to the body, in Tritaxeopus cornutus, is as great as in Octopus vulgaris\(^3\).

The integument of the body is beset with scattered wart-like prominences, chiefly on the dorsal aspect; and, of these, four or five of the largest affect a longitudinal disposition.

The tegumentary eyelids are well developed; and each supports prominences on the upper border, of which the two anterior are so large and pointed as to simulate horns, whence the nomen triviale of the present species.

The fleshy stem or basis of the arms is, in transverse section, rather semicircular than trihedral. The flat side supports the suckers. They begin at the brachial basis (ib. fig. 2) in a single series, and, alternating in position after the third or fourth, assume the ordinary biserial arrangement; then the two series diverge after

1 Dr. Gray, in the 'Catalogue of the Mollusca in the Collection of the British Museum;' Part i. (12mo, 1849)

—Cephalopoda antependia—defines the genera Octopus, Cistopus, Pinnoctopus, as having "arms with two rows of cups" (p. 4), in contradistinction from Eledone and Cirrotenthis, which have "arms with one row of cups."

2 "B. Bras latéraux les plus longs" (Histoire naturelle générale et particulière des Céphalopodes Acétabulifères, &c., fol. 1839, p. 17).

3 M. d'Orbigny remarks on this character of "la couenne;"—"Son volume extraordinaire distingue de suite l'Octopus vulgaris des autres espèces" (op. cit. p. 25). It applies, however, more precisely, to the female of the species; and the subject of Pl. XXIII. fig. 1 of the present memoir is of this sex.
a short course to make way for the third supplementary row, which extends along the mid line of the acetabulliferous area to the attenuated terminal fourth part of the arm, where the biserial arrangement is resumed. A few suckers at the filamentary termination of the arms fall into the single series with which they began to appear at the base.

All the suckers are sessile. Each expands into a circular disk, the border of which is soft and thick; and therefrom converge a series of thin folds, opening into a central cavity which expands towards the bottom, whence rises a caruncle like the piston of a syringe. The mechanism of the Poulpe’s sucker is here repeated. The disk being applied to the surface to be seized, the piston is retracted, and the resultant vacuum converts the disk into a sucker\(^1\). The number of the suckers of a third arm (3) is 268: there is not more disparity of size between them than in the common Poulpes\(^2\).

The mantle, or body-tunic, is continued into that of the head along the basal breadth of the dorsal aspect of the body (Pl. XXIII, fig. 1, c); it terminates anteriorly and ventrally in a thickish free margin. From this wide aperture the “funnel” or respiratory tube projects; its base is not attached or articulated by cup-and-ball lateral cartilages, as in Decapoda; consequently it is more freely movable from side to side, and is commonly seen to project from one or other side, beneath or behind the eye, as at \(f\), fig. 1, Pl. XXIII. It is not provided with a valve.

This condition of the funnel, together with the tegumentary protective covering of the eyeball, has relation to the more frequent emergence of the animal from its proper watery element, and its continuance in some recess on shore during low water.

The colour of a \(Tritaxeopus\) so observed, and undisturbed, is a dullish pink, reflecting from parts of the “crown” a subviolet tint. But when irritated and alarmed it rapidly assumes tints varying from bluish red to deep violet. The inner surface of the coronal membrane, \(a, a\), is of a lighter tint. The inner circular lip (fig. 2) is whitish.

The mandibles have the usual deep-brown horny texture, the ventral one overlapping the narrower and shorter upper one; both are trenchant, curved, and pointed.

The accessory series of suckers in \(Tritaxeopus\) may be noted as a step toward the Decapods, more especially the family \(Sepiidae\), in species of which the suckers are crowded into three or more rows on a greater or less extent of the ordinary arms, or on the peduncles or accessory pair\(^3\). A reciprocal approach to the Octopodal type is indicated by another brachial character, exemplified in the species next to be described.

---

1. Lectures on the Anatomy of Invertebrates,’ 8vo, 2nd ed., 1855, p. 611, fig. 222.
2. In a few species, \(Octopus fontanianus\), d’Orb., \(c, g\), three or four suckers on certain arms form a cluster much larger than the ordinary serial pairs.
3. In \(Cranchia\), as in \(Loliginidae\), the suckers are in two series on the ordinary arms (Trans. Zool. Soc. vol. ii. p. 107, pl. xxi. fig. 4).
Suborder **DECAPoda**, Leach\(^1\).

Fam. **SEPIADÆ**, Owen\(^2\).

Genus **SEPIA**, Lamarck\(^3\).

**Species SEPIA PALMATA**, Ow. (Plates XXIV. and XXV.)

Of the present species the name relates to the great extension of the interbrachial webs (ib. fig. 1, \(a, a\)), to which the nearest approach seems to be made by **Sepia orbignyana**, Férussac\(^4\), and **Sepia elegans**, d'Orb.\(^5\), but in so feeble a degree that their presence is not noted in the text (pp. 273, 280), or shown in the plates "(Seiches) 5 and 8;" the degree in which such webs are developed in these species, however, is given in a subsequent plate, below cited, where an oral view of the head, with arms outstretched, exhibits the slight development of the basal webs in each of the species.

The second specific character of **Sepia palmata** is shown by the fins (ib. \(a, \delta\)), which not only commence at the fore part of the body, but extend in advance thereof almost to the degree of the medio-dorsal production of the mantle; the fins are also produced further back than usual, and coalesce \((a')\) beyond the end of the body\(^6\). In **Sepia latimanus**\(^7\) the fins terminate near the pointed end of the body and leave no notch, but do not unite together.

To the relative proportion of the body to the head with its "corona," in which character the Cuttles come nearer than the Squids to the Poulpes, **Sepia palmata** adds a development of the interbrachial webs equal to that in **Octopus vulgaris** and the species last described (Pl. XXIII.). But the web is not continued in **S. palmata** between the arms of the fourth pair. These, however, develop a narrow fold of the integument from the outer and hinder surface (Pl. XXV. fig. 1, \(a'\)). The arms decrease in length from the 4th to the 1st, but in a very slight degree from the 4th to the 3rd. The acutabular surface supports four rows of suckers, in the usual alternate relative position. The suckers are small, rather more than hemispheres in shape, supported each by a peduncle attached to one side of their "pole" and giving them an oblique position. The acutabular cavity is small in proportion to its muscular walls, and is lined next its outlet by a broad corneous hoop, the free border of which is finely denticulate. The interbrachial webs

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\(^3\) Syst. des Anim. sans Vertèbres, 1801.

\(^4\) Hist. Nat. des Céphalopodes, fol., 1835-1848, p. 273 (Seiches), pl. v. and pl. xxvii. figs. 1, 2.

\(^5\) Ibid. p. 280 (Seiches), pl. vii., and pl. xxviii. fig. 5.

\(^6\) The terminal notch between the side fins is so common in the species of **Sepia** that d'Orbigny makes of it a generic character:—"Nageoires—commençant à la partie antérieure même du corps, on au moins à très peu de distance; le bordant latéralement sur toute sa longueur, en laissant entre elles, en arrière, une forte échancreur" (op. cit., p. 250).

\(^7\) Op. cit., Seiches, pl. xii. fig. 1; Quoy et Gaimard, Zool. de l'Astrolabe, Atlas, Mollusques, pl. ii. figs. 2-11.
contract to their terminal attachment, which is at about one third of the length of each arm from its free pointed end; at the terminal part a ridge is continued from the subsidence of the web along the outer or peripheral side of the arm (Pl. XXIV. fig. 1, a', a').

The tentacles, d, d, rather exceed the length of the body when outstretched; their comparatively slender subcylindrical stems slightly narrow to their abruptly expanded extremities, e, f, g. These are chiefly formed by the acetabuliferous disk, the proximal end or margin of which, projects freely from the supporting pedicle. The acetabula are somewhat irregularly disposed, and are unequal in size; the four or five largest, greatly exceeding in size those of the arms, are at the middle and rather toward the proximal end of the terminal disk (Pl. XXV. e, e); they decrease in size towards its circumferenee to that of the brachial cups. The dorsal surface of the cup-bearing disk is transversely furrowed (Pl. XXIV. fig. 1, f); the border of the tentacle opposite that which supports the disk is produced into a narrow fold or "velum" (ib. g). The large cavity or sac into which the tentacles can be withdrawn is situated beneath or on the ventral side of the eyeballs: the wrinkled disposition of its parietes in the empty state is shown at h, h (Pl. XXV. fig. 1).

The aquarium enables the home-naturalist to comprehend the use of this complex mechanism of cephalic prehensile organs. The Cuttle makes a hollow in the submerged sand on which it rests; the tentacles are drawn in, out of sight, the arms are contracted and collected en masse, as in the cut, fig. 1. If a fish should glide or a crab crawl within

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sight or smell, the Cuttle is roused, opes wide its eyes, separates and stretches out its arms, and manifests its emotion by change and heightening of its colour; it then moves craftily to the correct distance, takes aim, uplifts the dorsal pair of arms (*), divaricates the side pairs (2, 3, 4), and, darting out the tentacles, seizes and draws in the prey with a rapidity the eye can scarcely follow (fig. 2)\(^1\).

\(^1\) I am indebted for this statement, and the drawings from which figs. 1 and 2 are taken, to my late esteemed friend Mr W. A. Lloyd, Conductor of the Aquarium at Westminster, and lately in charge of that at the Crystal Palace. The same phenomena have been witnessed at the Brighton Aquarium.
The outer lip in *Sepia palmata* is attached to the velum at the interspaces of the arms. From that between the first pair a fold extends and expands upon the inner border of this circular lip, and develops therefrom a short tentacle, of a bright red colour in the recent Cuttle. A similar fold and process extend from the interspace between the second and third arms, and from the sheath of the tentacle between the third and fourth arms. A pair of similar folds of smaller size and developing shorter pointed processes, are continued upon the outer lip from the interspace between the fourth pair of arms. The fold of the outer lip developing the pink processes may be regarded as a middle lip. The inner circular lip immediately surrounding the mandible has a fringed external border. The above characters are shown in Plate XXV. fig. 1.

The head of *Sepia palmata* has the usual proportions of the genus, broader than long, but here in breadth not quite equalling that of the pallial aperture; it contracts to a kind of neck behind the eyes. These (Pl. XXIV.) are more dorsal in position than in Octopods, are not visible on the ventral surface (Pl. XXV.), on which the Cuttle rests and lurks in wait for its prey. The cephalic integument is continued over the eye-ball, but becomes transparent opposite the iris, the curtain of which (Pl. XXIV. i) is visible and notable in the present as in other *Sepia*. There is a slight fold indicative of a lower lid, *k*; the upper one bears posteriorly three caruncles regularly disposed. Anteriorly is the small orifice of the lacrymal sac.

The dorsal part of the head, between the orbits, shows a depression lodging the anterior production, *m*, of the mid part of the dorsal border of the pallial aperture: into this production enters the fore part of the "sepium" (Plates XXIV. & XXV. fig. 2). A corresponding depression on the ventral side of the head, between the tentacular sacs, lodges the funnel (Pl. XXV. fig. 1, *n*).

The fins, *o, o',* produced from the entire side-border of the mantle or body-wall, nearer the dorsal than the ventral surface, extend forward in an unusual degree; and continuing backward, they round the hinder end of the body, meet, coalesce, and extend beyond that part, *o'.

The superior degree of development of these forward-propelling instruments may be correlated with the superaddition of the backwardly propelling webs, *a, a*, in the present doubtless very active Cuttle. In connexion with the characteristic hinder production of the fins may be noted the absence of the "mucro" or pointed terminal apex of the "guard" of the reduced and modified belemnitic shell, which mucro usually projects, in other species of *Sepia*, from the notch left at the posterior interval of the there separated lateral fins.

Besides the absence of the mucro, the "sepium" of *S. palmata* differs from that of *S. officinalis* and most other Cuttles in tapering more gradually to the hind end, in the greater proportion of the sheath to the phragmocone, and in the lateral margins of the sheath being well definable, and extending beyond the lamellate mass from end to end.

The dorsal surface of this mass or "phragmocone" has a subtrilobate form (Pl. XXIV.
fig. 2, b), the mid lobe more prominent than the side ones b'; on the ventral surface (Pl. XXV. fig. 2) the hinder two thirds of the mid lobe, b, are traversed by a median longitudinal groove. This is barely indicated in the sepium of S. officinalis, but is continued through the whole length of the same part and surface of the sepium of S. australis, d'Orb., which has a sharp and slender well-produced "mucro." The specific characters of the sepium of S. palmata are well brought out in a comparison of the figures of that part in the plates of the richly illustrated work of the French cephalopodists. The form which comes nearest to the sepium of the present species is that of S. longimanus of Quoy 2.

The colour of Sepia palmata, in the quiescent state of the Cuttle, is a dull or dirty subviolet-pinkish.

The subject of Plates XXIV. and XXV. was captured off the shore of Norfolk Island, Australia. The figures are reduced to three fourths of the natural size.

Genus Sepioteuthis, Blainville 3.

Species Sepioteuthis brevis, Owen. (Plate XXVI. fig. 1.)

The present form of Decapod agrees with Sepia in the extent of attachment of the lateral fins (ib. e, e); but the development of the internal shell is restricted to the sheath, or part homologous with the "guard" of the Belemnite, the chamber-walls of the phragmocoéne not being developed, and no part of the shell being calcified.

Of this form I have received a specimen from the Japanese sea, the arms of which had suffered some mutilation; but the proportion of the body to the head, of the breadth of the body to its length, and the narrowness of the lateral fins forbade its reference to any of the previously described or defined species of Sepioteuthis to which, or to their descriptions, I have had access.

I submitted the specimen to dissection, found that it was of the male sex; and, as these organs have not, to my knowledge, hitherto been made known in the genus Sepioteuthis, I add a figure of them, in situ, to the few remarks now submitted on the characters of the species.

The head is short and broad across the eyes. These have a tegumentary covering, transparent as in Sepia, and leaving the curtained iris (ib. fig. 1, m) visible. Behind the prominence of the eye-ball a low ridge of integument, with a subcrenate border, n, extends in a parallel curve, and, from its relation to the acoustic foramen, has been compared to an external ear 4.

The cephalic arms are short, provided on their dorsal or peripheral surface with a longitudinal tegumentary fold, d', and on the opposite surface with two rows of acetabula

2 Zoologie de l'Astrolabe, fol., tom. ii. p. 68, Mollusques, pl. 2. figs. 2, 11.
in the usual alternate disposition (Pl. XXVI. fig. 1, 1, 3). The dorsal pair (1) of arms are the shortest and most slender; the third and fourth (ventral) pairs are the longest and thickest. Only the basal part of the stem of the left tentacle, \( p \), remains in the specimen described.

On each side of the base of the funnel is a narrow elongate cartilage, \( q \), excavated for the reception of a cartilaginous prominence, \( r \), of similar form, from the juxtaposed inner surface of the muscular mantle. The infundibular tube is shown slit open along the ventral wall, exposing the terminal valve, \( s \). The masses of the "musculi retractores infundibuli" are shown at \( t, t \). The anterior or descending aorta, \( v \), is drawn from the intervening recess of the above muscles. The posterior aorta has been removed near its origin, \( v \). The systemic ventricle is transversely elongate and bent at a right angle, as in *Sepia*.

The vena cava, \( w \), is partly withdrawn from the intermuscular recess; and its two divisions, with their glandular tunics, are shown diverging to the lateral branchial hearts, \( x, x \), each of which has a small fleshy appendage. The margin of the gill lodging the branchial vein is shown at \( y \). The trunk of each vein enters the contiguous end of the transverse ventricle, the right rather more advanced than the left. The branchial lamellae are narrow and numerous.

The digestive viscera, agreeing closely with those of *Sepia*, have been removed to bring more clearly into view the circulatory, respiratory, and generative organs. A part of the liver, with its peritoneal capsule partially reflected, is shown at \( z \).

The testis, \( a \), occupies a peritoneal compartment at the hinder end, or fundus, of the abdominal cavity; on removing the serous coat, as in the figure, the fibrous tunic is exposed. To a part of the inner surface of this membrane are attached the seminal tubes, which diverge and branch dichotomously, filling the cavity, and terminating blindly. They are bathed in the seminal fluid, which escapes by rupture of the tubules into the fibrous sac, whence it escapes by a foramen leading to a long, slender and tortuous "vas deferens." This tube opens into a larger one, the size of which is chiefly due to the thickness of its fibrous and glandular parietes, which present narrow transverse plicae toward the cavity of the present canal, which has been termed a "vesicula seminalis:" it is shown at \( c \). The anterior end of the "vesicula" communicates with a second, oblong, blind glandular sac (ib. \( d \): it has been compared to a "prostate gland." Without sanctioning such homologies with the parts so called in the mamalian class, it is certain that the seminal fluid or spermatozoa are packed into capsules, contributed by the glandular parts of the above accessory organs, the capsules being therein moulded into the filamentary form. These "spermatophores" are conveyed by a short and wide duct to an oblong pouch, \( f \), sometimes called (after the naturalist and theologian who first drew attention to the moving powers of the filaments) "Needham's pouch" (bursa Needhami). A short canal conducts the spermatophores to the base of the penis, \( h \).
Genus Sepiola.

Species Sepiola oweniana, d’Orb.

I subjoin a description and figure of the male organs of Sepiola oweniana, d’Orb.\(^1\) (Pl. XXVI. fig. 2) for comparison with those of Sepiola grantiana, d’Orb.\(^2\), from which the difference of the subject of fig. 2, Pl. XXIV. is so great as to lead me to conclude that the complexities of the organs had failed to be unravelled by the deservedly esteemed French authorities on the present highly organized class of Mollusca.

In Sepiola oweniana the testis (ib. fig. 2, a) is pyriform, convex on one side, the opposite surface converging to a low ridge, from which the sperm-duct (vas deferens, b) is continued. This duct is relatively shorter and has fewer convolutions than in Sepioteuthis. The “vesicula seminalis,” c, is relatively longer, more slender, and shows a short fold in its forward course. The prostate, d, is rounded, its secretion is carried into the fore end of the “vesicula” by a relatively longer duct than in Sepioteuthis and Octopus. The duct, e, proceeds from the confluence of those of the vesicula and prostate, and, describing a turn round the hinder and smaller portion of the spermatophorous pouch, opens into its fundus. This pouch, f, is relatively larger than in Sepioteuthis or than in Octopus\(^3\); it is oblong, partially divided into two compartments by the slight constriction along which the vesiculo-prostatic canal curves. The spermatophorous duct, short and wide, g, comes off near to the large anterior end of the pouch, and conveys the movable “filaments of Needham” into the base of a conical penis, h.

Fam. TEUTHIDÆ, Owen\(^4\).

Section a\(^5\).

Subfam. Loligopsinæ, d’Orb.\(^6\)

Genus Loligopsis, Lam.\(^7\)

Species Loligopsis ocellata, Ow. (Plate XXVI. figs. 3–8, & Plate XXVII.)

This species, in the relative magnitude of the head and shortness of the trunk, departs from the generic character derived by d’Orbigny from the few specimens of the singularly modified Decapods forming Lamarck’s genus “Loligopsis” at the date of publication of the great work quoted below\(^8\). Nevertheless the essential characters of the

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\(^2\) Ibid. *Sepiola*, pl. ii. fig. 11.
\(^3\) See Cuvier, Mémoires &c. des Mollusques, 4to, 1817, “Poulpe,” pl. iv. fig. 5, c.
\(^5\) Ibidem (1836).
\(^7\) Extrait du Cours d’Hist. Nat., 1812.
genus are exemplified in the combination of the large naked eyeballs, the large and loose funnel (extending, when not reflected, as at m, Pl. XXVII. fig. 1, to the interspace of the eyeballs), the short but broad and here rounded terminal fins, k, k, and the very long, slender, and seemingly non-retractile tentacles, t.

The head, of which the prominent eyeballs, o, o, form the broadest part, is not contracted at its fore part, and is but very slightly so behind. There is no lacrimal depression, nor any rudiment of eyelids. A series of small spots around the margin of the wide orbit scarcely rises above the surface. The iris or capsule of the lens seems to be naturally exposed; the conjunctiva, p, continued from its periphery, is reflected upon the back part of the eye-globe as far as the entry of the nerves from the optic ganglion; the long diameter of the lens is in the line of its axis.

The cephalic arms are subequal, moderately long. Those of the dorsal pair (Pl. XXVII. 1, 1) are each 5 inches in length and 5 lines in basal breadth, those of the ventral pair (ib. 4, 4) are each 5½ inches in length and are rather narrower at the base. Each arm presents a quadrate transverse section, being tetrahedral (Pl. XXVI. fig. 4); the inner or central angles (ib. ib. e, e) are fringed with a very narrow delicately scalloped membrane, to the inner side of which the suckers, f, f, are attached each by a slender pedicle (fig. 5, p). The three pairs 1, 2, 3 of arms are attached to each other at their bases by two small webs, the broader one at the central, the narrower one at the peripheral angles; the arms 3 and 4 are connected basally by the peripheral web, g, only, which is broader than in the others, and forms the outer wall of the depression lodging the base or root of the tentacle. The tentacles, t, t, arise close together from a glistening mass of ligamentous substance at the inner part of the ventral side of the head, a little in advance of the orbits, whence they diverge to issue at the interspaces between the arms 3 and 4.

There seems not to be any cavity capable of receiving them entire in a retracted state, as in the ordinary Squids and Cuttles. Their clavate acetabuliferous ends, which may be supposed to have existed from the analogy of other species of Loligopsis (L. veranii, e. g.), in which the tentacles were fortunately entire in the captured specimen, have been broken off in the present instance, as in the species Loligopsis cycletzii, Lesueur, figured in the first volume of the Society's 'Transactions,' pl. ii. p. 21, as L. guttata, Grant; and in Perothis pellucida, or Perothis escholtzii, Rathke 1.

The brachial acetabula, attached or, as it were, suspended to the central borders (figs. 3, 4, e, e) of the ordinary arms, are small, not exceeding 1½ millim. at their base; this adheres by a short and pyriform peduncle (fig. 5) to, or close to, the brachial fringes. They are consequently in two series, of which the alternate arrangement is feebly shown. The two rows are as distinct at their basal beginning as in the rest of the course

1 Mém. de l'Acad. Imp. des Sciences de St. Pétersbourg, tom. ii. p. 159, pls. 1 & 2. This species is held by d'Orbigny to be identical with the Leachia (Loligopsis) cycletzii of Lesueur. I have added in outline, to one of the broken tentacles in pl. v. & vi., the clavate end as figured in pl. viii., d'Orb. op. cit.
(Pl. XXVI. fig. 3). They slightly enlarge toward the middle of the arm, and thence gradually decrease in size to the attenuated end. Each sucker is subspherical (Pl. XXVI. figs. 4, 5, 5'); the aperture of the cavity is circular, with a tumid margin; and the corneous lining terminates there by a finely spinous border.

The outer lip, or buccal membrane (Pl. XXVI. fig. 3, h), is from 7 to 8 lines in breadth; the free border is produced into seven angles, corresponding to the places of attachment of as many brachial "fræna" to the outer surface of the lip. Of these the dorsal one, i, is azygous and rises from the web at the basal interspace of the dorsal pair of arms l, l. The contiguous pair of fræna are similarly attached to the basal webs between the first and second pairs of arms. The fræna of the third pair are attached to the beginning of the ventro-marginal fringe of the third arm; those of the fourth pair are attached to the beginning of the contiguous marginal fringe of the fourth pair of arms. The labial processes corresponding to the fræna are simply pointed and short, not acetabuliferous. The surface of the outer lip, extending from the scalloped border to the inner lip, is finely villous. A narrow simple border, i, is developed from the continuation of the outer to the inner or proper lip. This lip is thicker, more muscular, and shows a crenate (hardly to be called fringed) border. The point of the ventral mandible is exposed in fig. 3 (Pl. XXVI.).

The rostral part of the upper dorsal mandible (ib. fig. 6, a) is short and stout, and sends down from its basal half a broad process, b, making the vertical diameter of the rostrum equal to the entire length of this mandible. The apophysis, c, is subquadrate. The rostrum of the lower ventral mandible (fig. 7, c) is longer and more acute, and has no basal process; its upper border is continued at f upon the apophysial part; the apophysis, g, is relatively more extensive than in the upper mandible; and the lower angle is produced.

The length of the specimen of Loligopsis ocellata here described, from the tip of the longest outstretched arm to the end of the body, is 1 foot; the length of the head with its brachial appendages is 7 inches 9 lines; the length of the body, less the funnel, is 4 inches 3 lines. The transverse diameter of the fore part of the body is 2 inches 3 lines.

Halfway toward the hind end the body gradually contracts thereto, and terminates in an obtuse point between the bases of the fins. The fore border of the mantle is produced into a low angle at the middle of the dorsal side (Pl. XXVII. fig. 2, f). The fins (ib. fig. 1, k, k) are subcircular, attached for an extent of 1 inch 1 line to the sides of the hind part of the mantle, rather nearer the dorsal than the ventral surface. The combined breadth of the fins is 2 inches 6 lines; the longitudinal diameter of each is 1 inch 2 lines.

The colour of the specimen when first received was crimson shading to violet, with dark spots, brightest on the ventral and lateral surfaces. The spots average 1 line in diameter, are circular or full-elliptical in shape, with a white centre; their resemblance
to so many little eyes suggested the "nomen specificum." On the arms they are limited to the outer or peripheral facet, and thereupon are well marked, arranged in an irregular triple row along the basal third, and in a double row for the rest of the extent. The ground-colour is fainter on the contiguous brachial facets, but is as well developed upon the central as on the peripheral facets of each arm. The tentacles and fins showed little or no pigment.

The funnel is of large proportional size, extending along the ventral side of the head almost beyond the space between the eyes. Its free exserted part is shown, reflected, in Pl. XXVII. fig. 1, m. On each side of its intrapallial base is the cartilaginous socket, 9 lines in length by 3 lines in breadth, for articulating with the corresponding cartilaginous prominences on the opposed inner surfaces of the mantle. Coexisting with this articular apparatus ("appareil de résistance," d'Orb.) is the infundibular valve.

Both the above structures of the funnel, common, as a rule, in Decapods, are either nonexistent or unnoticed in previously described species of Loligopsis.

The gladius or pen of L. ocellata (Pl. XXVI. fig. 8) is 4 inches 5 lines in length, 9 lines in extreme breadth. The shaft, r, extends forward about 9 lines in advance of the vane, s, but is continued along the mid line of that part, gradually attenuating, to the subobtuse end, which occupies the interpinnate prominence of the body. The shaft commences in the medio-dorsal production of the fore part of the body. The vane gains its extreme breadth about one fourth of the way to the hind end, toward which it gradually narrows. This likeness of the "gladius" to the feather, the present species of Loligopsis shows in common with most of the ordinary squids (Loliginidæ). In Loligopsis veranii there is a vane-like expansion at both ends of the gladius, with a long intervening slender shaft. In Loligopsis pavo the fore part of the shaft is longer than the hind part supporting the vane. A similar shape of gladius occurs in L. cyclura (L. guttata, Grant).

The following are from notes taken on dissection of the specimen above described:

The cartilaginous cranium presents on its dorsal aspect a general convexity with a transversely cordiform outline, the point being anterior, the notch posterior. The ventral surface offers two lateral convexities, with a middle longitudinal channel perforated by the two large pallial nerves and, above them, by the large vein. Two muscles of the eyeball arise from the lateral part of the anterior margin, about a line apart; they converge and expand upon the sclerotic. A second muscle arises from the mesial surface near the hind edge of the ventral plate of the cranium, and expands upon the corresponding surface of the eyeball. A third muscle passes transversely between the two

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3 Ibid. Loligo, pl. vi. fig. 4.

4 Ibid. p. 322.
eyeballs, anterior to the ventral border of the cranium. The muscles of the “corona” come from both dorsal and ventral surfaces of the cranium.

The gullet is long, slender, without partial dilatation. The stomach is an oblong caecal pouch, an inch in length. The pylorus, situated near the cardiac orifice, conducts by a very short canal to the second, spirally disposed, pouch, the blind end of which forms only a single turn with an obtuse apex. The intestine makes a single bend forward, is short, and at its anal termination is provided with a pair of slender tentacles, each 1½ line in length.

The liver consists of a single oblong elliptical mass, 2 inches in length, 9 lines in breadth; its capsule shows a glistening surface. Two hepatic ducts emerge from its hinder end, each about an inch in length, and developing clusters of quasi-pancreatic follicles. Beyond these the ducts open upon a groove continued from the spiral glandular pouch into the beginning of the intestine. The ink-bladder is fusiform, narrow, coextensive with and parallel to the straight terminal part of the alimentary canal, with the termination of which it communicates by a short and wide duct. Each branchia consists of 40 pairs of plicate plates; the suspensory folds are coextensive with the gill. Each branchial heart is simple, without appendage. But on the division of the vena cava leading thereto is the usual glandular supposed “renal” organ; its capsule is thick and pulpy; and it communicates with the abdominal cavity by a widish opening with a coloured margin. The size of each renal sac was 1 inch by 9 lines.

The systemic heart is of an elongate lozenge-shape, receiving the branchial veins at nearly opposite transverse angles, near the fore part of the ventricle. This sends off one large posterior aorta and a smaller anterior artery. The peritoneal or lining membrane of the mantle is reflected upon the viscera about an inch behind the anterior free border of the mantle, and also from the capsule of the gladius, along which it is attached. The two chief lateral nerves of the muscular mantle are each accompanied by a more slender nerve, which expands into the stellate ganglion from which radiate the nerves to the anterior third part of the mantle. From the hind end of the ganglion a small nerve is continued on, parallel with the unganglionic chord, to the attached bases of the terminal fins, which thus derive their nervous supply from both the sensory and motory chords. The sex of the specimen was female; the organs of generation were as in Loligopsis cyclura 1.

I am indebted to Tradescant Lay, Esq., for the subject of the above description, which was captured in the Chinese sea.

1 L. guttata, Grant, Trans. Zool. Soc. vol. i. pl. ii. fig. 3, g, figs. 8, 9.
Genus Ommastrephes, d'Orbigny 1.

Species Ommastrephes ensifer, Ow. (Plate XXVIII.)

In the family of Squids (Loliginidae), to which the present specimen belongs, the group differentiated by d'Orbigny under the generic name above given includes it by the form of the lateral cartilages on the inner surface of the mantle and of the cavities on the sides of the base of the funnel adapted thereto 2, by the absence of eyelids, and by the orifice of the eyeball (Pl. XXVIII. fig. 1, o), with which is associated the depression in the integument anterior to the eye, termed "lacrimal sinus," I.

In this group the species Ommastrephes bartramii, Le Sueur 3, and O. ovalaniensis, d'Orbigny 4, come nearest to O. ensifer in the development of the tegument forming the ventral margin of the acetabuliferous tract of the second (ib. 2 a) and third (ib. 3 a) arms. But such development is much exceeded, especially in the third arm, in O. ensifer; it is moreover associated with a production of the integument of the outer ridge or surface of that arm, in a subangular form (ib. 3 b), which expansion, combined with that of the acetabular velum (a), gives to the third arm the shape of an eastern scymitar, whence the specific name proposed for the present species. Should this be deemed a character of subgeneric value, I would propose the term "Xiphoteuthis" 5 for the present and other species that may be found to possess it.

The following are dimensions of the individual on which the species is founded:—

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Length (in)</th>
<th>Lin.</th>
</tr>
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<tbody>
<tr>
<td>Length of body</td>
<td>15</td>
<td>6</td>
</tr>
<tr>
<td>&quot; of head to interspace of dorsal arms 1</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>&quot; of arms 1</td>
<td>8</td>
<td>9</td>
</tr>
<tr>
<td>&quot; of arms 2</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>&quot; of arms 3</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>&quot; of arms 4</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>&quot; of tentacles (outstretched)</td>
<td>21</td>
<td>0</td>
</tr>
<tr>
<td>&quot; of attached base of fin</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Breadth of the pair of fins</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>&quot; of body in advance of fins</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>&quot; of fore end of body</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>&quot; of head across the eyes</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Breadth, extreme, of arm 2</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>&quot; of arm 3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Total length from apex of body to end of outstretched tentacles 3 feet.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 Histoire Naturelle des Céphalopodes Acetabulifères, 4to, 1835–1848, p. 341.
2 In op. cit. described as the "appareil de résistance," p. 341.
3 Journal of the Academy of Natural Sciences, Philadelphia, for 1821, p. 90, pl. vii.
5 Zéphos, sword; revidis, squid.
The free (anterior) border of the mantle, or body-wall, is even, not produced as in most *Loliginidae* into a point, either at the mid line of the dorsal aspect (Pl. XXVIII.), or at any part of the ventral one. The part of the funnel projecting from the latter aspect, rests in a recess on the corresponding surface of the head, like a cannon in its carriage. Such provision, added to the complex basi-lateral joints of the expulsiatory tube, must, by increasing its resistance to the force of the ejected respiratory current, correspondingly increase the reacting force of that ejection in the movement of the mollusk.

The fins (ib. e, e) are attached to two fifths of the terminal part of the body; their united breadth is twice that of the length attached. They are relatively larger, more powerful, organs of natation than in either of the above-cited species of *Ommastrephes*.

The outer circular lip has its attachment to the bases of the arms strengthened, as in *Loligopsis*, by narrow muscular ridges or fræna, which are here continued at one end upon the inner side of the base of the arm for a short distance, ending in a point, and at the other end extend to the apex of the triangular process (ib. f') of the outer lip. These labial processes are not acetabuliferous, as in many Squids ¹. The two inner lips, answering to those in *Octopodidae*, are also present.

The chitinous substance of the beak is rather thin, but hard enough at the sharp-pointed tip for its prehensile function in this piscivorous Cephalopod. The longer (under or ventral) mandible (ib. e) shows basi-lateral expansions notched at the hind border. The shorter (dorsal) mandible is without such side plates.

The acetabula are in a double alternate series on each arm, are relatively small, sub-dilated at the base, which is attached by a longish subcentral pedicle (Pl. XXVIII. fig. 2); the cavity is bounded by a slightly tumid circular lip lodging the base of a hoop of chitine, the free border of which is denticulate, with some of the teeth longer than the rest.

The acetabuliferous expansion of the tentacles (ib. fig. 1, t) supports a double alternate row of larger, similarly armed, subsessile cups, and a third series of somewhat smaller ones. These diminish in size and number towards each end of the cupped surface.

In most species of *Ommastrephes* one or more pairs of the ordinary arms have the outer surface, or that opposite the cup-bearing one, not rounded, but ridged longitudinally, the two sides inclining from the acetabuliferous borders to such ridge. In *Ommastrephes sagittatus* the ridge is slightly prominent in the second pair, and partially produced in the third pair of arms, forming a narrow dorsal fold or "velum." In *O. bartramii* the fold, or fin-like development of skin is continued from the whole length of the dorsal ridge, and a second fold or "velum" is developed from the outer border of the series of suckers in the second and third pairs of arms.

¹ "Descriptions of some new and rare Cephalopoda," Proceedings of the Zoological Society, 8vo, 1836, p. 106. "In this repetition of the structure of the external series of cephalic processes there is an evident analogy to the different series of labial processes of *Nautilus*."—Ibid.
Both dorsal and ventral brachial cutaneous folds, or "vela," are greatly developed in *Ommastrephes ensifer*, more especially in the third pair of arms (Pl. XXVIII. fig. 1, 3); and in these the disposition of the muscular fibres for contracting or folding the web or net is indicated through the integument (ib. a). A fasciculus is continued from the base of the peduncle of each sucker of the outer row, which extends with a slight curve toward the free border of the ventral web, and expands as the fibres spread out to terminate in that border.

In the extent of this brachial membrane the present species of Decapod comes nearest to that form of Octopod (the Argonaut) in which the tegumentary expansion of a certain pair of arms is in excess. In *Argonauta* the so-called "sails," we know, relate to the formation and support of a rudimental shell. Although no such relation can be predicated of the brachial vela of our female *Ommastrephes ensifer*, it may be a question whether they are equally developed in the male. Should he similarly possess them, it may then be supposed that, by means of such brachial developments, the fish which has been struck by the spines of the horny rim of the suckers may be enveloped by the webs, which can be so wrapped about it as more effectually to retain it till the other acetabuliferous arms are brought to bear upon the prey.

Cephalopods have been sometimes figuratively called "sea-spiders;" and in the present species we see something superadded to the prehensile spiny-crowned suckers analogous to that with which the air-breathing Octopod envelops the struggling wasp or blue-bottle in a rapidly outspun web.

In the mechanism for catching its finny prey exemplified in the above-noted characters of *Ommastrephes ensifer*, we recognize a power of obtaining a supply of nutriment favourable to the acquisition of the bulk which the subject of the present description had attained. If, in place of the spiny hoop, each sucker were armed with one large hook, an oceanic swift-swimming Cephalopod would have increased power over the shoals of fishes whence its nutriment was derived, and still greater dimensions might be concomitantly attained.

**Genus Onychoteuthis**, Lichtenstein 1.

A much larger Cephalopod, parts of which have come under my observation, is that which received the following notice in Hawkesworth's "Account of the Voyages of Discovery in the Southern Hemisphere, successively performed by Commodore Byron and Captains Wallis, Carteret, and Cook." 2

In the 2nd volume ("Lieut. Cook's Voyage"), H.M.S. 'Endeavour' having rounded Cape Horn, and being then in latitude 38° 44' S. and longitude 110° 33' W., is the following entry, of date between the 1st and 8th of March, 1769:—

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1 Das zoologische Museum der Universität zu Berlin, no. xv. (1818), p. 1592.
2 In 4 vols. 4to, 1773.
“Mr. Banks also, about this time, found a large cuttle-fish, which had just been killed by the birds, floating in a mangled condition upon the water; it was very different from the cuttle-fishes that are found in the European seas; for the arms, instead of suckers, were furnished with a double row of very sharp talons, which resembled those of a cat, and like them, were retractable into a sheath of skin, from which they might be thrust at pleasure. Of this cuttle-fish we made one of the best soups we had ever tasted.”

The grounds on which I formed a personal acquaintance with such débris of this remarkable Cephalopod as might have remained, after it had furnished Lieut. Cook and his scientific fellow-voyagers, Banks and Solander, with a welcome change of diet, are the following:—

When preparing, in 1829, my first Catalogue of the Hunterian Museum,” being struck with the number of marine oceanic Invertebrata, dissected and undissected (Salpœ, nos. 119 n, 120, 121–128; Pyrosoma, no. 119 c; Janthina, nos. 154, 155; Boltenia, no. 119), which Hunter had obtained, I was informed by Mr. Clift that his Master had supplied Mr. (afterwards Sir Joseph) Banks with wide-mouthed stoppered bottles, containing alcohol, for the preservation of such marine animals in a state fit for dissection, as might be captured in the circumnavigatory voyage about to be undertaken by Lieut. Cook. Some of Hunter's bottles containing the above specimens bore a label, J. B., as noted in the ‘Catalogue.’ It was probable, therefore, that Sir Joseph Banks might have stowed viscera and other portions of the great Hook-armed Cuttle in one of the bottles for his anatomical friend.

In preparing the second Catalogue of the series of dissected specimens I came upon the following parts of such a Cephalopod:—

Portions of the arms (Pl. XXXII. figs. 1, 2, & 3); a beak with the tongue, radule, and surrounding lips (Pl. XXXI. fig. 1); a systemic heart-ventricle (Pl. XXXII. fig. 6); and, among the “Dry Preparations” was the terminal part of the body with an attached pair of rhomboidal fins of a Cephalopod (then No. “1436,” now “E. 1066”) answering in size to the above specimens in spirits (Pl. XXXI. figs. 2–4, reduced).

The heart, or part of that complex circulating apparatus in Cephalopoda, differed moreover in shape from the systemic ventricle in Octopoda and Sepiææ; and I found the nearest approach to it, in form, in a small kind of Squid which had hooks upon the expanded ends of the tentacles.”

1 Tom. cit. p. 70.
2 Catalogue of the Contents of the Museum of the Royal College of Surgeons in London. Fasciculus I., comprehending the First Division of the Preparations of Natural History in Spirit (Vegetabilia and Animalia invertebrata), 4to, 1830, p. 33.
4 Descriptive and Illustrated Catalogue of the Physiological Series of Comparative Anatomy in the Museum of the Royal College of Surgeons in London,' vol. i. 4to, 1852, p. 15, no. 63; 2nd ed., 8vo, 1852, p. 15, no. 63.
5 Ibid. vol. ii. 4to, 1833, p. 84, no. 308; 2nd ed., 8vo, 1852, p. 84, no. 308.
6 Descr. and Ill. Cat. vol. ii. no. 902 A, p. 35; and no. 106 b, Nat.-Hist.-Series Cat. ut suprá, p. 33.
The hook-armed Calamaries designated under the generic name *Onychoteuthis* by Lichtenstein have since been separated and grouped under other genera, of which the two best-marked are distinguished by the disposition of their peculiar weapons.

In one group the hooks or claws are restricted to the tentacles; in the other they are developed upon both arms and tentacles.

To the first of these Calamaries the original generic term is now restricted, as the type species (*Onychoteuthis banksii*) exemplifies such partial location of the hooks.

The term *Euplooteuthis* is applied, by d'Orbigny, to the group in which the arms as well as the tentacles bear hooks. A fossil species similarly provided has been termed *Acanthoteuthis*. Other genera have been proposed on minor modifications, but have not met with acceptance.

I propose to offer some anatomical observations derived from a species of the first genus, before describing the preserved parts of the large example of the second genus of these most formidable Dibranchiate Cephalopods.

The first observations are results of a partial dissection of a unique specimen of *Onychoteuthis* (O. *raptor*; Ow.), nearly allied to the type species.

My subject (Pl. XXIX. figs. 1 & 2) is 8 inches 6 lines in length, of which the body gives 5 inches 8 lines, including the infundibulum. The fins are rhomboidal and terminal, 5 inches 2 lines across, and each of a length of 2 inches 8 lines. The arms decrease in length from the ventral to the dorsal pair, but not consecutively, their order, as to length, being 4, 2, 3, 1. Each is provided with a double row of small pyriform sessile acetabula. The swollen extremity of each tentacle, \textit{t}, supports a double series of hooks, each projecting from a subelliptic fleshy capsule; there are about 15 in each row, the outer ones being the longest: at the base of the uncigerous expansion is a circular group of small acetabula, \textit{t}, the function of which is specially noted in the article *Cephalopoda* of the 'Cyclopaedia of Anatomy.'

The eyes repeat the character of the Ommastrephic group, as noted in *Ommastrephes ensifer*, except that the "lacrymal fossa" is less marked.

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2 *Loligo banksii*, Leach, 'Zoological Miscellany,' 1817, no. iii. p. 141, and Appendix to Tuckey's 'Narrative of the Congo Expedition,' no. ii. p. 401. The specific name was given by Dr. Leach, under the impression that the small hook-armed Cuttle caught off the coast of Africa might be the species noted in "Cook's Voyage" above cited. In the following year (1818) the same species received from Lichtenstein (op. cit. p. 1502, no. 4, Taf. 19) the name *Onychoteuthis bergii*. Lde pastrein's figure is copied by Féruas and d'Orbigny in their 'Histoire Naturelle des Céphalopodes,' 4to, 1835-1848, "G. Onychoteuthis, pl. v."


4 "When these latter suckers are applied to one another, the tentacles are firmly locked together at that part, and the united strength of both can be applied to drag toward the mouth any resisting object which has been grappled by the terminal hooks. There is no mechanical contrivance which surpasses this structure: art has remotely imitated it in the fabrication of the obstetrical forceps, in which either blade can be used separately, or, by the interlocking of a temporary joint, he made to act in combination."—*Cyc. of Anat.* vol. i. 1836, p. 529, fig. 215.
In *Onychoteuthis banksii* the dorsal surface of the head shows a few short longitudinal ridges not present in *O. raptor*, and the arms shorten in the order 4, 3, 2, 1. The tentacular hooks are also more numerous than in *O. raptor*; and the tentacles themselves are relatively more slender.

A mesial longitudinal section of the mantle and some further dissection exposed the following parts (Pl. XXIX. fig. 2):—

The infundibulum has on each side of its base an elongate narrow cartilaginous cavity, *a*, which articulates with a prominence of corresponding shape, *b*, from the inner surface of the opposed side of the mantle. Near the apex of the funnel lay the "valve," *c*, of a semicircular shape. At the base of the funnel opens the vent, *d*; the anal end of the rectum supports a pair of filamentary appendages, *e*, *e*'. The duct of the "ink-bag," *g*, terminates just within the anal verge. At the base of the gills, *h*, *h*', are the branchial hearts, *i*, *i*', each with a small fleshy appendage, *k*. A portion of the systemic heart is exposed at *m*. Portions of the "musculi retractores infundibuli" are shown at *n*.

The specimen was a female, and probably young. The long narrow ovary, *o*, not developed as at the sexual period, occupies the narrow pointed fundus of the abdominal cavity. Seemingly single outwardly, its inner capsule forms a mesial septum, indicative of the parial character. From each moiety is continued an oviduct, *p*, which, after some convolutions, terminates in an enlarged outlet, the thick soft lining membrane of which is disposed in folds radiating from the central aperture, *q*. The nidamental glands, *r*, are a pair of elongate bodies situated between the oviductal outlets, beyond which the narrower end of the accessory glands extends forward between the branchial hearts.

The digestive organs being removed, are shown in Pl. XXIX. fig. 3. A long, slender oesophagus, *a*, is continued, as in other Decapods, without ingluvial dilatation, to the stomach, *b*. This is large, oblong, with thinner parietes than in the canivorous Octopods, but with the muscular fibres radiating from centres on opposite sides of the bag. The pylorus is a slit with tumid borders, and communicates with a second cavity, *c*, into which open the hepatic ducts, conveying the bile, and also the secretion, probably pancreatic, of the clustered follicles *d*, *d*, developed upon and from the ducts of the liver. The intestine is continued with a slight bend straight to the tentaculate vent, *f*. The liver appears to be a single elongated gland with a glistening longitudinally fibrous capsule, *g*. On removing this a delicate inner layer seemed to form a septum, indicative of a bilobate condition. The caecal ends of the constituent lobules are shown in the moiety *h*, from which the fibrous capsule has been removed. The large elongate ink-bag, subbiñad at its base, is shown at *i*; its duct is short.

The branchial lamelle are marked *a*, fig. 4; the suspensory ligaments are shown at *b*; the systemic veins, with their appended follicles, at *c*, *c*; the branchial hearts and their appendix, at *d*, *d*; the branchial arteries, at *e*, *e*; the branchial veins, at *f*, *f*; the systemic heart, of a rhomboidal or lozenge shape, with its two aorta, ascending and descending, is shown at *g*.
The mandibular, radular, and salivary organs are almost in miniature what is shown in the same apparatus of the large Cephalopod next to be described, and justify the reference of the Hunterian specimen no. 308 to the following genus and species:

**Genus Enoploteuthis, d'Orb.**

**Species Enoploteuthis Cookii, Ow.**

The beak (Pl. XXX. figs. 1, 2, 3) consists, as in all Cephalopods, of an upper (fig. 1) and a lower (fig. 3) mandible; and, as in all the Dibranchiate kinds, the hardest part does not exceed the density of horn. In each mandible may be distinguished an anterior exposed, or "rostral" part (a b c f), and a posterior concealed part (d g), which, as affording attachment to the biting-muscles, may be termed "apophysial." This is the part in which the corneous density degenerates into a kind of gristly flexible tissue.

As in all Cephalopods, the lower mandible receives the upper when the beak is closed.

The rostral part of the upper mandible (fig. 1) sends forward a long, somewhat slender, decurved, sharp-pointed "uncus," a, 11 lines (= 23 millims.) in length at the lower border, as defined by the "ala." This part, b, descends vertically with a feebly convex anterior border to apply itself to the inner surface of the corresponding part of the lower mandible (fig. 3, f). The upper border of the "uncus" is continued backward, in a convex curve, 3 inches from the apex. The hind border, c, of the rostrum has an extent in a straight line of 2½ inches; it describes a sigmoid curve concave forward in the upper three fourths, convex below, both curves feeble. The "apophysis," d, d, is continued 3½ inches behind the rostrum. Its upper part begins 9 lines (= 20 millims.) below the hind and upper apex of the rostrum; the lower border quits the rostrum much nearer the lower apex of the ala, b. Much of the interior border of the apophysis becomes free very near the hind border of the rostrum, c, leaving a long but shallow groove for the tendinous insertion of the supramandibular muscle; but a ridge-like extension continues the under or oral surface of the rostrum backwards, forming a horny roof of the fore part of the mouth, the extent of which is shown in the vertical section given in fig. 1, Pl. XXXI. The apophysial plate expands vertically as it retrogrades to its mid extent, Pl. XXX. fig. 1, d, d, where the vertical diameter is 2½ inches; it then contracts, describing a sigmoid curve to the upper apex. The whole length, in a straight line, of the upper mandible is 4⅓ inches. The extent of the hinder cartilaginous border is from 2 to 3 lines, as indicated by the dotted outline in fig. 1.

The lower mandible (ib. fig. 3) has a smaller apophysis and a shorter but deeper and rather less sharply pointed uncus, e (Pl. XXX. figs. 2 & 3). From the base of the uncus is continued a broad ala, f, overlapping the corresponding part, b, of the upper

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1 Histoire Naturelle des Céphalopodes Acétabulifères, p. 336.
mandible. The apophysis is strengthened on each side by a broad ridge or rising, $g$, extending longitudinally to the terminal apex.

The muscular masses inserted into the mandibular apophyses are of a very dense tissue. The hinder fascicles open, the fore ones close, the beak. The outer and inner plates of the lower uncus recede in a less degree than those of the upper one; both are occupied by the condensed or tendinous modification of the mandibular muscular mass.

A thick fleshy inner lip, fig. 2, $l$, of a circular or sphincteric shape, immediately surrounds or invests the mandibles: it is reflected from the base of the rostral part of the upper mandible at a greater distance (about double) than from that of the lower mandible (as shown in the section fig. 1, Pl. XXXI). The free anterior border of this lip is coarsely notched or divided into lobes, answering to the finer and more numerous marginal plates present there in most of the smaller forms of Dibranchiates. The outer lip is attached by eight frenæ radiating from the outer side of the inner lip to the bases of the eight ordinary arms. Each frenum sends off from the middle of its free margin a process which is fimbriate (Pl. XXXI, fig. 1, $i$, $i$), but does not develop any suckers.

The lingual apparatus consists of the tongue proper and the rasp or "radule," to which are added a pair of "fauces folds" bearing on their inner surface small but distinctly visible horny denticles. The tongue proper (ib. fig. 1, $j$) is partially divided into two lobes, into the contracted base of which is inserted a slender "retractor linguae" muscle, $f$. The "radule," $k$, encasing the third lobe of the lingual apparatus with its horny plate, bears on the upper and fore part thereof seven longitudinal rows of fine recurved spines. The faucial folds, $l$, $l$, are continued from the sides of the base of the radular lobe and from the covering of the lingual salivary glands, $m$, as far back as the beginning of the oesophagus, $n$. Each fold is $2\frac{1}{2}$ inches in length, and 7 lines in breadth at the dentigerous part, behind which they gradually narrow to their oesophageal termination. The horny armature is on the inner surface of the broader anterior portions of the folds; the spinules are slightly recurved, and affect, though less regularly than on the radule, a longitudinal disposition.

The lingual salivary glands are compressed, parial, in close contact. Their vertical extent is about one third of their length. They are convex and thick posteriorly, $m$, becoming flattened and contracting as they advance to send off each their duct, which opens into the cleft between the faucial fold and radule (as indicated by the bristles).

The oesophagus, $n$, has a thick muscular and longitudinally plicate epithelial tunic; the diameter of the contracted tube is half an inch$^3$.

The systemic ventricle (Prep. no. 963, Hunterian Physiological Series; Pl. XXXII. fig. 6) presents the same rhomboidal figure in Onychoteuthis raptor (Pl. XXIX. fig. 4, $g$), with a similar relative position of the valvular terminations of the branchial

$^3$ A reduced cut of the subject of fig. 1 is given (fig. 225), and a general notice without details, in p. 621 of my 'Lectures on the Comparative Anatomy and Physiology of the Invertebrate Animals,' Svo, 1855.
veins, and valvular beginnings of the two aortae. The proportionate size of the ventricle is the same which the mandibles bear to those in *Onychoteuthis raptor*.

There seems no reasonable doubt, therefore, that we have in the subject of figure 6, Pl. XXXII. the chief part of the organs of circulation in Cook's "great hook-armed Cuttle-fish." The muscular part of this heart is thickest at its widest part, near the entry of the branchial veins, \(a, a\), and gradually thins off to the fore and hind ends where the aorta, \(b, b'\), are sent off. The fasciculi of fibres are disposed in different planes, and decussate each other obliquely. The terminal aperture of each branchial vein is provided with a pair of semilunar valves, \(c\). The origin of each aorta is guarded by two similar but smaller valves. The right branchial vein terminates on a plane anterior to the left, and slightly affects the regularity of the lozenge-shape of the heart.

I have reserved the most obvious and certain evidences of the genus and present rare and huge species to close such account of *Enoploteuthis cookii* as can now be contributed to the Cephalopodal chapter of Zoology.

Fortunately part of one of the ordinary eight arms (Pl. XXXII. fig. 1) was rescued from the cooking-galley of the 'Endeavour,' and, with the few viscera above described, was put into spirits for the anatomist at home. A section has been taken, probably by Hunter, from the base of the portion transmitted. The circumference of this section (ib. fig. 3) is 4\(\frac{3}{4}\) inches. The transverse section fig. 2 gives the form and diameters of the present truncate end of the portion of arm fig. 1. The arm is somewhat compressed, ovate, narrowest where it supports the uncinate acetabula, \(a, a\). Its substance is mainly muscular. The integument is smooth and thin; there is no trace of ridge, duplicature, or production at either the line of the dorsal or of the acetabular surfaces, such as are seen in the vela of *Ommastrephes ensifer*. Both sections show the subcentral cavity, \(b\), for lodging the bloodvessels and a nerve; a much smaller cavity, \(c\), near the interspace of the acetabula appeared to lodge a nerve only. The muscular fibres are mainly in two groups; the mass of the external longitudinal ones, \(d\), is, in section, thickest at the acetabuliferous part, and gradually decreases to the opposite and larger end of the section. The transverse or radiating fibres, \(e\), pass from the thin aponen-rotic line, \(f\); dividing their mass from that of the longitudinal ones, \(d\), to the stronger aponenrotic wall, \(g\), of the subcentral nervo-vascular canal; the fibres of a well-marked fasciculus, \(g\), act more especially upon the acetabuliferous part of the arm, tending to retract it, and to strengthen or support the hooks when these are infixed in a prey and when they are acted upon by the flexor and other muscular fascicles working the movements and applications of the entire arm. The central two thirds of the general muscular mass is condensed, seemingly by a greater admixture of tendino-fibrous tissue than in the peripheral third: it suggests the idea of a flexible supporting or skeletal part of the arm.

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1 This was the ground of my determination of no. 903, in the 'Catalogue' above quoted, p. 84.
The acetabula are uncinated and of similar structure to each other, differing in little else save size, which diminishes as they are situated nearer the free extremity of the arm. Their number in the portion preserved (Pl. XXXII. figs. 1 & 3) is fifty, of which four have been lost, as shown in fig. 1. They are arranged in a double alternate series, in proportional numbers and at nearly proportional distances throughout. This arrangement, with the size and shape of the hooks, shows that we have not here the acetabularis extremity of one of the pair of "tentacles," as in Onychoteuthis raptor (Pl. XXIX. figs. 1 & 2, t).

Each acetabulum, in Enoploteuthis cookii, consists of a "pedicle," a (figs. 4, 5), a cup, b, with a horny circular lining, c, produced into the hook, d. The pedicle is conical, $\frac{1}{10}$ of an inch (=3 millims.) in length in the larger acetabula; its apex is inserted, not into the pole, or middle of the base, of the cup, but nearer that side toward which the hook is bent, which in most cases is toward the base of the arm.

The fleshy cup has the form of an irregular, rounded, hollow, truncate cone, of which the base is somewhat concave; and the cavity, excavated for the lodgment of the annular basis of the hook, leaves an apical aperture for the protrusion of the uncinate portion. The hook is developed, in reference to the sides and the fore end of the supporting arm, from the outer and fore part of the border of the horny hoop.

Now, here it may be remembered that the homologous hoop or partial horny lining of the sucking-cup in all Decapods is commonly more or less denticulate at its free border, usually minutely so. In many Squids the spines gradually gain length at the outer part of the hoop's margin (Loligo plei, Bl., for example 1). The development is proportionally greater in Loligo brongniartii, Bl. 2. In Ommastrephes ensifer (Pl. XXVIII. fig. 2) the partial development is restricted to fewer spines, but is greater. In Loligopsis guttata four of the spines at the outer side of the armed border of the hoop in the tentacular suckers are much longer than the rest. In Enoploteuthis cookii the development is concentrated on one part of the hoop, but is excessive, forming the characteristic claw of the genus.

The base of this hook is so extended as to seem to expand into the horny lining of the acetabulum, in the flesh of which it sinks. This lining, soft and whitish at its inserted border, becomes corneous (or chitinious) and thickens as it rises above the brim of the fleshy cup to form the hook. Of the fleshy or muscular mass the fibres (fig. 4 a, fig. 5 a, g) exterior to the horny ring are circularly disposed, adapted to compress the base of the hook and protrude it. The central fibres (ib. f) are longitudinal, and converge to be inserted into the hollow base of the hook for its retraction. This action is analogous to that by which the ordinary Cephalopods create the vacuum of the sucking-cup in the act of adhering to and seizing their prey; but in Enoploteuthis the base of the hook extends too far into the substance of the acetabulum to allow of such retraction, while

1 D'Orbigny, op. cit. Loligo, pl. xxiv. figs. 17, 18. 2 Ibid. Loligo, pl. iv. figs. e & d.
the production of the hook prevents the application of the soft unlined free margin of
the cup; the free surface continued into the cavity is subuplicate.

Figure 4 (Pl. XXXII.) shows a vertical section, in the line of curvature, of the hook
and its supporting cup, with a subjacent part of the arm. In the enlarged outline of
part of this section (ib. fig. 4, a) are shown: — a, the pedicle; b, the acetabulum; c, its
cavity lined by the circular base of the hook, d; e, the fleshy cushion which rises into
the hook’s basal cavity; f, the longitudinal fibres which retract the cushion and hook;
and, g, the circular fibres which protrude the cushion and hook.

Figure 5 is of a vertical section of the posterior or convex part of the hook and ace-
tabulum, showing the depth to which the hoop or base of the hook extends into the
fleshy mass of the acetabulum. In *Enoploteuthis* the walls of the cup are the thickest,
and the cavity is the smallest, in the Cephalopodous class.

Of the dried end of the body of Cook’s large Cephalopod in the Hunterian Museum
(now no. e. 1066), which in 1830 I inferred to have been part of that captured during the
great navigator’s “First Voyage,” I submit three drawings of the natural size (reduced
in Pl. XXXI.), one of which, fig. 4, is rather a diagram of the end amputated, which is
at the fore part of the origin of the pair of terminal rhomboidal fins. Notwithstanding
the degree of shrinking which this tegumentary and muscular mass has undergone in the
process of desiccation, the total length of this portion is 1 foot 5 3/4 inches; the extreme
breadth between the fins is 6 3/4 inches. The fins, of thinner substance than the mantle,
have undergone more loss of shape from drying; but, though shrivelled and crumpled,
they manifest the rhomboidal form common to the rest of the genus.

In *Enoploteuthis cookii* the fins attain their greatest breadth about one fifth of their
length from the fore end of their base, gradually narrowing from the angle so formed to
the end, or very near to the end, of the obtusely pointed termination of the body. Their
line of attachment extends along the dorsal side of the body (Pl. XXXI. fig. 3)—at first
within an inch or two from the lateral contour, but gradually nearing the sides as they
descend and contract to their terminal subsidence. Fig. 2 (ib.) shows the ventral surface
of the dried specimen; figure 4, the amputated end.

I find no described or figured species of *Enoploteuthis* which presents this form of the
terminal fins. The nearest approach to it is made by the *Enoploteuthis armata*, Quoy1;
but the angles at the outer margins of the fins project, as in *Onychoteuthis raptor*, halfway
toward the pointed end of the pair. In *Enoploteuthis leptura*, Leach2, each fin has a
right-angled triangular figure, and they do not extend to the end of the body. In *Enop-
loetteuthis lesueurii*, d’Orb.3, the base of each rectangular fin commences, as in *Sepioteuthis*,
at the fore end of the body, but terminates some way anterior to the pointed hind end.

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I estimate the combined breadth of the terminal fins in *Enoploteuthis cookii* when recent, taken at the outer angles, to have been not less than 1 foot 4 inches.

In the desiccation of the body-skin the transverse arrangement of the superficial muscular fasciuli is indicated; the thinner and more yielding ventral wall is shown by the median longitudinal infolding of that part in the process of drying.

Considering that so much of the fleshy part of the great hooked Squid was cooked as to serve the appetites of at least three, and perhaps four, of those at table in the Commander's cabin, I infer that a goodly proportion of the body anterior to the fins went to the culinary galley, and that the basal attachments of the fins did not extend, as in *Enoploteuthis lesueurii*, to the fore margin of the mantle.

On the supposition that the proportion in advance of the fins was that which is shown in *Onychoteuthis raptor* (Pl. XXIX. fig. 1), one may set down the length of the body of *Enoploteuthis cookii* at 3 feet. The length of the head to the setting-on of the arms would be, according to the same proportions, about 10 inches; and the length of the longest arm might be 15 inches, of which the terminal half may have been cut off for Hunter's collection. If the outstretched tentacles were each as long as the body, 3 feet may be added to the combined length of head and body to give an approximate idea or estimate of the total length of the Cephalopod in question, viz. 6 feet 9 inches. I have ventured on a reduced restoration in fig. 1, Pl. XXXIII.

In a work on the Natural History of Chili, of which the second edition appeared in 1810, the author, on the authority apparently of the latitude and longitude assigned by Lieut. Cook to the place of capture of his great hook-armed Cuttlefish, includes it in the Chilian fauna; but, as he adds nothing to the quotation from Hawkesworth's account of the voyage (antea, p. 146), I conclude that he had not received or seen a second specimen of this remarkable species. All that is given relative thereto in Molina's work is, verbatim, as follows:—


M. d'Orbigny, referring to the above work, merely observes, with regard to the *nomen specificum*, that the term "unguiculata" is objectionable, seeing that it is a character common to the genus, in fact the essential character of the section *Enoploteuthis*. But as to his proposition to substitute the name of the Italian compiler, I think Cephalopodists will agree that in common justice the honoured name of the original describer should be attached thereto. Dr. Leach desired to do honour to the captor of

*Vol. XI.—Part V. No. 4.—June, 1881.*
the great Squid when he applied the name "Banksii" to a small African hook-armed species, which, in 1817, he deemed identical with the larger one of the Pacific Ocean. M. d'Orbigny limits his notice of this truly remarkable Cephalopod to the following passage:—"On ne connaît de cette espèce qu'une partie d'un bras sessile gigantesque, couvert de crochets sur toute sa longueur. Ce caractère étant celui des Enoploteuthis, je l'ai placé dans ce genre. Je dois à l'obligance de M. Richard Owen un beau dessin de ce bras déposé au Musée du Collège des Chirurgiens de Londres."—Op. cit. p. 339 (1848). The drawing was a copy of that (Pl. XXXII. fig. 1) which accompanies the present paper. My esteemed correspondent and fellow-labourer made no use of it for his great work.

_Cephalopods remarkable for large Size._

**Genus Plectoteuthis**, Owen.

**Species Plectoteuthis grandis**, Owen.

It has been shown (p. 144) that the side of the arm opposite the acetabuliferous tract is longitudinally and mesially ridged, and there more or less produced, in certain Squids (Loliginidae); but in the British Museum is preserved one of the eight ordinary arms of a Cephalopod which, from the characters of the cups (Pl. XXXV. fig. 2), is referable to the genus _Ommastrephes_, d'Orb., but which supports them on a relatively broader flattened tract (ib. ib. a), and presents on the opposite or dorsal side (Pl. XXXIV. fig. 2) a similar flattened tract, a, from each margin of which a fold of the integument, b, is produced, of varying breadth. A transverse section of the arm consequently gives a quadrate instead of triangular form, in this respect repeating the character shown in _Loligopsis ocellata._

The cups or suckers are arranged in a double alternate row along their tract, the margins of which are produced into a well-defined fold or thin seam (Pl. XXXV. fig. 2, c, c), but of minor breadth than the dorsal folds. This plicatile condition of the ordinary arms has suggested the generic name.

The length of this arm, which has been amputated at or near its base, is not less than 9 feet; the diameter of the amputated base from within outwards is 4 inches; the same from side to side is 3 inches; the total circumference is 1 foot. At this basal part of the arm (Pl. XXXV. fig. 1) the acetabula have not begun to be developed; it would seem to correspond to the non-acetabular tract extending, in most Loliginidae, a short way from the outer lip. Here, in _Plectoteuthis_, the folds are restricted to the dorsal pair (ib. fig. 1, b, b), but they do not exceed an inch in breadth. The opposite surface, a, a, is convex across; this convexity broadens into flatness as the arm extends and begins to develop its cups. The circumference, taken midway between the two ends of the arm, is 9 inches. The breadth of the acetabuliferous tract at 6 inches from the amputated end is 5½ inches with the marginal folds outstretched; the interspaces

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1 Gr. _πλεκτός_, folded, _χεῖρ_, Squid.
between a pair of suckers, taken at the basal attachment of their peduncles, is 2 inches, where they are widest apart. The greatest width of the acetabuliferous tract within the marginal folds is $3\frac{1}{2}$ inches.

The section of the basal part of the arm shows the muscular mass to be divided by a thin aponeurosis (Pl. XXXV. fig. 1, d) into a peripheral (e) and a central (f) portion. The peripheral muscular mass, e, at the inner side, a, shows a thickness of 6 lines; it is traversed by the main artery of the arm, g. This part of the peripheral mass gradually diminishes on each side to a thickness of 2 lines, and then as gradually increases to 4 lines at e; when, bending in to the outer side of the arm, it thins off to half a line, the aponeurotic boundary coming there almost into contact with the outer integument. The transverse diameter of the inner muscular mass at the dorsal third is 2 inches 8 lines; at the ventral third it is 2 inches: and here the section shows the nerve, h, in a canal of 5 lines diameter, the nerve being surrounded by loose cellular tissue including venous channels.

The cups gradually increase in size to the sixth or eighth, which has a diameter of three fourths of an inch; and here the acetabuliferous tract and its marginal folds show the dimensions given in fig. 2, Pl. XXXV. They begin very gradually to diminish beyond the basal ten or twelve inches of the arm.

Of the large cups the peduncle is 7 to 8 millims. in length; its base is 5 millims. in breadth, and gradually contracts to 2 millims. before insertion. This is at the side of the base of the cup, where the cup is least deep; and here there is a depression for receiving the peduncle (Pl. XXXV. fig. 3).

The base of the cup is 20 millims. in diameter; it is slightly convex, shows a fleshy tint, which changes to a white aponeurotic appearance at the periphery; and this character of the exterior of the cup continues to the aperture, which is circular and 10 millims. in diameter. From this aperture slightly projects the margin of the broad chitinous hoop lining the walls of the cavity. The bottom of the cup, 12 millims. in diameter, is soft, muscular, covered by a thin, transparent aponeurosis, and seems, by its size, to have been capable of assuming the shape requisite to act as a kind of piston, and by the vacuum so produced to cause outward pressure to aid in fixising the teeth of the denticulate free border into the surface to which the arm may have been applied.

The suckers, as they extend along the arm, diminish in diameter in a greater degree than in depth, and the smaller acetabula make a nearer approach to the spheroid form (Pl. XXXIV. fig. 2); but each hangs by a proportionately long peduncle until they come near the end of the series, where they show but 1 millim. diameter, passing out of sight at about 2 inches from the pointed termination of the there gradually attenuated arm. The basal cups of the same side or series occur at first at intervals of 24 millims.; and as the longitudinal interval shortens, the transverse one increases to an extreme of 2 inches, then progressively diminishes with the diminishing size of the arm.

The integument of the acetabuliferous tract shows a denser surface and paler tint.
than that covering the rest of the arm; the breadth of the marginal fold along the basal 12 inches of the arm (Pl. XXXV. fig. 2, c) is about 20 millims. The surface of the fold towards the non-acetabuliferous part of the arm shows the same deep colour as that part. The opposite surface of the fold continued from the acetabuliferous tract has the paler tint of that tract. The contrast was doubtless greater in the living Squid, when the pigment was in lively motion along the free surface.

In the interspace of two cups of the same side the integument shows two low folds or risings, produced by a pair of muscular bundles detached from the mid-acetabuliferous space to the edge of the ectacetabular fold, for the contraction or narrowing of that fold. Each dorso-marginal fold (Pl. XXXIV. fig. 1, b, b) shows a breadth of about 2 inches as far as where it extends along the middle third of the length of the arm; thence the breadth gradually decreases; and the folds finally subside about 4 inches from the end of the arm (ib. fig. 2).

The total length of the above-described cephalic arm (one of the ordinary eight) is, I may repeat, 9 feet; its circumference at mid-length, folds inclusive, is 9 inches; the number of acetabula which it supports is not less than two hundred and ninety-two.

The known species of the Loliginidæ vary in the relative length of the arms to the body. In Loligo vulgaris, Lam.¹, the length of the longest is about one half of the body, measured from the end of the anterior prominence of the dorsal margin to the posterior apex of the mantle. In Ommastrephes duvaucellii, d’Orb.², the length of the same arm is four fifths that of the body or trunk similarly measured. In Loligo todarus³ the length of the same arm is equal to five sixths that of the body. According to the latter standard the length of the body of our Plectoteuthis may be estimated at 10 feet 6 inches, according to the first standard at 18 feet. In both estimates the length of the head, or part intervening between the trunk and origin of the arms, must be added; it is commonly one third the length of the trunk. If this be taken at 18 feet, the total length of Plectoteuthis grandis may have been 33 feet.

The above-described material evidence of the huge dimensions attained by certain species of Cephalopoda has long formed part of the stores in the British Museum; and there is no note or record of its origin⁴. I proceed, therefore, next to notice similar large specimens of which the localities are known.

Of these a satisfactory and instructive instance is the following:—In the general observations on the fauna of the isles of St. Paul and Amsterdam by the accomplished zoological member of the French expedition of the “Transit of Venus” (9th December, 1874), M. Ch. Velain states that “at the early part of November in that year a tidal wave stranded on the north shore of the Isle of St. Paul a Teuthid of the group of

¹ D’Orbigny, op. cit. Loligo, pl. 22; the arms are somewhat shorter relatively in the Squid figured as L. vulgaris in pl. 8.
⁴ It is briefly referred to by Mr. W. Saville Kent, F.L.S., in the ‘Proceedings of the Zoological Society,’ March 1874, p. 179.
Ommastrephes, which measured not less than 22 feet 10½ inches in length from the end of the body to that of the tentacles" 1.

In a subsequent account 2 M. Vélain notes in this locality two species of Squid (Ommastrephes) which are seen to dart, like arrows, from the surface of the sea, and afford food to the penguins (Eudyptes chrysolopha); also a small Poulpe, taken in the sea which occupies the crater, and which is referred to Octopus vulgaris. This is captured by the fishermen of the island for bait; and the same men testified to the apparition nearly every year of a gigantic Cephalopod. Fortunately, on the 2nd of November, 1874, one of these molluscan giants was cast by unusual storm-waves upon the northern beach of the island, and became the subject, as it lay, of the photographer of the expedition, M. Cazin. The photograph is copied in the plate, fig. 8, given on p. 81 of M. Vélain's "Observations" in the undercitied volume of the 'Archives de Zoologie,' and forms the subject of the cut, fig. 3.

Fig. 3.

Of this large Cephalopod the acetabula are said to be provided "with a corneous hoop, finely denticulated," on which character, and their disposition upon the arms,


M. Velain was led, in his brief notice to the Academy of Sciences, to refer the huge specimen to Steenstrup's genus Architenthis. But in the later notice he specifies the singularly truncate character of the arms, which do not narrow to a point as in all other Cephalopods; he refers also to a totally different hinder termination of the "gladius." This, however, is not shown in the photograph of the entire animal; nor is the kind of difference specified. But, on the ground below cited, the author proposes to refer his subject to a distinct genus, "Mouchezis," in honour of the commandant (Monchez) of the expedition.

Of this specimen one of the tentacles, the beak, and pharynx were exhibited to the Academy of Sciences; and those parts are doubtless preserved in the Museum of Natural History, Jardin des Plantes.

If the stunted terminations of the ordinary cephalic arms of Mouchezis be accidental to the individual specimen, the characters of the brachial acetabula, both as to structure and arrangement, conform with those of the arm of the great Squid (Plectoteuthis grandis) above described. Of the existence of folds of skin extending from the margins of the acetabuliferous tract or the opposite parts of the arm of Mouchezis, no mention is made.

What is remarkable in the tentacular pair is their great length, almost equalling that, relatively, in Loligopsis veranii. The prolonged attenuation of the pointed end of the body approaches to that character in Loligo subulata, Lam.; but it may be remarked that the corresponding end of the gladius in that species is not drawn out to the same degree.

Assuming a cephalic arm of Mouchezis to have been one fourth the length of the extended tentacle, which is estimated at 16 feet, such arm would be less than half the length of the great Ommastrephic arm in the British Museum.

The total length of Mouchezis, from the tip of the outstretched tentacle to the pointed end of the body, is set down as nearly 23 feet, leaving 8 feet for the length of the body. If, therefore, the tentacles of Plectoteuthis bore like proportions to those of Mouchezis, the total length of that Cephalopod must have greatly surpassed the Teuthid of the Isle of St. Paul.

1 "Ses dimensions, ses venteuves circulaires, garnies d'un cercle corné finement denticulé, leur disposition sur les bras, semblait motiver ce rapprochement, mais certains autres caractères l'en éloignent; en particulier la forme singulièrement écourtée des bras, qui paraissent tronqués brusquement au lieu de terminer en une pointe effilée, comme dans tous les Céphalopodes, ainsi que la terminaison inférieure, toute différente, de l'osselet dorsal."—Op. cit. p. 83.

2 D'Orbigny, op. cit. Loligopsis, pl. 2. fig. 1.
3 Id. ib. Loligo, pl. 17. figs. 1 & 2.
4 The above comparisons imply confidence in the accuracy of the dimension 7'-15 m. assigned to Mouchezis. It would be acceptable to Cephalopodists if figures of the natural size of the parts of the mouth preserved, corresponding with those (Pls. XXX. & XXXII.) of Cook's Hooked Squid, were published. Figures, nat. size, of one of the cephalic arms and of the acetabular expansion of the tentacle of Mouchezis would be equally welcome.
The locality I next proceed to notice in connexion with Cephalopods of unusual size is the North Atlantic. For the first of these instances I am indebted to the Rev. M. Harvey, of St. John’s, Newfoundland, who transmitted two photographs of parts of a specimen with the following notes of its capture:

“Two weeks ago” (December 1873) “two fishermen lying off St. John’s observed an object floating in the water which they took to be a portion of a wreck. On reaching it one of the men struck it with the boat-hook, whereupon the supposed piece of wreck became alarmingly lively, ‘rearing a parrot-like beak as big as a six-gallon keg,’ with which it smote the boat. Next it ‘shot out from its head two huge livid arms, and began to twine them about the boat.’ Happily an axe lay handy, and with it the boatman, recovering from the surprise into which this unexpected attack had thrown himself and his mate, cut off both the arms as they lay over the gunwale, whereupon the fish backed off and ejected an immense quantity of inky fluid that darkened the water for a great distance about.”

In the above account, published with photograph no. 2 (Pl. XXXIII. fig. 2), the passages quoted are verbatim testimonies of the boatmen, and bespeak, besides their emotions, the known characteristics of a Cephalopod, viz. the parrot-like beak, the protrusile tentacles, and the emission of the defensive ink.

Tentacles of 18 feet would easily stretch across or even clasp an ordinary fishing-boat. The beak, “as big as a six-gallon keg,” wielded by an animal “60 feet in length and 5 feet in diameter, with a tail 10 feet across, as observed in the air,” may be relegated to the region of fable, from which the prosaic naturalist is forbidden to adorn his descriptions.

The photograph no. 1 is of the head, arms, and tentacles of a Decapod differing from Sepia, and resembling Sepiotheuthis, Loligo, Loligopsis, Ommastrephes, and Onychoteuthis, in having the acetabula in two alternate rows on each arm. It differs from Onychoteuthis in having the suckers of the tentacles as well as of the arms not provided with hooks. In this photograph five of the cephalic arms are shown with more or less of the acetabular surface exposed; and there seems to be some difference in their relative length; but this cannot be precisely determined and applied to the homologues of the arms, 1–4, as, for example, in Ommastrephes ensifer (Pl. XXVIII. fig. 1). There is no indication of vela or of membranous extensions of the arms, as in that species and in Plectoteuthis.

The terminal acetabuliferous expansion of the tentacles in photograph no. 2 (Pl. XXXIII. fig. 2) supports along the three middle fifths two alternating series of large suckers; an indeterminate number of irregularly disposed smaller ones are pretty closely scattered over the proximal and terminal fifths of the expansion; a few small suckers are added in a single row along each border of the double row of large ones. The acetabular expansion of the tentacle is gradual, and does not exceed at its broadest part more than two diameters of the supporting stem. The length of the expansion is
eleven times its greatest breadth; the number of the larger suckers is twenty-four, twelve in each row, on each tentacle. The terminal fifth of the expansion gradually attenuates to a point.

In the above characters the following species, *Ommastrephes sagittatus*, d'Orb.\(^1\), resembles the great Newfoundland Squid, but differs in the larger relative size and smaller number of the proximal group of the smaller tentacular acetabula. The larger acetabula, moreover, are only eight in each row; and these rows are closer together. There is no trace, in any of the species figured, of the oblique ridges which divide the alternating pairs of the larger tentacular suckers, which ridges, in the Newfoundland Squid, are continued from those that define the shallow depressions from which the large suckers severally project; these seem to be sessile or to have very short peduncles. The above characters, well shown in the photograph, I have not found figured or described in any other species of *Ommastrephes*.

In the letter from the Rev. M. Harvey, of St. John's, Newfoundland, accompanying the photographs, "the eight shorter arms are" [stated to be] "each 6 feet in length and 10 inches in circumference at the junction with the central mass." They are also said to "taper to a fine point," to be "all armed with denticulated suckers,—in all eleven hundred in the ten arms." The tentacles are stated to be "each 24 feet in length, with suckers at the ends." "The eyes measured about 4 inches in diameter."

These particulars are also given in the Rev. Mr. Harvey's letter to the London Stereoscopic Company, which is published with the photographs; and with respect to the subject of no. 2 he states:—"This large arm, cut off by the fishermen in Conception Bay, measures 19 feet in length." This is, I conclude, the proportion of the 24 feet previously allotted to the tentacle when entire. But in the note attached to photograph no. 2 Mr. Harvey states:—"The entire length was thirty-five feet, 10 feet being left attached to the body and 6 feet having been destroyed." But this would seem to be given from the report of the boatmen. "The broadened extremity" (of the tentacle) "is armed with one hundred and sixty sucking-disks, about 1\(\frac{1}{4}\) inch in diameter." In this enumeration the small and large suckers are counted together, and no notice is taken of the well-marked difference of size between the twenty-four suckers in the two alternate rows of twelve each, and the intercalated smaller suckers, together with the proximal and distal groups of still smaller ones, which are shown in both the photographs.

It is probable that the diameter or breadth of the sucker relates to one of the larger series.

In a paper by Mr. A. Verrill "On the Cephalopods of the North-eastern Coast of America"\(^2\) a brief notice is given of Mr. Harvey's Squid, in which a length of 17 feet

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1 Op. cit. p. 344, Loligo, pl. iv. See also the terminal expansion of the tentacles, op. cit. Ommastrephes, pl. i. fig. 1.
2 Transactions of the Connecticut Academy of Arts and Sciences vol. v. part 1 (1880).
is assigned to the preserved portion of the tentacle, and a diameter of 1 1/4 inch to the largest tentacular acetabulum. Mr. Alexander Murray, Provincial Geologist of Newfoundland, agrees, from observation of the preserved specimens, with Mr. Verrill in these admeasurements.

Dr. Packard¹ has assigned the name *Architeuthis princeps* to Mr. Harvey's great Newfoundland Teuthid; but no generic characters are noted.

Mr. A. Verrill, in the paper above cited, gives an instance of a Squid captured in Coomb's Cove, Fortune Bay, in the year 1872, and quotes the following admeasurements, made by the Hon. T. R. Bennett, of English Harbour, Newfoundland, as being "perfectly reliable":—

<table>
<thead>
<tr>
<th>Description</th>
<th>Feet</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of body (probably including the head)</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Length of the tentacle</td>
<td>42</td>
<td></td>
</tr>
<tr>
<td>Length of one of the ordinary arms</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>

The cups on the tentacles were "surrounded by a serrated edge, like the teeth of a hand-saw."

Of another specimen, taken in Trinity Bay, Newfoundland, September 24th, 1877, the following admeasurements are recorded:—

<table>
<thead>
<tr>
<th>Description</th>
<th>Feet</th>
<th>Inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of the body to the base of the arms</td>
<td>9</td>
<td>5</td>
</tr>
<tr>
<td>Circumference of the body</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>&quot;                           , head</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>Length of the longest cephalic arm (fourth)</td>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>Circumference of its base</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>Diameter of a large sucker</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Length of the tentacle</td>
<td>30</td>
<td>0</td>
</tr>
<tr>
<td>Length of terminal expansion of tentacle</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>Circumference of stem</td>
<td>0</td>
<td>5</td>
</tr>
</tbody>
</table>

The above admeasurements are given on the authority of the Rev. M. Harvey.

In the 'Sitzungsberichte der Gesellschaft naturforschenden Freunde zu Berlin,'² Dr. F. Hilgendorf records observations of a huge Teuthid exhibited for money at Yedo, Japan, in 1873. It unfortunately, when seen by the author, lacked both the head and abdominal sac; the arms also were more or less injured; and the tentacles had been amputated at mid-length ³. In the arrangement in double series of the horn-lined

² No. 4, 1880.
³ "Der Eingeweidesack entfernt, der Kopf ebenfalls ausgenommen und dessen Haut aufgeschnitten und von der Körperrand getrennt, die Arme mehr oder weniger geschädigt, die beiden Fangarme in der Mitte abgeschnitten."—Ibid. p. 65.

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suckers the specimen agreed with the Loliginidae, in which family *Ommastrephes illecebrosa*¹, *O. pelagicus*², and *O. vanicoriensis*³ repeat the character of the posterior confluent fins ("mit einander verwachsene Flossen am Hinterleib ").

In portions of a similarly large Squid exposed for sale in the Yedo fish-market Dr. Hilgendorf subsequently noticed the thickened end of the two longest arms ("das verdichtete Endstück der beiden längsten Arme," l. c. p. 67); and, concluding that such arms could not belong to a species of *Ommastrephes*, he proposes for the great Japanese Squid, to which he assumes them to belong, the generic name *Megateuthis*. But it may be questioned whether this enlargement of the ventral arms may not exemplify a sexual rather than a generic character⁴; no other is assigned save that of size.

The following admeasurements are given of the original subject:—

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Centim.</th>
</tr>
</thead>
<tbody>
<tr>
<td>From the hind end of the mantle to its fore border along the back</td>
<td>186</td>
</tr>
<tr>
<td>Length of the longest of the eight arms</td>
<td>197</td>
</tr>
</tbody>
</table>

The extreme size assigned by Aristotle to one of his *Malakia* is to a Decapod; and this squares in the main with that of Cook’s Hooked Squid; the brief notice⁵, as usual, favourably contrasts with the marvellous Ccuttles of his uncritical successor Pliny.

Any notice of Cuttlefish seen from the deck by seamen of any grade, the admiral inclusive, is unavailable for the prosaic naturalist, when no part of the alleged monster has been obtained, preserved, or described by a competent zoologist. To him the report, for example, transmitted by the Minister of the Marine to the Academy of Sciences, Institute of France, and given in the ‘Comptes Rendus,’ 30th December, 1861, is unavailable by reason of the commander of the war-ship ‘L’Alecton’ forbidding the means of capture.—"Officiers et matelots me demandaient à faire amener un canot et à aller garrotter de nouveau l’animal et l'amener le long du bord. Ils y seraient peut-être parvenus, mais je craignais que dans cette rencontre corps à corps le monstre ne lauchât ses longs bras armés de ventouses sur les bords du canot, ne le fit chavirer et n'étouffât peut-être quelques matelots dans ses fouets redoutables chargés d'effluves électriques" (p. 1264).

From the accompanying statement of the scene in the Pacific Ocean, its subject seems certainly to have been a Cephalopod, not a Torpedo. The dimensions of the "*Poulpe monstrueux*, qui nageait à la surface de l’eau, et mesurait de 5 mètres à 6 mètres de

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¹ D’Orb. ut suprà, *Loligo*, pl. iii.   ² Ibid. pl. xviii.   ³ Ibid. pl. xxi.   ⁴ See Steenstrup in ‘Kongelige Danske Videnskabernes Selskabs Skrifter,’ 5te Række, Bind iv., 4to, 1856.   ⁵ "οι τευθοι καλόμεναι ἑπιπολί μείζων γέγονον γῆς καὶ πέντε τῆκεν τὸ μέγεθος."—Arist. Hist. Animal, lib. iv. cap. i. ⁶ "But the so-called Squids (Loliginidae) are much the largest (of the *Mollusca* or Cephalopods); some even attain the length of 5 cubits," probably equivalent to 7 feet 6 inches English. The Greek πέντε θέκες is usually taken at 10 1/4 inches.
longueur" (p. 1265), are affected by the same conditions of guess and emotions as are those of the 60 feet ascribed by the Newfoundland fishermen to their assailant. "Les yeux, à fleur de tête, avaient un développement prodigieux et une effrayante fixité. Sa bouche, ou bec de perroquet, pouvait offrir près d’un demi-mètre" (ibid.) The character of the eyes squares with a species of *Ommastrephes*; a beak of about 2 feet diameter recalls the dimensions assigned to the same part of this Squid by the Newfoundland fishermen.

The statement by the estimable naturalist Péron¹:—"non loin de l’île de Van Diemen, nousaperçûmes dans les flots, à peu de distance du navire, une énorme espèce de Sépie, vraisemblablement du genre Calmar, de la grosseur d’un tonneau," adds to our knowledge of the geographical distribution of large Cephalopods. but not to that of their exact dimensions.

Steenstrup’s notice² of a large Cephalopod is of more worth, though made on fragments only of a specimen which the fishermen of the coast of Jutland had cut to pieces for bait. The mouth (or part corresponding to the subject of Plate XXX. fig. 2 and Plate XXXI. fig. 1 of the present paper) is somewhat vaguely stated to be "of the size of an infant’s head." It is referred to a decapodal genus, *Architeuthis*, as *Architeuthis dux*. Another large species, seen or taken on the coast of Greenland, is noted by the same estimable naturalist as an *Architeuthis monachus*; but the generic distinction from *Ommastrephes*, d’Orb., is not given.

The Mediterranean Calamary obtained by Eschricht at Marseilles, and now, or part of it, preserved in the Museum of Copenhagen, is stated to be 1 mètre 850 millims. (French) =6 feet 1 inch (English) in total length, tentacles and trunk included—*i. e.*, I conclude, in the position in which *Enoplotheuthis cookii* is restored in Plate XXXIII. fig. 1. Here we have an allied Decapod of about the same length, "vela" being developed from some of the cephalic arms. Prof. Steenstrup has assigned to Eschricht’s large Mediterranean Squid the name *Ommastrephes pteropus*.

The largest Cephalopod described in the great work of Pernssac and d’Orbigny is the *Ommastrephes giganteus*³. To this species M. d’Orbigny assigns:—"Longueur totale 1 mètre 110 millim." (3 feet 8 inches), "longueur du corps 440 millim." (1 foot 4½ inches). It is not stated whether the admeasurement of total length included the outstretched tentacles with the head and body. But in any case the size counted as gigantic falls far short of that evinced by the brachial arm of *Pleutoteuthis grandis* and the admeasured parts of the great Squids captured in Fortune Bay and Trinity Bay, Newfoundland.

The character of unusual size is not limited to the Decapod division of Cephalopoda; but the evidence of alleged monstrous Poulpes (Octopoda) is less exact.

¹ *Voyage aux Terres Australes*, tome i. p. 18.
In the account given by the government diver of the colony of Victoria, Australia, in his Report, as cited in the weekly journal entitled ‘The Colonies and India’¹, it appears that, pursuing his avocation in the estuary of the river Moyne, and having occasion to explore a hole in the bed, “his arm was seized by the tentacles of an Octopus, part of which he brought to shore, after mutilating his assailant with strokes of ‘a small iron bar.’” This part, probably consisting of the head with more or less of the crown and arms, “being laid out, measured over 8 feet across.”

We may assume this measurement to have been taken from the tip of one outstretched cephalic arm to that of the opposite arm. Now the length of the longest arm of my Australian Tritaxeopus (Plate XXIII. fig. 1) is 1 foot 11 inches; the breadth of the head intervening between the third pair of arms is 2 inches 2 lines; so, from the tip of one of such arms to the opposite one gives 4 feet.

If the Victorian diver took his measurements from tip to tip of the corresponding pair of acetabuliferous arms, and we deduct the breadth of the intervening part of the head according to the scale of Tritaxeopus, the length of such outstretched arm of the Moyne-river Octopod may be set down as 3 feet 10 inches; and the extent of the pair, with the intervening head reckoned at 4 inches 4 lines in breadth, would give 8 feet 2 inches, closely agreeing with the diver’s statement.

Stretching out the first dorsal pair of arms in a line with the body, the total length of Tritaxeopus cornutus is 1 foot 6 inches; allowing the like proportion to the dorsal arm of the Moyne-river Octopod, its total length may be set down as 3 feet.

The ascertained differences in the proportions of arms, head, and body in the known species of Octopods do not, as a rule, support an inference of any notable error in the dimensions above estimated of the Moyne “Monster or Devil-fish,” respecting which the diver states:—“After a while I found the grip begin to relax a little; but he held on until I had almost cut him to pieces; and then he relaxed his hold from the rock, and I pulled him up.” This statement, with that of the circumstances of the first attack, viz. the seizure of the diver’s arm, which he had thrust into a hole, by an arm of the Octopod, exemplifies the same habits of that form of Australian Cephalopod which have been noted in our common European Octopus.

There seems then to be no sufficient ground for the heading “Conflict of a Man with a Gigantic or Monster Cuttlefish,” superposed to the government diver’s Report, copied from the official statement into the journal above cited. The assailant seems not to have been more than thrice the ordinary average size of the Octopus vulgaris.

An Octopus with sucker-bearing arms of from 3 to 4 feet length, may well have afforded the subject of the accomplished Japanese sculptor (cut, fig. 4), whose work is graphically de-

¹ Number for 21th January, 1880.
scribed in the subjoined paragraph of an article in 'Land and Water' by my friend Frank Buckland, M.A., F.Z.S.:—

"This carving is an inch and a half long, and about as big as a walnut. It represents a lady in a quasi-leaning attitude; and at first sight it is difficult to perceive what she is doing; but after a while the details come out magnificently. The unfortunate lady has been seized by an Octopus while bathing (for the lady wears a bathing-dress). One extended arm of the Octopus is in the act of coiling round the lady’s neck, and she is endeavouring to pull it off with her right hand; another arm of the sea-monster is entwined round the left wrist, while the hand is fiercely tearing at the mouth of the brute. The other arms of the Octopus are twined round, grasping the lady’s body and waist: in fact, her position reminds one very much of Laocoon in the celebrated statue of the snakes seizing him and his two sons. The sucking-disks of the Octopus are carved exactly as they are in nature; and the colour of the body of the creature, together with the formidable aspect of the eye, are wonderfully represented."

This work of art is in the possession of Mr. Bartlett, of the Zoological Gardens.

The exciting incidents with which M. Victor Hugo adorns his narrative of ‘The Toilers of the Sea’ relate to the attacks of a large Pouipe. The fishermen of the Channel Islands and opposite coast of France retain the belief in a still huger species, which coils its cable-like arms about the mast of the sailing-vessel and capsizes the craft, the crew of which it devours. De Montfort, in his ‘Histoire Naturelle des Mollusques,’ admitted a figure of the achievement of the monster “Pieuvre;” but this, with the “Kraken” and the “Great Sea-Serpent,” still remains a denizen of the dreamy ocean of credulity and romance.

Sufficient, however, of the evidence needed by the naturalist has been obtained to demonstrate that the greatest bulk in the molluscan subkingdom is attained by members of its most highly organized class; in this also is manifested the most extensive range of the character of individual bulk.

From the diminutive Cranchia, size rises, in the dibranchiate Cephalopods, to that of Cook’s hook-armed Squid, to that of the castaway on the Island of St. Paul (fig. 3, p. 157), to the still greater dimensions of the assailant of the Newfoundland fishing-boat, and to that of the huge possessor of the subject of Plates XXXIV. and XXXV.

Far back in time, moreover, a similar series of specific dimensions is indicated by remains of extinct members of the lower or tetrabranchiate order of Cephalopods. Their chambered and siphonated shells ranged from diminutive kinds not surpassing

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1 Other references to recorded gigantic Cuttlefishes, with judicious critical remarks, will be found in the instructive work entitled 'The Octopus; or, the "Devil-fish" of Fiction and of Fact,' 12mo, 1875, by Henry Lee, F.L.S., F.G.S., F.Z.S.

2 Trans. Zool. Soc. vol. ii. pl. xxii. fig. 1. I do not cite Loligo laticeps (fig. 6) or Octopus semipalmatus, because they were taken from an extensive mass of the Sargassum or Gulf-weed, a favourite breeding-place of pelagic Cephalopods, and were probably immature specimens of their species (p. 111).
that of the modern *Spirula* to a coiled Ammonite (*Am. leptophyllus*, Bedwell) 4 feet in diameter; and of the straight camered kinds (*Orthoceratites*) Dr. Bigsby has noted a specimen of *Huronia vertebralis* in the cliffs of Drummond Island 6 feet in length. The constructors and occupants of such shells may have approached in size to the larger naked Cephalopods recorded in the present paper.

**DESCRIPTION OF THE PLATES.**

**PLATE XXIII.**

*Tritaxeopus cornutus*, Ow.

Fig. 1. Dorsal view, three quarters natural size.
Fig. 2. Oral environment, one quarter natural size.

**PLATE XXIV.**

*Sepia palmata*, Ow.

Fig. 1. Dorsal view, natural size.
Fig. 2. Sepium or "cuttle-bone," natural size.

**PLATE XXV.**

*Sepia palmata*, Ow.

Fig. 1. Ventral view, natural size.
Fig. 2. Sepium, natural size.

**PLATE XXVI.**

*Sepioteuthis brevis*, Ow.

Fig. 1. Ventral view, dissected, natural size.

*Sepiola oweniana*, d’Orb.

Fig. 2. Male organs of generation, magnified.
Loligopsis ocellata, Ow.

Fig. 3. Oral environment, natural size.
Fig. 4. Transverse section of cephalic arm, magnified.
Fig. 5. Sucker, showing denticulate hoop, magnified.
Fig. 6. Upper mandible, natural size.
Fig. 7. Lower mandible, natural size.
Fig. 8. Gladius or “pen,” less than natural size.

PLATE XXVII.

Loligopsis ocellata, Ow.

Fig. 1. Ventral view, natural size.
Fig. 2. Dorsal view of head and part of mantle, natural size.

PLATE XXVIII.

Ommastrephes ensifer, Ow.

Fig. 1. Dorsal view, half natural size.
Fig. 2. One of the largest suckers and denticulate hoop, natural size.

PLATE XXIX.

Onychotethis raptor, Ow.

Fig. 1. Dorsal view.
Fig. 2. Ventral view, dissected.
Fig. 3. Digestive organs.
Fig. 4. Circulating and respiratory organs.
   (Natural size.)

PLATE XXX.

Enoploteuthis cookii, Ow.

Fig. 1. Upper mandible.
Fig. 2. Both mandibles or beak, with inner lip reflected.
Fig. 3. Lower mandible.
   (Natural size.)
PLATE XXXI.

Enoploteuthis cookii, Ow.

Fig. 1. Vertical longitudinal section of mouth, natural size.
Fig. 2. Ventral surface of pinnigerous termination of body.
Fig. 3. Dorsal surface of pinnigerous termination of body.
Fig. 4. Section of pinnigerous termination of body.
(Figs. 2–4 much reduced.)

PLATE XXXII.

Enoploteuthis cookii.

Fig. 1. Terminal portion of a cephalic arm, natural size.
Fig. 2. Cut end of ditto.
Fig. 3. Section of basal part of ditto.
Fig. 4. Section of uncigerous acetabulum.
Fig. 4'. Outline of ditto, magnified.
Fig. 5. Section of uncigerous acetabulum.
Fig. 5'. Outline of ditto, magnified.
Fig. 6. Section of systemic ventricle, natural size.

PLATE XXXIII.

Fig. 1. Restoration of Enoploteuthis cookii.
Fig. 2. Tentacle of Architeuthis princeps, less than natural size.

PLATE XXXIV.

Plectoteuthis grandis.

Fig. 1. Dorsal surface of cephalic arm and vela, from a section near the base.
Fig. 2. Acetabuliferous surface of termination of the arm.
(Natural size.)

PLATE XXXV.

Plectoteuthis grandis.

Fig. 1. Transverse section of non-acetabuliferous base of cephalic arm.
Fig. 2. Acetabuliferous surface and vela of basal part of the arm.
Fig. 3. Side view of a basal acetabulum.
(Natural size.)
TRITAXEOPEUS CORNUTUS, One 3/4 Nat. size.
Fig. 1, SEPIOTEUTHIS BREVIS. Figs. 3-8, LOLIGOPSIS OCELLATA
ONYCHOTEUTHIS RAPTOR nat.size
ENOPLOTEUTHIS COOKII. nat. size.
ENOPLOTEUTHIS COOKII

Fig 1, Nat. size, 2.4 reduced
ENOPLOTEUTHIS COOKII Fig 1-5 Nat. Size.
Fig. 1. LENOPLOTEATHIS COOKII (reduced restoration) Fig. 2. TENTACLE of ARCHITEUTHIS PRINCEPS Red"
From Data stone. By J. Erxleben.

PLECTOTEUTHIS GRANDIS.
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P. L. SCLATER,
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XI. On the Structure and Development of the Skull in the Urodeles.

By W. K. Parker, F.R.S.

Received June 1st, read November 16th, 1880.

[Introductory Remarks.

In the 'Philosophical Transactions' for 1877 (part 2, plates 21–29, pp. 529–597) I have given an account of the development of the skull in this group, that of Siredon being worked out in several stages, that of Seironota in the larva and adult, and the skull of Proteus in the adult only.

In a second paper treating of the skull in this group (Trans. Linn. Soc. ser. 2, Zool. vol. ii, pp. 165–212) I have given figures and descriptions of the larval and adult skulls of several more types of the tailed amphibia.

In the present paper, through the kindness of Dr. Sclater and the late Professor A. H. Garrod, F.R.S., I am able to explain the morphology of the skull of the Menopoma and of Siren lacertina (of the latter in two stages), and through Professor Flower's kindness, to add to that of the Sieboldia. I had already provided myself with a fine series of native Newts, in various stages; and for comparison with the skull of the larger kinds just mentioned I could not have had better materials.

The reader will be able to put these three contributions together as a regular series, only interrupted by some little distance of time, and by their necessary appearance in the 'Transactions' of three different Societies.

The following works have been of great value to me in this piece of research, viz.:

vol. xi.—part vi. No. 1.—January, 1882.
The Skull of Sieboldia maxima mas adultus, 4 feet 2 inches long.

The general form of this skull (Pls. XXXVI. & XXXVII.) is semielliptical and very flat; the greatest breadth is across the quadrate condyles; and this measurement is about one tenth greater than the length along the axis. The maxillary arch reaches outwards so far as to give a measurement just intermediate between the length and the greatest breadth; its backward stretch is only halfway from the fore margin to the condyle of the corresponding quadrate.

The direction of those condyles is outwards, a little downwards, and slightly backwards; behind they reach as far as to be opposite the narrowed waist of the occipital cincture.

Generally speaking, the skull is subconvex above, and gently hollow below; but there is, notwithstanding the persistence of the frontal and sagittal sutures, a definite, rather sharp, median crest.

The whole maxillo-premaxillary arc is ankylosed into a single bone; the palatines and vomers of the same side are confluent; and the paraphenoid has coalesced with the occipital bones below: this is due to the great age of this individual. The published figures do not show this 1.

On the whole, the metamorphism of this skull has been arrested at the same stage as that of an ordinary “Caducibranch” of the first summer, or immediately after the loss of the gills. See Plate XL. figs. 6 & 7.

The Investing Bones of Sieboldia.

The superficial bones are dense, smooth, and often perforated by vessels; they have a considerable thickness in several instances; and they form about half the materials of the building. But there is no definite line to be drawn between those investing bones that keep entirely free from the chondrocranial tracts and those that graft themselves upon certain parts of those tracts: for instance, the palatine keeps free from the cartilage; but its segmented pterygoid process (the “pterygoid” of the adult) ossifies all the proximal part of the pterygoid outgrowth of the suspensorium.

The three pairs of submesial roof-bones (parietals, frontals, and nasals) reach from the foramen magnum to the outer nostrils (Pl. XXXVI. fig. 1, p, f, n, e. u.), and form an oblong tract which only partially hides the underlying structures; for the endocranium is spread out below, and contracted at the top of the low side walls. These symmetrical upper plates are all imbricated from before backwards; and the parietals (p) have only their square hinder part, or about two fifths of their length, free from the overlapping frontals (f). The fore part of each becomes a long, sharp, slightly out-turned wedge of bone.

1 Fauna Japonica, pl. viii. figs. 1, 2; Wiedersheim (9), pl. ii. figs. 21, 22.

2 One of the lesser Japanese Urodeles, viz. Onychodactylus, undergoes less metamorphism than this gigantic kind (see Trans. Linn. Soc., Zool. 1880, pl. xix. figs. 1-8).
Over the foramen magnum they unite to form a rounded process, just as the azygous paraphenoid (Pl. XXXVII. fig. 1, p.a.s) forms a rounded process under this archway, but much further back. On each side, over the broad free end of the hourglass-shaped occipital cincture, each parietal sends a bevelled, ovoid, dentate plate; in front of this plate each bone is higher and thicker, and at its anterior notched edge articulates with the squamosal (sqf). Again, in the temporal region each bone is developed into a short spur, in front of which, in the postorbital region, the bone bends inwards, and then stretches gently outwards to its pointed fore end, where it lies on the ethmoid, and binds the outer face of the prefrontal (p.f); the sagittal suture is formed by the meeting of the raised inner edges of the two bones.

The frontals (Pl. XXXVII. fig. 1, f) reverse the form of the parietals; they are sharp wedges behind and are dilated in front, where they diverge abruptly to let in the nasals (n). These bones reach backwards halfway between the foramen opticum and the f. ovale (II, v); in front the diverged part binds against the top of the maxillary (mx) and the inner edge of the prefrontal (p.f), whilst the nasals (n) overlie the notch formed by their divergence.

The frontal suture has large irregular teeth; and the edges are sharp where the two bones are interlocked (fig. 2).

The nasals (n) together form an oxhead-shaped plate, the cheeks of which articulate with the top of the maxillaries, whilst the horns run in between the nasal processes of the premaxillaries and the nasal cartilage surrounding the outer nostrils (na, e. n).

Their narrow hinder end rests by a squamous suture upon the notched frontals; their median suture has strong teeth; their surface is hollow towards the middle, subsca- brous, and pitted.

There are only two pairs of supero-lateral bones, viz. the prefrontals and squamosals. The former (p.f) are irregular conchoideal splints, lying outside the fore half of the frontals, and articulating also by their front edge with the ascending plate of the maxillaries. They are pinched in at the anteorbital region, and only half conceal the nasal roof (na); their outer and fore margin is notched; and they overlap the frontals by a squamous suture. They are half the size of the frontals.

The squamosals (sq) are strong, oblong, carinate bones; they articulate above with the parietals by a rounded head with raised borders, are crested in a rugged manner along their outer surface, and the crest crosses over from the hinder part of the upper ribbed edge to the fore edge below. The hind edge is rounded, and the front edge rather straight, so that they are semielliptical below; they bind strongly on the half bony suspensorium. Here we see the economy used in this group as to bony plates; for this squamosal answers to the proper squamosal (temporal) of most Ganoids and of the Siluroid Teleostean, and also to the preopercular.

There are only two bones in the marginal arc; for each premaxillary has become ankylosed to the maxillary (px, mx) of the same side; but the former are only one
fourth as large as the maxillaries, which yet only reach halfway to the hinge of the lower jaw.

The nasal processes of the premaxillaries (n, *pa*) are sharp wedges let into the upper part of the nasals; they articulate one with the other by sharp teeth, and they are hollowed out above. At their sharp ends they diverge; and here the middle nasal passage can be seen, bounded behind by the nasals.

The whole palatal dentigerous part (Pl. XXXVII. fig. 1, *px*, *mx*) forms rather more than the third of a large circle, and is only divided by the median suture. The ranks of long pupiform teeth stand against the sharp dentary edge of the bones which grow into the palatal region to an equal extent beyond the tooth-bearing part.

Each maxillary (*mx*) is a thick rib-like bone, its notched ascending plate being the "head;" the outer surface is convex, pitted, punctured, and more or less irregularly mamillate. The free jugal part enlarges, and then has a rounded and bevelled end.

Below (Pl. XXXVII. fig. 1), the concave edge of the great dentigerous arc is fitted with a similar structure, which, however, is only one third the extent of the outer part; this is also divided at the mid line; it is composed of the vomers and palatines (*v, *pa*), which also are ankylosed together.

Together these bones present a thick convexo-concave dentary edge in front, in the concave part of which the ranks of straight teeth stand. Then these smooth dentigerous wings give off each a subtriangular plate, joined to its fellow by a harmony-suture. These gently lessening plates have a rounded notch at their margin where they come off from the wings, and then grow backwards beneath the great parasphenoidal floor (the left being larger than the right), and end as sharpish wedges. The outer two thirds of the dentigerous wings belong to the palatines (*pa*); these bones pass to the hinder flat part for a short distance; but the main part of the smooth plates belong to the vomers (*v*).

The parasphenoid (*pa*s) forms a floor to all but the outer edges of the endocranium; it is wide behind, growing out in toothed processes in the basitemporal region, but narrower forward where it passes over the hinder angles of the vomers.

There it is thin, and is grooved or scored both in straight lines and obliquely; along its middle third it articulates, by an irregular suture, with the inner edge of the pterygoid.

It is not distinguishable from the hinder half of the occipital cincture, under the foramen magnum, and evidently has yielded much of the bony matter that forms the cochleate median process that underlies the concave facet for the odontoid rudiment; further forwards the parasphenoid is free; it is flat in front and convex behind.

The dentary (Pl. XXXVI. figs. 2 & 3, *d*) is a long, large, thick bone, which gives the outline to all but the condyle and angle of the mandibular ramus; it rises into a small coronoind process under the end of the maxillary, sends up an outer alveolar wall for the outer rows of teeth, and grows inwards below (fig. 3) to form the edge of
the jaw. The splenial (spl) is smaller, but large also; it reaches, as in *Menopoma* (Pl. XXXVIII. fig. 3, *spl*), nearly to the angle, inside; it carries teeth along its fore half, and is thin all the way, ending a little behind the symphysis, where Meckel's cartilage (*mk*) is exposed.

b. The Endocranium of Sieboldia.

The chondrosteous inner skull of this species is very massive; about half of the cartilage of which it was composed is ossified. It is much hidden by the investing plates; but its parts are largely traceable notwithstanding.

The occipital arch is like a low hour-glass, the foramen magnum (Pl. XXXVII. fig. 2, *f.m*) is circular below and narrow above; it has cartilage bounding it in both places. The condyles (*oc.c*) are large, oval, and look obliquely inwards and backwards; between them, in the opening, there is a concave joint for the odontoid rudiment. Where the cincture is pinched in, there we see a common passage for the ninth and tenth nerves (fig. 1, ix, x). Each exoccipital bone (*e.o*) just faces the capsules of the ears with a hollow bony plate, answering (partially) to both the opisthotic and epiotic. Above, the supraoccipital synchondrosis is covered with the parietals (Pl. XXXVII. fig. 2, *p*); below, the basal cartilage is floored with a compound plate, formed by fusion of the parasphenoid with the exoccipitals.

In front the prootics (Pl. XXXVI. fig. 1, *pr.o*) occupy a rather small part of the front face of the capsules, which are unossified to a great degree across their middle part; in the postero-external face below we see the large oval stapes (Pl. XXXVII. figs. 1, 2, *st*), which is ossified and ossifies half the columella (*p.ky*). The shallow cranial barge has its low sides ossified in the orbital region; each bony tract, or sphenethmoid (*sp.e*), runs halfway from the optic to the oval foramen (*ii, v*), and runs three fourths of the way to the wings of the ethmoid, where it stops abruptly.

The actual roof and floor are extraneous; for the "tegmen crani" only exists as a rudiment before and behind, and the basal plate (parachordal passing into prochordal) is in two widely separated moieties; in front the "intertrabecula" only exists as an internasal conjugation.

The nasal region (*na*) is unossified; it is very broad, is confluent with the dilated cornua trabeculae, the form of which has been transferred to the vomero-palatine bones (Pl. XXXVII. fig. 1, *v.pa*). In front the premaxillaries fill in the large semicircular notch between the cornua and the nasal roofs. In the angle between the maxillary and prefrontal each nasal roof is exposed; it is gently convex, and has an elliptical shape; it does not reach the maxillary, the dyke between is filled up with a fibrous mat.

c. The Visceral Arches of Sieboldia.

Behind, the nasal sacs appear larger than they actually are; for the large, thick, arcuate ethmopalatines (*epa*) have followed their curve, and are confluent with their
hind wall. These preoral, endoskeletal palatines are also confluent with the trabeculae, from which they were at first distinct, standing out at right angles from them, and having, if any, a slight curve backwards, naturally looking towards the postoral suspensorium.

These "visceral" bars are not pedate terminally; they bound the space in which the inner nostrils (i.n) lie, which have the vomero-palatine wings on their inner side; these passages are a marvellous width apart, almost thrice that of the outer openings (e.n); they are twice as large, and look forwards, but most inwards, following the line of the maxillary arch.

In extreme contrast with the arrested preoral bars—mere proximal rudiments at best—we have the mandibular pier and arch, the suspensorium, carrying the mandibular rami.

This is not merely a cartilaginous structure, more or less ossified directly, but there are two large bones added to each pier, and three to each ramus.

Primarily (see in the Newts, Pls. XI. & XLI.) the suspensorium was a thick segment of cartilage sending upwards three snags for union with the skull proximally, and downwards and outwards a condyle for articulation with the elongated terete Meckelian rod.

The proximal attachments of this huge suspensorium can be seen from the surface; below, on the left side, the true head or pedicle is hidden by the pterygoid and parasphenoid; but on the right side (Pl. XXXVII. fig. 1, pd) it can be seen passing into the basis cranii, with which it is confluent. Above, the ascending process (Pl. XXXVI. fig. 1, ap) is seen as a broad tract of cartilage continuous with the alisphenoidal wall.

It has been ossified to some degree both by the sphenethmoid and pterygoid (sp.e, pg); but a clear edge of cartilage is seen in front of the foramen ovale (v) running outwards to the third process.

This third (or otic) process (ot.p) is an angular mass of cartilage confluent with the ear-capsule; in the angle formed by it with the ascending process a part of the prootic (pr.o) can be seen. The body of the suspensorium is a thick phalangiform mass, ending outwards in the large, oblique, reniform quadrato condyle, which looks downwards and is directed slightly outwards. The upper and the hinder part of this thick bar is unossified, and rises behind the edge of the squamosal into a swelling ridge, a sort of natural hypertrophy of the copious cartilage.

The lower edge of this mass is notched and produced for the attachment of the ephyal (e.hy). The antero-external part is solidly ossified as a quadrate bone (q); and this is confluent with the pterygoid (pq). The upper surface is strongly clamped by the squamosal, which almost buries itself in the substance of the cartilage, as if it had been pressed into it whilst soft and ductile, but it does not graft itself upon it.

There is no pterygoid cartilage, now, growing directly out of the fore edge of the
suspensorium; but towards the front margin of the pterygoid bone (pg) an "epi-
pterygoid cartilage" (ep.g) is seen; its length is equal to half the width of that bone, in
a groove of which it lies, and beyond which it projects towards the jugal process of the
maxillary, to which it is attached by a ligament. This cartilage—a mere sigmoid style
—had once a large base, which grew directly out of the front of the suspensorium; the
pterygoid bone has used up this wide proximal part.

That bone (pg), which at first grew out from the palatine as an edentulous snag, has become individuated and transformed into a most important part of the cranio-
facial building.

It is, now, far from its original root, a huge two-leaved blade, with a sharp twisted
falcate handle, which handle is thoroughly ankylosed to the quadrato bone (q).

Above (Pl. XXXVI. figs. 1, 2) the inner blade is sutturally joined to the sphenethmoid (sp.e), and even to the parietal on the right side; below (Pl. XXXVII. fig. 1) it articu-
lates on each side with half the edge of the parasphenoid. This latter articulation is a
gross and dim foreshadowing of the light and elegant articulation of the pterygoid with
the basis cranii in Lizards and many Birds.

Both the individuated epipterygoid cartilage (e.pg), and the bone (pg) by its outer lobe,
are obliquely attached to the distal part of the maxillary by an oblique ligament.

Between the temporal process of the parietal and the ascending process of the
suspen sorium the trigeminal nerve can be seen in the large foramen ovale, its double
outer part (v2), passing outwards, over the cartilage, and its orbito-nasal branch (v1)
rinning beneath it; this branch escapes again outside and above the optic nerve (II).
The mandible (Pl. XXXVI. figs. 2, 3) has a huge reniform condyle; and the thick
upper end is largely ossified by the ectoosteal articulare. The Meckelian cartilage (nik)
runs nearly to the end of the jaw.

The hyoid arch is typically segmented above, but has more than the normal joints
below; there is a pharyngo-hyal (p.hy) confluent with the stapes to form the columella,
and an epihyal (e.hy) articulated with the hind margin of the suspensorium.

In the Frog the pharyngo-hyal, which is equivalent to the hyomandibular and
symplectic of fishes, forms the jointed columella; but in that type, as in all the Anura,
the columella keeps distinct from the stapes, as the incus does in the Mammalia; the
Urodele foreshadows the "Sauropsida" in having a compound (hypo-otic) columella.

The stapes (Pl. XXXVII. figs. 1, 2, st) is a thick, oval, ossified disk of cartilage; and
its ectoosteal plate runs onto the round, narrow, proximal end of the pharyng-hyal,
ossifying it. The distal half is not ossified, and is dilated into a peoate mass, which on
the left side is confluent with the suspensorium, and on the right side is distinct and
is articulated with it; over this part the main trunk of the facial nerve (VII) runs.
Halfway down, the suspensorium is notched, sinuously. To this part the epihyal (e.hy)
is attached by ligamentous fibres; it is semioval, with the attached edges sinuous; it
is about equal in size to the pharyngo-hyal; this segment possibly corresponds to the
distinct symplectic of the Sturgeon and Paddle-fish.

The lower part of the hyoid arch is longer and broader than the large mandibular
ramus (Pl. XXXVI. fig. 2, c.hy); its lower part is broken up into three small segments,
equalling in average size the upper elements.

This broad but solid rib of cartilage is arcuate; in general form it is narrower above,
and broader below, the top part (st.h) being both notched and rounded; the broad lower
part is emarginate, and has two lateral facets for the hypohyals (h.hy).

There are two hypohyals (h.hy, h.hy') attached to the supero-external angle of the
great cornu; but these have become confluent (see in Menopoma, Pl. XXXIX.);
together they form a thickish rod hooked inwards to join the median piece (b.hy), which
has coalesced right and left with these small distal hypohyals (Pl.XXXVII. fig. 4, h.hy').

The third hypohyal (h.hy"), is a truncated oval, attached by its broad part to the
infero-internal angle of the great cornu (c.hy).

Outside the largest hypohyal there is another very small nucleus of cartilage on the
left side.

The ligaments connecting the parts at the angle of the mouth are well seen in this
skull. The "suspensorio-stapedial ligament" has the pharyngo-hyal in its substance,
and the "hyo-suspensorial" (h. s.l) has the epihyal (e.hy) in its upper end; the "mandibulo-hyal" (m. h.l) runs upwards and backwards under the distal part of that ligament
from the angle of the jaw, and is attached nearer the end of the styloid part of the
ceratohyal.

In Menobranchus none of these ligaments have cartilage in their substance.

The basihyal (b.hy), contrary to rule, sends a process backward towards the first basi-
branchial; it is pyriform, with the narrow end behind, and is confluent right and left
with the small second hypohyals.

The third and fourth branchial arches are not retained in this species; they are in
Menopoma, and also in a small Japanese "Cryptobranch," viz. Onychodactylus (Trans.
Linn. Soc. ser. 2, Zool. vol. ii. 1880, pl. xix.).

The next basal element is roughly marked out into a first and second segment
(Pl.XXXVII. fig. 3, b.br); it is a roughly orbicular plate of cartilage notched in front
and on each side; and the left side is the larger of the two.

The first branchial arch has lost its upper element; there is only an unossified cerato-
branchial (c.br'), an arcuate, solid, thickish rod, hooked inwards above.

The second arch is one fourth larger; but it has two parts—an epi- and a cerato-
branchial (c.br", e.br"), marked out by extensive ossification; as phalangiform bony bars,
united by cartilage; the upper segment is a little less than the lower.

Recapitulation of the Cranial Elements of Sieboldia, and Comparison with Menopoma.

As the description of the skull of Menopoma comes next, and as these two skulls

1 I am not sure that the segment here called "epihyal" does not answer to the "interhyal" of Fishes;
if so, then the styloid end of the "cerato-hyal a would be the non-segmented "epihyal."
differ rather in size than in form and parts, I shall anticipate what is said of the lesser skull in this comparison.

The whole series of investing bones are singularly alike in these two types; but in Sieboldia there is no small bony plate in the mid line in front, such as we see in Menopoma (Pl. XXXVIII. fig. 1).

In this large kind, in age, the premaxillaries are ankylosed to the maxillaries, the pterygoids to the quadrates, and the parasphenoid to the exoccipitals.

The shape of the skull is very similar; but the larger skull is very unsymmetrical, the right side being the larger of the two; the left vomer, however, is the larger bone.

In both, the palatines and vomers have recombined subsequent to the throwing off by the former of the bony pterygoid; in both that bone uses up all the proximal part of the pterygoid cartilage.

The columellae (pharyngo-hyals combined with the stapedial plates) are marvellously alike in both; but the left has coalesced with the suspensorium in the large kind.

The epihyals are free in Sieboldia, and confluent with the suspensorium in Menopoma; in the latter the three pairs of hypohyals and the basal piece are free; in the large kind the first and second hypohyals are confluent, right and left, with the basihyal.

This large kind and the Menopome come very close in their structure to the common Newt when its gills are almost gone; but whilst in the American species the gill-arches are all retained, and become more or less ossified, in this Japanese species the third and fourth are absorbed, and the first loses its upper segment, and remains unossified. I have no doubt that careful dissection of the larynx would show some rudiment or rudiments of the distal end of the second basibranchial; but I have only figured them as they existed in the Menopome (Pl. XXXIX. fig. 4, t. hy, lv). I had not the opportunity of dissecting these parts in the large kind. I may remark, however, that in old age that bar becomes largely absorbed in Triton cristatus (Pl. XLI. fig. 7); but some part of the end of the bar is generally retained in the Urodèles, whose "thyrohyal," as in birds, is made out of a median or azygous piece, and is not symmetrical as in the Anura.

It is worthy of remark that in this kind, as in the Menopome, the pterygoid cartilage is largely developed; it is arrested in Proteus, Siren, and Menobranchus, which resemble early larve of the "Caducibranchs;" and also that the broad proximal end is afterwards absorbed.

I call its remnant the "epipterygoid" cartilage, under the impression that this piece, enucleated, so to speak, in these types, breaks out again in the Lizard, and has all but an isthmus of its basal part suppressed in the Chelonia.¹

¹ See my paper on the Lacertian skull (Phil. Trans. 1879) and on the Chelonian skull (‘Challenger’ series, vol. i. pl. x.): in the Lizard it is a long, distinct rod of cartilage, subrect on the pterygoid bone; in the Turtle it is less erect, smaller, and hangs on the "pedicle" of the mandibular pier, from which it becomes segmented afterwards, when it ossifies. I begin to see the meaning of the remnants of the Ichthyopseidan suspensorium that break out again in the Sauropsida.
On the Skull of the adult Menopome.

This is a very flat skull, with the general outline semielliptical; the suspensoria form more than a right angle with the axis of the skull, and therefore are somewhat bent backwards. The narrowest part of the occipital ring and the condyles are alone behind the larger condyles of the suspensorium.

The maxillary margins reach more than halfway to those condyles; for these bones are well developed for a Urodele.

There are two tracts of teeth in both the skull and mandibles; the whole fore palate and maxillary region is nearly semicircular.

There are very large pterygoids; and these are far removed from their root, viz. the palatines; altogether this skull has undergone much more metamorphosis than the Eel-like types, viz. Proteus, Menobranchus, and resembles that of the young of an average "Caducibranch " when losing its gills.

The inferior arches are very large, and, instead of undergoing the metamorphic changes and loss of substance as in the higher forms, become strongly ossified, without any relative change of form or size; so that this type really belongs to the "Proteidea."

s. The Investing Bones of the Skull of the Menopome.

Roofing-plates of bone extend from the foramen magnum to the snout (Pl. XXXVIII. fig. 1); and flooring-bones extend from the edge of that passage up to the marginal bony arc (Pl. XXXVIII. fig. 2).

The hindmost of the upper series, the parietals (p), form, on the whole, an oblong tract, reaching from the foramen magnum to the ethmoidal region; they widen out over the auditory capsules, and are deficient on their inner edge in front, where the frontals (f) wedge themselves in.

Their dilated and raised temporal process has the two forks of the squamosal (sq.) locking into it obliquely; their inner part, alongside the sagittal suture, is somewhat roof-shaped, but scarcely amounts to a ridge; together they are only three fifths the width of the skull-floor. The obtusely angular and notched hind part of these bones only partially covers the widest part of the occipital cincture.

The frontals (f) are only half the size of the parietals; together they cover a Y-shaped tract; for these bones are narrow toothed wedges behind, whilst in front they widen somewhat, and are divaricated to let in the nasals (n), much more than the parietals did to take them in.

Their outturned fore end is overlapped by the round-edged ascending plate of the maxillaries (mx); and this part almost reaches the outer nostril (e.n). Here the nasal roof is exposed behind the passage as a pyriform tract of cartilage, whose point ends between the frontal and nasal.

The nasals (n) have a toothed suture between them, which continues the open sutural line along the low ridge of the skull; they also are wedges, broad in front and
pointed behind; and they fill in three fourths of the reentering angle between the frontals.

In front, the premaxillaries ($p_{x}$) do not repeat this, but the nasal process of each bone notches the corresponding nasal in its middle.

There is on each side a third outturned bone parallel with the fore part of the nasal and frontal, and articulating with the latter; this is the prefrontal or external ethmoidal plate ($p_{f}$). Each bone is an arcuato-oblong plate, four times as long as it is broad, with irregular edges, and articulating with the frontal within, with the parietal behind, and with the back of the ascending plate of the maxillary in front; the outer edge of the bone lies on the nasal roof ($n_{a}$), which appears outside it.

The likeness to a round arch which is seen in the upper view of the front of the skull is increased greatly by the presence of a small, round keystone between the broad premaxillaries ($p_{x}$); this is a median ethmoidal ossicle or prenasal bone ($p_{n}.l$), the true but azygous homologue of the pair of bones wedged in between the premaxillaries in _Siren_ (Pl. XXXVIII. fig. 3, _et n_).

The premaxillaries have a broad dentaor margin one third the extent of that of the large maxillaries (fig. 2); above they are scooped for the narial passage ($e_{n}$), they then send upwards a broad but sharp-pointed nasal process ($n_{p}.x$), which is let into the nasal; the _left_ is larger than the _right_. Between these thin plates the median nasal passage ($m_{n}.p$) is seen; in _Siren_ (fig. 3) it lies between the paired dermo-ethmoids.

The maxillaries ($m_{x}$) are large falcate bones with a rounded ascending blade running up the face; their pointed jugal process is opposite the foremost third of the orbital region, and extends some distance behind the broad nasal roof.

The broad lower edge is covered with a copious rasp of teeth, which extends nearly to the end of the bone, and corresponds in front with a similar growth on the palatal part of the premaxillaries; the upper surface of these bones is smooth and gently convex, the convexity running down from that of the prefrontal.

The squamosals ($s_{q}$) are roughly oblong bones with dilated ends. The upper end is bifurcate; but the lower fork, which runs backwards over the side of the auditory capsule, is short as compared with what is seen in _Menobranchus_ and _Proteus_.

The main lobe above runs obliquely outwards and forwards, and has a ribbed edge; from the hind fork an oblique ridge runs downwards to the lower end, which is angular; this lower part strongly clamps the quadrato bone ($q$), but it covers very little of the upper face of the suspensorium, distally, as compared with the squamosal of _Siren_.

The paraprosphenoid (fig. 2, _pa.s_) is more than equal to both the parietales, covering, as it does, the wider surface of the floor as compared with the roof. It reaches beyond the basioccipital synchondrosis as a round process; this, by a series of steps, gradually enlarges until the bone reaches its widest (basi-temporal) part under the foramen for the facial nerve (vii).
Under the orbital region the parasphenoid scarcely lessens its width; but in front, opposite the ethmo-palatine (e, pa), it narrows into a rounded but splintery end, which is covered by the vomers (v).

These latter bones (v) look larger than they are; for they are ankylosed to the palatines (pa); together these bones reach along two fifths of the inner edge of the maxillaries.

The vomero-palatine bones are separated from the marginal series by a curved fossa, which is nearly a quadrant; and their fore edge is covered with a second row of rasp-like teeth; but these are smaller than the outer row.

The two vomers are united by a harmony suture, and end behind as broad, splintery flaps, the right flap being the larger of the two. Behind the teeth they are roundly notched as if for the inner nostrils (i. u); but these are much further outwards, and a tract of the membranous nasal floor intervenes.

The palatines (pa) are so much of the compound bones as lie outside these notches; in front they bulge into the crescentic valley, and thus reveal their existence as additions to the vomer; they end as an ear-shaped lobe to each large bony tract.

The pterygoids (pg) which arose as medullous outgrowths of the palatines, are separated from them by a space larger than the latter bones; they are thickish, smooth, angular slabs of bone, whose main part is obliquely four-sided or lozenge-shaped, and from which there grow two large angular processes that look forwards, and one that grows far backwards. The inner process, in front, runs forwards, binding the parasphenoid and sphenethmoid, and ending where they end. The outer front process is not far from the jugal process of the maxillary, and carries the remnant of the pterygoid cartilage (e, pg). The hind process carries the inner arcuate edge of the bone backwards to the hinder margin of the quadrate condyle (q, c); this long, retral process clamps the quadrate bone inside as strongly as the squamosal does above.

The space between the two front processes has a gnawed edge, and the upper surface (fig. 1) is scooped, within for the optic nerve (11), and without for the pterygoid cartilage (e, pg).

Also along its upper part, postero-laterally, the pterygoid forms a solid scooped floor for the unossified proximal parts of the suspensorium (a. p, ot. p).

The mandibles together form three fourths of a very regular oval; and the dentaries (Pl. XXXIX. fig. 4, d) form a large part of each ramus; they reach very nearly to the angle behind. Their upper or dentigerous edge (Pl. XXXVIII. fig. 3, d, spl) is thick, and their infero-lateral surface is rounded; they meet at the chin by a broad surface.

The splenidals (spl) are also dentigerous; they are slenderer by far than the dentaries, do not reach so far forward, but go further backward, where they dilate and form a coronoid crest; for indeed they answer to both splenial and coronoid.

The articulars (ar) are properly ectostean plates, and set up ossification in the cartilage; they are strongly wedged in between the other two bones.
b. The Endocranium of Menopoma.

Much of the inner skull can be traced from the outside, where it is not fairly covered by the outer bony plates; for a further elucidation of it the reader is referred to the similar skull of the larva of Triton (Pl. XL.).

The foramen magnum (Pl. XXXVIII. fig. 1, f.m) is superior, triangular, and small; the occipital condyles (oc. c) are subpedunculate, large, wide apart, and oblique; their direction is inwards, downwards, and forwards, and their form oval.

The exoccipitals (e.o) can be seen to be distinct from the prootics (pr.o); they form the sides of the hourglass-shaped hind skull. In front, below, they reach almost to the foramen ovale (vb, st); above, they overlie it; below, on their sides, they are perforated for the ninth and tenth nerves (ix, x).

Between them, behind, there is a shallow transversely oval cup of cartilage, floored by the parasphenoid; this is for the odontoid rudiment of the first vertebra.

Outside the parasphenoid, below, the vestibule is exposed; and in the middle region the capsule is unossified; there is the large fenestra ovalis outside, with the compound columella (p.hy, st), and a little further forward the passage for the facial nerve (vii); this nerve is seen riding over the columella; the stapedial portion of this organ is an oval disk of bone (st) with a cup-like process for the stem or "medio-stapedial."

Above (fig. 1, pr.o) the prootic is exposed in the postorbital region; it crops up in front of the temporal part of the parietal, and of the head of the squamosal (p.sq); it bounds the foramen ovale (v) inside and behind.

The fontanelle is covered above; and the great basal membranous space is floored below; the sides of the endocranium formed by the trabeculae are exposed above, all along the orbital region, and below, between the parasphenoid and pterygoid in front.

Most of this basilateral tract is ossified as the "sphenethmoid" (sp.e). It is separated from the prootic, behind, by the ascending process (a.p); and in front it reaches to the ethmo-palatine (e.p.a).

At its hinder third this bone is perforated and grooved by the optic nerve (ii), which also forms a channel in the pterygoid. The unossified cornua trabeculae are very broad; they and their internasal conjugation are hidden by the investing bones.

The nasal roofs (na) are very large and wide; and they have a considerable pyriform tract uncovered behind the nostrils (e.n), and appear, above, in the angular space between the prefrontals and maxillaries.

Below (fig. 2, i.n) the inner nostrils are seen to be very large, oval, oblique spaces, seven or eight times as large as the outer.

c. The Lower Arches of the Menopome.

Behind the nasal roof, and confluent with it externally, and then separated by a

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1 Wiedersheim (op. cit. pl. ii. figs. 24, 25) shows that the large hollow nasal pouches are quite confluent with the cornua trabeculae; in front there is a large round notch of greater extent than the confluent part.
crescentic space, we see a broad elbowed tract of cartilage; this is the ethmo-palatine (e.pa); it arises from the trabecula, where it has grown into the ethmoidal wing; with this wing the palatine cartilage is confluent. In Siren (Pl. XXXIX. figs. 3, 4) the homologous cartilage is quite separate, both from the nasal roof and from the ethmoid.

The suspensorium is a very massive and complex structure; it is partly ossified, and to some extent confluent with the next arch, and also at three points with the endocranium. The pedicle (fig. 1, pd) passes into the basis cranii above the angle formed by the divergence of the pterygoid and parasphenoid (fig. 2, pg, pa.s); the ascending process (fig. 1, a.p) passes into the "alisphenoidal" wall in front of the foramen ovale (v); outside that foramen, at a distance equal to its height, the otic process (ot.p) has become confluent with the auditory capsule in front of the middle of the squamosal (sq). The body of the suspensorium is narrow at that part, and then expands greatly below; its direction is mainly outwards, but also a little backwards and downwards; it is thickened behind; and this thick edge ends in a free process above.

The oblique subreniform condyle (q.c) is extremely large; its broad end is behind and a little within; above this condyle the fore part of the lower half of the bar is well ossified as a quadrate bone.

There was a large quasisymplectic cartilage growing from the fore margin of the suspensorium, viz. the pterygoid cartilage; this has been largely ossified by the pterygoid bone, and only a tongue-shaped piece is left in front; it looks outwards and lies in a groove in the bone; this is now a separated primordial "epipterygoid" (e.pg).

The articular part of the lower jaw (Pl. XXXVIII. fig. 4, ar, ar.c) is to some extent solid bone due to the grafting of the superficial "articulare" on the cartilage, which, however, persists inside the ramus. The condyle is oblique, sinuous, and subreniform.

The articular is only visible, below and within, up to the foramen for the nerves and nutrient vessels; it is wedged in between the large dentary and almost equally large splenial (d, spl).

The hyoid arch is composed, altogether, of six pairs of pieces and an odd one; there is on each side a pharyngohyal, an epihyal, a ceratothyal, and three hypohyals, these latter, right and left, being united by a small basihyal (Pl. XXXVIII. figs. 1, 2, and Pl. XXXIX. figs. 4, 5).

The pharyngohyal element (p.hy) is for the first time in the vertebrate series used as a "mediostapedial"; it is shaped like a small bell-flower, being dilated into the campanulate form, distally; this broad end is set against the hind margin of the squamosal (sq). Behind and above its narrow rounded end (apex) is enclosed in a calyx of bone derived from the discoidal ossified stapes (st); the cup for the mediostapedial cartilage is an oblique outgrowth from the fore part of the disk.

Between the mediostapedial and the small fork of the squamosal (Pl. XXXIX.
fig. 5, sq, p.hy, st, vii) the facial nerve emerges, riding on the unossified part of this new auditory element.

The second or “epihyal” element (e.hy), is not specialized for auditory purposes like the first piece; it is a pyriform lobe of cartilage, one half larger than the pharyngohyal element, but flatter; its narrow end is free above, and is close behind the projecting end of the ribbed lobe of the suspensorium; with this part it has coalesced, except at its ends.

This part is found in the “hypo-suspensorial ligament;” the upper piece is found in the “suspenso-stapedial.”

The next piece, the ceratohyal (Pl. XXXIX. fig. 4, c.hy), is larger than the mandibular ramus; it is flat, but of great solidity; it is bent below the upper third into an elbow, with a very obtuse angle; and the part above is ossified like a flattish phalangeal bone; the apex (st.h) is soft. The lowermost flattened part is very dilated, and ends in a sigmoid condyle, to which is articulated the largest and smallest hypohyal (h.hy', h.hy²). The former is outside the lesser piece; it is a suboval plate; the lesser piece is finger-shaped with a scooped base. Attached to the largest, at its distal end, is the middlesized piece (h.hy³); it is reniform in outline, and by its more rounded end meets its fellow of the opposite side; its “hilus” is behind. In a small space between these two the basihyal (b.hy) is articulated: it is nail-shaped; and the head is the articular part. Contrary to rule, through the overgrowth of the arch, this conjugating piece is thrust behind the junction of the two sides of the arch.

There are four pairs of branchial arches, lessening in size from before backwards. The first of them (Pl. XXXIX. fig. 4) is very similar to the ceratohyal; it is almost as long, but only half the width, and is segmented into an epi- and a cerato-branchial (e.br¹, c.br¹); the upper part is the larger, and is bent backwards into an obtuse “elbow,” where, as in the ceratohyal, its lower two fifths is ossified. Articulating with this part is the ceratobranchial, which is unossified, and is a somewhat flattened rod, separated from its fellow below by the second basibranchial lobe (b.br³).

The second branchial arch is nearly as large as the first; but both its pieces are ossified, all but their ends, as phalangiform rods, which are very thick and round where they meet (e.br², c.br²); the lower piece is almost straight, the upper is gently curved, with the convexity forwards. The third epibranchial (e.br³) is nearly as large as the second, of the same shape, and equally ossified; but its ceratobranchial piece is a mere nucleus of cartilage (c.br³) attached behind the joint of the second arch.

The fourth arch (e.br⁴) is only a small epibranchial, half the size of the one in front of it, and only ossified for two fifths of its extent. The second ceratobranchial carries all the three upper parts (e.br²-⁴) and the rudimentary third ceratobranchial (c.br⁴).

The basal pieces are reduced to one very large plate and the rudiment of a second;

¹ In the “Anura” the counterpart of this small keystone is a mere binding tract of simple cartilage, not nearly as large as the ends of the two bars which it fastens together.
the main part (Pl. XXXIX. fig. 4, b.br\textsuperscript{1}) is half the width of the interspace of the mandibular rami, and is inversely heart-shaped, with a notched narrow as well as a broad end.

The hinder notch on the broad end is filled in with a small thick block of cartilage, the rudimentary second basibranchial (b.br\textsuperscript{2}); it has a convex fore margin; but its sides and end are concave; with its sides the narrow rounded ends of the first ceratohyals articulate.

There is behind this part no cartilage along the mid line until we come to the larynx (lx). I am satisfied, however, from the study of other species that a basibranchial has been absorbed, all but its fore part and its posterior horns (see in the larval Triton, Pl. XL. fig. 5, b.br\textsuperscript{2}). The two small rods (Pl. XXXIX. fig. 4, t.hy) are apparently the thyrohyals, or modified remnants of the last retral basibranchial.

In Siren this retral part is retained (Pl. XXXIX. fig. 3, b.br\textsuperscript{2}); and so it is in Proteus and Menobranus (Phil. Trans. 1877, pl. 28. fig. 1, b.br\textsuperscript{2}, and Proc. Zool. Soc. 1874, March 17, pl. xxix. fig. 1, and pl. xxx. fig. 2, B.b\textsuperscript{2}).

d. Summary of Characters of the Menopome's Skull.

1. The breadth of the skull and the roundness of its general outline, except behind, is noticeable; this is combined with great flatness.
2. The subpedunculate, large occipital condyles, with the intermediate scooped part for the "odontoid rudiment."
3. The large and perfect tract of cartilage between the exoccipitals and prootics.
4. The large size of the nasal roofs and the confluent ethmo-palatines, and the arrest of the axis between the nasal capsules, so that there is no projecting prenasal, the nasal capsules projecting beyond the septum.
5. This skull agrees with those of Menobranus, Siren, and Cryptobranchus in having all the three heads of the suspensorium confluent with the skull.
6. The ethmo-palatine agrees with that of the more metamorphosed types in being confluent with both the trabecula and the nasal capsule.
7. The palatine bone, after giving off the pterygoid, coalesces with the vomer.
8. The pterygoid bone, after becoming free, grows to a great size, and ossifies most of the largely developed pterygoid cartilage.
9. There is a normal osseous centre in the quadrato region.
10. The splenial is very large, almost as long as the ramus.
11. The hyoid arch gives up its uppermost ("pharyngohyal") segment to the auditory apparatus to form a columnella by union with the stapes.
12. The epiphyal is confluent to some degree with the back of the suspensorium, and is not a functional extrastapedial.
13. The ceratohyal is half ossified above; there are three hypohyals and a small retral basihyal.
14. There is a rudimentary ceratobranchial on the third arch; both parts are ossified in the second branchial; and all the epibranchials are more or less ossified.

15. The hind part of the second basibranchial is nearly all absorbed, distal rudiments only remaining as thyrohyals; the first basibranchial is a very large foliaceous cartilage, and is not distinct from the rudiment of the second.

16. There is a prenasal bone.

E. Comparison of the Skull of Menopoma with that of Onychodactylus.

In this small Japanese Salamander (see my second memoir on the Urodelas Skull, recently published in the 'Linnean Transactions') the skull is arrested at a very similar stage to that of the gigantic kind, and of the Menopome, and corresponds very closely with that of the Newt during metamorphosis (Pl. XL. figs. 5-7). What I have just remarked as to the formation of the "thyrohyals" will be clearly elucidated by reference to my figures of these parts in Onychodactylus (op. cit. pl. xix. fig. 3, b.br).

Siren lacertina.

a. Young specimen, 13½ inches long.
b. Adult, 18 inches long.

The skull of Siren resembles that of the other Eel-like Urodela, viz. Proteus, Amphiuma, and Menobranchus, but differs from each and all of these in several curious particulars. It is flat; and its general outline forms three fifths of a long ellipse.

a. The Investing Bones of the Skull.

The parietals (Pl. XXXVIII. fig. 5, and Pl. XXXIX. fig. 1, p) are relatively very large; they extend from the line of junction of the occipital and auditory territories behind, to the line of junction of the ethmoid and septal regions in front.

These bones are gently emarginate at all the parts of their external border; and each bone is produced externally into three projections. The first of these is gently hooked outwards, and lies over the sharp epiotic horn (ep); the next is a short triangle, it lies on the prootic region (pr.o), between the orbit and the shallow temporal valley; and the third binds on the limited ethmoidal wing of the trabecula (tr).

The hinder margin of each bone is also gently emarginate; the two bones meet, and have their edge scooped for muscular attachment, close over the front of the narrow occipital ring.

The sagittal suture is open, and is a little longer than the frontal; the parietals run on and form the outer half of the roof, parallel with, and as far as the frontal suture is exposed; they do not, however, cover the endocranium (sp.e) perfectly, but leave a considerable part naked, just as they do over the auditory capsules behind.

The frontals (f) are only half the size of the parietals; they wedge in between those
bones for half their length; and two fifths of the frontals are between the fore half of
the parietals.

They are overlapped by two pairs of bones in front (px, et.n); yet their fore part,
narrowing in, reaches nearly to the point of the nasal sacs.

These two pairs of bones, the frontals and parietals, form a shallow, sloping, but a
scarcely crested roof; the latter rise most in the fore part of the sagittal suture
(Pl. XXXIX. fig. 1, p).

The median suture is continuous from the occipital ring to the premaxillary edge;
two submesial bones finish this suture in front; they are two thirds the size of the
frontals, are oblong, have rounded ends in front, and are styliform behind, where
they are intercalated with the frontals, and repeat the imbrication of those bones
on and between the parietals.

The right bone is the larger of the two. In the middle of their suture there is a
small round passage, like the "parietal fontanelle" of a Lizard; this is the "middle
nasal passage" (m. n. p). These bones lie inside the nasal processes of the premaxillaries
(px), and far from the rudimentary nasal roof (na); they are not the nasals, which I
do not find in this species, but correspond to the two long, narrow, superethmoidal
splints of the Pike (Huxley, Elem. Comp. Anat. p. 168, fig. 69, s). Similar bones acquire
an immense length in Lepidosteus. They are represented by a single piece in a large
number of types above and below the Urodeles (e.g. Clarias, Salmo, Iguana, &c.), and
are simply "dermo-ethmoids."

Embracing these bones, we see another pair of bones more than half as large,
hooking round and close to their foremost two thirds, and appearing as small elliptical
plates, which are covered with horn, and have no teeth, on the lower surface
(Pl. XXXVIII. figs. 5, 6, px); these are the premaxillaries—symmetrical, but feebly
developed bones. These bones meet in front, bending round the superethmoidal
plates; and this front part, with its fellow, forms an arcuate tract below. The max-
illaries (mx) are small seed-like centres opposite the middle of the premaxillaries.

Another lateral bone is seen behind; this is the squamosal (sq), a falciiform bone
with its point behind and above clamping the epiotic "horn," and discoid below, where
it has taken on the form of the suspensorium, the articular region of which is dilated like
a snail's foot. This is a very simple subcutaneous scale, very much like a preopercular,
but bent in the opposite direction, and modified by the curious distal dilatation; it has
no posterior process like that seen in the Menopome (Pl. XXXVIII. fig. 1, sq, and
Pl. XXXIX. figs. 5, 6, sq).

Beneath, the endocranium is almost completely floored by the parasphenoid (pa.s); here this bone attains almost its greatest relative size, but it confines itself to the basis
cranii; it is longer, relatively, in the Sturgeon, where it runs under the fore part of
the spine.

In the lower view (Pl. XXXVIII. fig. 6, pa.s) this bone is seen to be a large slab,
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gently convex, smooth, and of moderate thickness; it reaches nearly to the foramen magnum (f. m), is rounded, leaves the occipitals uncovered, and widens in a leafy, lobate manner up to the fore edge of the auditory capsule. Its margin then is cut away in a concave manner, and is less by one third; in the orbital region it completely floors the endocranium, enlarging gently up to the aliethmoid (tr). The bone then loses another third of its (greatest) breadth, lessens still more forwards, and then ends in a rounded manner close behind the decurved processes of the premaxillaries. The narrowing of the parabasinal in front is sufficient to show the edge of the premaxillaries in the under view (Pl. XXXVIII. fig. 6, px, pa.s).

The next bony plates on the inferior face of the skull are the vomers (Pl. XXXVIII. fig. 6, and Pl. XXXIX. fig. 1, v), to which are attached the arrested palatines (pa). These two pairs of bones are in a very rudimentary condition, being an oblique bony tract uniting into one series the anterior palate teeth, and having the hinder fourth segmented off as a palatine rudiment, just as in the embryos of the higher Urodeles or "Caducibranchiata" (see Pl. XL. fig. 1, v, pa).

These vomero-palatine tracts are arranged as a loop or arch, unfinished in front at its crown, the two tracts being united by a short ligament; the fore end is narrow, and the hinder end broad; and each tract is sigmoid, and is covered beneath by ten or twelve sigmoid rows of long, sharp, recurved teeth (Pl. XXXVIII. fig. 6, and Pl. XXXIX. fig. 1).

About three of these rows belong to the palatines (behind), and the rest to the vomers; where the palatines and vomers unite there is the inner outline of the internal nostril; this dentigerous structure is extremely elegant on account of the regularity and curve of the rows. The paired bones are curved in a sigmoid manner, so that each row repeats the same curve on a smaller scale; it has all the beauty of a doubly compound leaf."1

The investing bones of the lower jaw are remarkable, the dentary (d) forming half the mass of the jaw, and covered with horn at its dentary edge, whilst the splenial, which carries teeth, is very small.

Like the upper jaw the lower jaw is much decurved; it is very large and massive. The dentary (Pl. XXXIX. figs. 1, 3, d) is very thick and solid where it meets its fellow, to which it is joined by strong ligamentous fibres; it becomes double its front height in the middle; and this "coronoid" crest is so far forward as to be below, the ethmopalatine cartilage (e, pa).

1 The Siren is very instructive in several respects; but the fact of its having the outer dental line covered with horn, whilst the inner only carries vomero-palatine, and, as we shall see, splenial teeth, is like a mixture of the Tadpole and the adult Frog in one type. It may be noted that the inner or submarginal line, in cases where there are two or more rows of teeth, as in Lepidosteus, may carry the largest of those organs. As an exceptional type in its own group it may be compared to the larva of Dactylethra and Pipa, where, contrary to the rule of their Order, there is no suctorial mouth covered with horn.

2 & 2
The dentary lessens again irregularly, and ends below the hind part of the articular condyle (ar. c).

Above (fig. 3, d) it has a clear, sharpish, cultrate edge, after the horny sheath has been removed, and then a wide scooped tract up to the coronoid crest.

The splenial (spl) is about three fifths the length of the fore half of the dentary, and is equidistant from the ends of that region; it lies over the Meckelian rod (mk), between it and the dentary, and is a very delicate, styliform, dentigerous splint. The other bone of the mandible is ectosteal; it is wrongly called “angulare” by Professor Huxley in his short but excellent description of this skull in the ‘Encyclopædia Britannica’ (Art. Amphibia, p. 758); it is the superficial part of the true “articulare.”

b. The Endocranium of Siren lacertina.

I have figured the endocranium, cleared of the investing bones, shown from above (Pl. XXXIX. fig. 2), in the lesser specimen; this structure also can be seen as showing through the paraspheoid below (Pl. XXXVIII. fig. 6), partly above (fig. 5), and in the side view (Pl. XXXIX. fig. 1); these are from dissections of the larger specimen.

The occipital condyles (oc. c) are large, reniform, obliquely turned inwards and forwards towards the mid line, and are separated from each other by a space half their own width; their aspect is thus inwards and backwards, and it is also downwards.

The moieties of the basal plate (Pl. XXXIX. fig. 2,) are united behind by a small isthmus in the younger specimen, but are distinct in the larger (Pl. XXXVIII. fig. 4).

In both the hinder parachordal tracts in the floor of the skull are represented by a thin, sharp selvage to the auditory capsules, but they run under the capsules and appear in front of them; the basal plate extends outwards to the fenestra ovalis (vb, st) as a thin underlayer. A wide heart-shaped “posterior basicranial fontanelle” (p. b.o. f) exists devoid of cartilage (but floored by the paraspheoid) from the foramen magnum (f; m) to the “posterior clinoid band” formed by the fusion of the apices of the trabeculae (a. tr), from which the notochord has retired (see embryonic skull of Lissotriton, Pl. XL. fig. 1, tr, ne). This narrowish band is curved backwards; and its fore edge forms the hinder boundary of the great front basal fontanelle, the so-called “pituitary space,” which reaches to the junction of the ethmoidal and septal regions.

Above, the superoccipital region (oc. r) is represented by a tract of cartilage shaped like a quadrant; the exoccipitals (e.o) nearly meet behind this tract, which perfects the occipital arch above.

The moieties of the endocranium are united in the adult by this upper band, by the clinoid belt below, and by the internasal (“intertrabecular”) wedge in front; in the young we get a fourth point of conjugation, viz. the basioccipital (Pl. XXXIX. fig. 2).

The hind skull, formed by union of the two pairs of basal plates (parachordals and
trabeculae) with the auditory capsules, is largely ossified by continuous (probably primarily) prootic-occipital centres (pr.o, e.o); these show division below but not above. Below, even in the larger specimen (Pl. XXXVIII. fig. 6), the middle third of the capsule is cartilaginous; this cartilage can be traced along inwards and forwards into the clinoid band, across, and into the side wall, lengthwise, as far as midway between the optic and trigeminal nerves (11, v).

Above, even in the young (Pl. XXXIX. fig. 2), there is only one bone right and left (pr.o, e.o); and this extends from the occipital condyles to the otic and ascending processes (ot.p, a.p), in which it ends as a broad plate, looking forwards and a little outwards. The square part which runs into the otic process, and the rounded growth of bone which runs into the ascending process, are connected by a narrowish belt of bone which forms the fore boundary of a pyriform cavity, partly covered in by a process from the outer tract of bone; this cavity, which runs into the auditory capsule, ends behind in a sigmoid slit, which turns inwards and then a little outwards, following the outer margin of the eminence caused by the anterior canal (a.s.c). It is bounded outside by the horizontal canal (h.s.c) in the same manner. This is the “aëeductus vestibuli (aq.v),” and is to be seen again in Polyodon (see Bridge, Phil. Trans. 1878, pl. liv.); it is the original auditory involution left unclosed in the capsule.

The auditory capsule sends out a double horn on each side; these projections are falcate, and have their convexity looking inwards and backwards, like the parietal bones in the Lacertilia.

These two pairs of projections, the outturned occipital condyles, and the parietal bones have all the same contour, and are all parallel with one another; the pedunculate stapes (st) adds a fifth to these postero-lateral wings of the skull, the whole form of which, from end to end, is that of a flat, subtriangular axis growing out in all directions into spines and leafy growths.

The stapes (st) is pyriform, and ends in a flat notched lobe, which may be an additional part that has coalesced with it, a pharyngohyal.

The upper and lesser wing of the auditory capsule is the epiotic projection (ep); it is bound down by the parietal horn and the sharp apex of the squamosal (p, sq); the lower, larger, and outer horn is the “pterotic” projection, a part very large in fishes, and well seen in some large American Frogs (e), Rana pipiens, Cystignathus ocellatus.

Leaving out for the present the roots of the suspensorium (a.p, pd, ot.p), we see a remarkable pair of postorbital projections (sp.o) growing in front of the prootic region (pr.o), but not ossified by it; they are between the ascending process (a.p) and the otic process (ot.p), and may be called the “preauditory horns.” These growths (as we shall see in the larva of Triton cristatus, Pl. XL.) are productions of the investing mass or hinder parachordals, and of the trabecular apices; for these oblique laminae, the hinder parachordals, wind round the front of the capsule, and appear in front of its
upper margin as wings of the posterior sphenoidal region; these are the unossified counterparts of the "sphenotics" of bony fishes, the roots of the "supraorbital bands."

"A ligamentous band passes from this projection to the eye-ball" (Huxley, op. cit.), which is very small, and is attached by this band to the anteorbital (e.pa); this band is a membranous "supraorbital."

Halfway between the ascending process and the optic passage (a.p, ii) the "sphen-ethmoid" bone (sp.e) begins; it is an ossification of the trabecula and its orbital crest, and therefore answers both to the orbitosphenoid and lateral ethmoid, and also to the primary half of the girdle-bone of those "Anura" which have an extension of bone into the orbitosphenoidal region, as in Dactylethra.

This ossification reaches in front of the ethmoidal region, and affects the hind part of the intertrabecula and cornu trabeculae (i.tr, c.tr); it meets its fellow below in the adult (Pl. XXXVIII.).

We have here, in bone, the simplest rudiment of the lateral ethmoid and cribriform plate of Man; for the olfactory nerves (i) are seen emerging obliquely from the cranial cavity, and escaping beneath and to the inside of the alithmoid (al.e), which answers to the roof of the "upper turbinal" of Man. These wings are straight-edged, look outwards and forwards, are not ossified to their end, and carry the rudimentary nasal roof (na) or "aliseptal" cartilages; these are ear-shaped, and cover only part of the nasal capsule.

Behind and below these wings another and rather smaller pair (tr) is seen; these are the flat hinges for the ethmo-palatine (ichthyic "palatine") cartilages (e.pa); they also are not ossified to their end.

In front of the sphenethmoid the endocranium forms a trifoliate structure: the outer "leaves" are the flattened, ear-shaped, outturned cornua trabeculae (c.tr); and the median part, which is thick and oval in the middle, ends in a rounded and papilliform "prenasal" projection (i.tr, p.n); this median process is seldom seen in the Urodeles, but occurs in Salamandra.

All the three terminal processes are decurved; both the upper and lower jaws are bent downwards, according to the primordial endocranial pattern.

c. The Visceral Arches of Siren lacertina.

Attached to the hinder and lower ethmoidal wings are a pair of pyriform cartilages less than the nasal roofs, and attached by their broad ends; these are the ethmo-palatines or true palatine elements (e.pa). These are separated by the whole orbital region from the piers of the mandibular arch (sp), which are very large cartilages, but have no quasi-symphletic outgrowth (pterygoid cartilage).

These latter, large, multilobate cartilages are complicated by the fusion with those of the pier of the hyoid arch (e.hy); they are totally unossified (unique in this respect), and retain the embryonic direction, which is forwards and outwards. The dorsal end of each
Development of the Skull in the Urodeles.

Suspensorium is bifurcate; and both the forks are confluent with the endocranium (the trabecula and its alisphenoidal crest). The part confluent with the base is the pedicle (pd); that which passes into the wall is the ascending process (a. p); outside these, above, we have the otic process (ot. p), which is confluent with the auditory capsule and the preaural horn. The body of the suspensorium (sp) is a suboval mass, set on the thick bifurcate stalk; the condyle (q.c) is subpentagonal, subconcave, and has its outer margin lower than the inner.

The suspensorium, having no pterygoid outgrowth, and no correlated pterygoid bone, is naked below; above it is covered up to the selvedge by the dilated squamosal (sq). The condyle of the articular (Pl. XXXIX. fig. 1, ar. c) is very high and convex externally, slopes inwards, has a subconvex lower surface, and is subpentagonal in outline.

The rest of the arch (Pl. XXXIX. fig. 3, mkl) is an undiminished Meckelian rod, lying in a trough formed by the dentary (d) outside, and the articular (ar) on the inside; the latter has a large angular process, and is but little grafted on the cartilage. The rods nearly meet at the chin, where the dentaries are very solid; the articular goes nearly as far as the cartilage. The splenial (spl) splices the rod for two thirds of its fore part, which is bent at an obtuse angle on the hinder part; this is the only dentigerous bone in the mandible, and is a very small oblong piece. The mandible is bent down at an obtuse angle from the point, where it rises into a considerable "coronoid process."

The notched, flat end of the stapes (st), whose general direction is outwards and backwards, is curved so as to pass into the hinder part of the broad suspensorio-stapedial ligament (s.s. l); this band widens forwards, and is attached to a lanceolate cartilage, half of whose anterior margin, above, is confluent with the suspensorium.

This cartilage is the epiphyal (e.hy.), and may answer to the extrastapedial and medio-stapedial in one piece, or possibly only to the former, the distal part of the stapes possibly having the "pharyngohyal" element fused with it, which part would correspond to the medio-stapedial.

Another broad ligamentous band ("hyosuspensorial" h.s. l) arises on the epiphyal cartilage (e.hy), and is inserted down the side of the front of the unossified upper part of the ceratothyal (c.hy); the seventh nerve (vii) passes over this cartilage and this band.

The hyoid bar is also connected with the angle of the lower jaw by the "mandibulo-hyoid ligament (m.h. l). This is a shorter band; and it passes inside the last, and is inserted in a fan-shaped manner on the outside of the middle of the cartilaginous tract.

This lower part (Pl. XXXIX. fig. 3, c.hy) of the hyoid arch is longer than, and nearly as thick as, the mandible; its lower half is ossified as a round phalangoid shaft, nearly to the end, whilst the upper half is a flatter and somewhat sigmoid tract; there is no separate hypohyal.

The basal bar is divided into two parts, of which the foremost is one third larger
than the other; it is dilated at its fore end into a subcircular disk; and this part represents, but is not segmented off as, a basihyal (b.hy). The bony shaft leaves a large crescent unossified in front, but very little behind (b.br').

The second (b.br") bar is much slenderer, and at its middle divides into three flat lobes, which are somewhat dilated at their free ends. The ceratohyals articulate with the dilated end of the first basal piece; this is suddenly narrow and compressed; it then broadens and is depressed. To this part the first branchial arch is articulated (c.br'); there is no joint in this; but the upper part, or epibranchial (e.br'), is left unossified; this is broad and falcate. The ossified part, nearly half, is a rounded phalangoid shaft of bone, the cerato-branchial (c.br').

The second cerato-branchial (c.br") is of the same length as the first, but slenderer; it is not so much ossified distally; this bone carries the falcate epibranchial (e.br") and is articulated to the middle of its dilated lower end.

No more ceratobranchials exist; but the second carries on the hinder pier of its distal end, a third epibranchial (e.br") also falcate, but smaller; then in turn comes the fourth (e.br"), still smaller and falcate, but bent in the opposite direction.

d. The Cranial Nerves of Siren lacertina.

I have figured most of the cranial nerves—not the third, fourth, or sixth. Their relations to the cranium are exactly as in Menobranchus. (See Huxley, P. Z. S. Mar. 17th, 1874).

I have already spoken of the olfactory nerves (i) which pass obliquely through the sphenethmoid (Pl. XXXIX. figs. 1, 2) to the partially roofed nasal sac.

The optic nerves (ii) pass out through a foramen near the end of the sphenethmoid; this passage is twice the diameter of the small nerve, but is not a large fenestra as in the Anura.

The trigeminal nerve (v) sends its orbito-nasal branch (v') under the ascending process; and the root of the second and third branches (v", v"") passes over the pedicle outside that process; the facial nerve (vii) winds round between the capsule and its parachordal plaster; near its root it sends forward the "vidian branch" (vii'), which runs outside and a little below the orbito-nasal to the front of the face, and whilst its main trunk (vii) passes out over the epiphal and hyosuspensorial ligament.

The glosso-pharyngeal and vagus (ix, x) pass out of a common passage in the exoccipital; I do not see a dividing bar in this foramen, such as exists in most of the "Anura."

e. Characters peculiar to the Siren's Skull.

The skull of this type comes nearest to that of Proteus, Menobranchus, and Amphiura in general form, and to the larval skulls of the species of Spelerpes; yet the larval skull of Triton is more like it in some important structures, leaving out the mere form (Pl. XL. figs. 2, 3).
1. In the first place, the horny sheaths to the edentulous jaws (the submarginal bones only, above and below, bearing teeth) make this skull unique as that of a "Urodele."

2. The peculiar form of the hind skull, throwing out falcate horns right and left.

3. The reappearance of the ichthyic paired dermo-ethmoids, and the suppression of the true nasals, the nasal roofs being arrested.

4. As a correlate of these submesial bones, the external position of the nasal processes of the premaxillaries, which are thrust apart by these bony wedges. Here the small maxillaries, as in the Siluroid fishes, are both present; they are symmetrical.

5. The preauditory spike coming up from the parachordal plate.

6. The short, dilated, unossified suspensorium, and the dilatation of the lower end of the squamosal as moulded upon it.

7. The confluence of an epihyal with the suspensorium, and the enlargement of the stapes by the addition of a flat stalk, possibly a confluent "pharyngohyal."

8. The arrest of the vomero-palatine bones, their sigmoid form, their elegant sigmoid rows of long hooked teeth, and the entire suppression of the cartilaginous and bony pterygoids.

9. The presence of a definite prenasal cartilage.

10. Besides the horny sheath and suppressed dentary teeth, the height, size, and curve of the mandible, with its very large condyle to fit into the equally large scooped facet of the quadrato.

11. The large size of the ceratohyals, and the absence of hypohyal segments.

12. The basihyal dilatation of the first basal piece, which carries the large first branchial; and the flat trifurcate form of the second basal piece, the proximal end of which carries the second ceratobranchial, which in turn carries the third and fourth arrested branchial arches.

These twelve characters show how important a type of skull this is, and how very isolated this kind of Urodele is in its own order; also it may be pointed out that if the larva of a type so far removed from Siren as Triton has some important characters in common with it, and which explain it better than any thing found in the other "Proteidea," the "lacunae" in this group of Amphibians must be very large indeed.

On the Skull of the native Species of Newts.

A. Chondrocranium of Larva of Smooth Newt (Lissotriton punctatus), \(\frac{1}{3}\) inch long.

In this early stage (Pl. XL. fig. 1) I have shown what parts were first hardened into hyaline cartilage; this may be compared with what has been already figured by Professor Huxley in Triton, and by myself in Siredon (Proc. Zool. Soc. 1874, pl. 3, and Phil. Trans. 1877, pl. 23).

From this small skull we learn that the trabeculae in their hinder and more solid
part are parachordal, and that their prochordal part is, as Rathke long ago asserted with regard to the Snake, a production forward of their parachordal or main part.

The large cranial part of the notochord is embedded, like a Belemnite, in the basis crani; and on its sides, in the cranial region, there are two muscle-plates (my); the third pair of plates in the figure (my') are spinal.

The hinder part of the cranial notochord (nc) has no investing cartilage, right and left; and all the rest of the cartilage, at present, belongs to the sense-capsules and the visceral arches.

The crested trabeculae (tr), at present, scarcely reach to the anteorbital region, and are only slightly curved inwards in front; for four fifths of their length they are prochordal; and at present they are rounded rods. The auditory capsules (au) are subglobular, and are already coated with a thin layer of cartilage; these balls are at a considerable distance from the hind part of the trabeculae; and the mass of cells forming the Gasserian and geniculate ganglia (v, vii) intervenes right and left.

In front of the capsule the suspensorium runs outwards from the middle of the trabecular curve, to which it is becoming fused; there is no division of the pedicle (pd) at present; but the otic process (ot.p) has already budded out, and is applying itself to the antero-external edge of the capsule.

The direction of the body of the suspensorium is outward and forward; and the condyle (q. c) is opposite the middle of the mid brain (c).

The mandibles (mk) are one third longer than the suspensoria; their articular part is rounded, and their distal end is narrow and almost pointed; the dentary (d) and splenial (spl) are already apparent; and the teeth on the latter are relatively large.

In front of the nasal capsules (ol) there is a transverse spicula of irregular bone carrying two teeth, this is the praemaxilla (pa).

Under the fore palate, within and behind the nasal sacs, there is on each side a spindle-shaped tract of irregular bone carrying a rasp of teeth. This tract is subdividing into two subequal pieces: the foremost is the rudiment of the vomer (v); the hinder tract is the palatine (pa).

In the figure the upper aspect of the head is shown, and the hind brain has been removed from over the notochord and muscle-plates; the pituitary body (py) is seen at the apex of the notochord; the eyeballs and earballs are of about the same size.

Behind the latter a mass of cells is seen; these are the rudiments of the ganglia of the ninth and tenth nerves, (ix, x).

Under the skull-floor a membranous film was becoming bony; this was the beginning of the parasphenoid. After this, very soon, bony tracts appear above the brain-cavity and outside the ear-capsules; these will be the frontals, parietals, and squamosals. The maxillaries are later in their appearance; and the very substance in which the endocranial bones form is not developed more than in rudiment.

I have not figured the postmandibular arches; they were becoming cartilaginous.
The Skull of the Larva of Triton cristatus, 2½ inches long, with branchia very large.

1. The Investing Bones.

The larval Newt is now truly representative of the "Proteidea." Its skull is not quite like that of any of the large "Perennibranchs," but is similar to and illustrates any or all of them.

The parietals (Pl. XL, fig. 2, p) are well developed; they reach back over the occipital roof (oc. r) to the middle of the auditory capsule, and stretch forwards, as narrow wall-plates, to the ethmoidal region; laterally each bone projects over the temporal region by a concave rounded process, which almost touches the squamosal—its normal supr-lateral correlate throughout the vertebrate series.

Narrowing in front of the scooped temporal wings, the parietals run forwards, getting less and less, and allowing the frontals to imbricate them in front and at the sides. The latter bones (f) together form an oval tract, narrow behind and broad in front; they do not reach the edge of the cranial wall, and end on the ethmoidal region, imbricated by the nasals and nasal processes of the premaxillary (n, n. px).

The nasals (u) lie outside those processes (n. px), and are long, thin, falcate bones, with their convexities inwards; they reach nearly to the front, and curve outwards behind, following the nasal roof (na).

The precocious premaxillary (px) is now a large bone, whose dentigerous margin (fig. 3) is a quadrant; the nasal processes, like the nasal bones, are long and falcate, and have their convexity inwards.

The diverging splintery hinder parts of these two processes are united by an isthmus of bone; in front of that bar there is an hourglass-shaped chink; the enlargement at the fore end is due to the presence of the "middle nasal passage" (m. n. p): see also fig. 3, where it is seen as an oval space in the palatine processes of the bone.

The maxillaries and prefrontals have not appeared as yet. The squamosals (sq) are hammer-shaped splints; the cochleate head is applied to the ear-capsule, and the styli-form handle to the postero-external edge of the suspensorium.

Below (fig. 3) the vomero-palatine tracts of bone have an incurved, hooked blade, and a flat dilating handle: most of the blade belongs to the vomer (v), now quite distinct; the rest is the palatine root of the palato-pterigoid bone (p. pg). These anterior parts are covered with recurved teeth. The shaft is narrowish at first, and then becomes subflabelliform, forming a rest for the fore edge of the suspensorium.

The parasphenoid (pa.s) is a large suboblong plate of bone, with gently concave upper, and convex lower surface; it is rounded behind, near the foramen magnum, angulate in the preauditory region, and has its sides first enlarging and then lessening just a little; but it is broad, and has a crescentic emargination in front, parallel with the internasal emargination, but ending at the hinder third of that tract.
b. The Endocranium of the same Larva of Triton cristatus.

This structure is very instructive, and is already very complete both in its general finish and in the development of the osseous centres.

The occipital condyles (oc. c) are large, oval, pedunculate, posterior, and somewhat interturned. The foramen magnum is directly posterior, and both above and below the skull has a large round notch between the projecting condyles; this is filled below by the large oblong "odontoid rudiment" (od. v).

That process is seen to be due to the development of a small intercalary vertebra (figs. 3, 4, od. v), the symmetrical parts of which are two small nodules of cartilage close to the edge of the basioccipital investing mass (vr').

The large space which the notochord runs through between the basis cranii and the first perfect vertebra (vr') is seen to be thus utilized; a new separate bony sheath is formed on the notochord at that part, in front of that which encloses the pith of the vertebra; and behind the cranial part this has already, in this larva, coalesced with the former.

This bony rod has the unossified lateral rudiments (fig. 4, iv') attached to its narrow fore part; they will be ossified from it afterwards; and thus the "odontoid" rudiment will become much broader.

The cartilage of the skull-floor has grown in front of the large cephalostyle (c.st); and a new tract of cartilage, now already confluent with the hinder or parachordal part of the trabecula, fills up the space as far as to the edge of the foramen magnum.

Through this unossified tract (tr, iv) the notochord (c.st) runs; the foremost larger half of it is invested with the foremost bony sheath, the apex of which in the retracted condition of the notochord lies behind the flat "postclinoïd" region, in which there is no "posterior basicranial fontanelle." Thus a vertebral rudiment breaks out in the fore part of the basioccipital region, a region which is related to the seventh (and eighth), ninth, and tenth nerves in these Ichthyopsida, and therefore not comparable to one vertebral (spinal) segment, but to a regional series of such segments.

The basicranial floor (fig. 5) is occupied by the large fontanelle from the postclinoïdal to the ethmoidal regions; it is shaped like a long egg, with the broad end foremost; its enclosure is formed entirely by the trabeculae.

The auditory capsules (av) are more oval and more oblique; they are turned outwards in front, and are now marked more evidently by the arched canals and bulbs of the membranous labyrinth within.

They have to be studied with the hinder skull; for they are floored by the parachordal cartilage, which runs outwards on each side as far as to the fenestra ovalis and stapes (st), and, creeping round under the fore part of the capsules, appear in front on the upper face of each capsule close behind the ascending processes of the suspensoria (fig. 2, a. p).
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These fore- and out-growing horns of cartilage—the "sphenotic" angles (sp.o)—are here nearly as largely developed as in Siren lacertina (Pls. XXXVIII., XXXIX.); they do not take the ossifying matter, but remain soft in front of the prootic bones (pr.o). The same thing occurs in the "Anura," but lower down in those types, where the shortened pedicle articulates with similar tracts ("basipterygoids").

From the cartilages of the occipital condyles, to the "horn" in front, the whole occipito-auditory tract is ossified above (fig. 2, e.o, pr.o); but below (fig. 3) only a crescentic tract of bone clasps the prootic and opisthotic regions; all the main part of the floor of the vestibule (vb), the stapes itself (st), and a narrowish tract of the tegmen tympani (t. ty) is unossified.

But up to the antero-internal edge of the fenestra ovalis the capsule has in all this part a second floor of cartilage from the wings of the investing mass (iv).

The stapes (st) is a large, oval plate, nearly half as large as the unossified vestibular floor; its direction is outwards and a little forwards; and the crescentic bony tract which reaches its fenestra behind is the homologue of that bar of the opisthotic which in the Sauropsida and Mammalia divides the fenestra ovalis from the fenestra rotunda.

The superocippital "tegmen" only stretches forwards to the middle of the auditory capsules; they, however, have a narrow selvedge of cartilage which runs forwards into the alisphenoidal wall (tr). The upper fontanelle runs from this part of the roof to the internasal tract; it is a long oval, pinched in somewhat in the postorbital region.

In the whole of the orbital region the inner skull is devoid of both roof and floor. Its sides are crescentic in section; for they grow inwards somewhat both above and below. From the ascending process of the suspensorium (a. p) to the anteorbital cartilage (e.pa) the wall on each side is ossified; these bones are the sphenethmoids (sp.e); they enclose an oblong skull-cavity, with only gently bulging sides; the optic nerves (see fig. 7, II) escape near the end of the wall-bones.

The internasal cartilage (i.n. e) is a flat plate with the outline of an hourglass, and it reaches halfway to the front margin of the face.

The large flabelliform cornua trabeculae (c. tr) which it binds together, enclose by their inner projections three fourths of a circle, bounded behind by the internasal band. The angles of these dilated cornua are rounded; the edge reaches from the palatine plate of the premaxillary to the internal nostril (i. n), a large, oval, oblique passage between the vomers and palatine on the inside, and the unossified membrane in the maxillary region on the outside (fig. 3).

Above (fig. 2, na), the nasal roofs are crescentic shells of cartilage, with their pointed horns looking forwards and inwards; the narrow nasal bones (n) only cover their inner horn.

Behind these cartilages, on the lower plane, the ear-shaped etbmo-palatines (e.pa) are
seen, confluent now with the trabaculae, but still distinct from the nasal roof, whose curve they follow.

The general direction of the suspensorium is outwards and forwards, forming an angle of 45° with the axis of the skull; it is a bilobate cartilage, with a small, square, bony centre in its distal part, close above the saddle-shaped condyle (q, q.c). The angle behind is rounded; it is the otic process (ot. p), which is wedged in between the tegminal edge of the auditory capsule and the squamosal.

The inner angle or proximal part ascends as a broad tongue of cartilage, which is confluent with the alisphenoid cartilage; this is the ascending process (a. p). It has a thick lobe underneath it, at a short distance from the trabecula; this is the pedicle, proper (pd), which is not confluent with the basis cranii; the part to which it articulated is an evident "basipterygoid" lobe. In the middle of the fore edge of the suspensorium a papilla of cartilage is seen in front of the "sphenotic horn;" this is the first appearance of the pterygoid cartilage (pg. c). This skull is now at a stage comparable to that of the adult Proteus, Menobranchus, and Siren. This cartilage, which appears here just before metamorphosis, is chondrified in the Frog simultaneously with the trabecula and the suspensorium.

c. Free Arches of a larger Larva of Triton cristatus, 2 inches 11 lines long.

These arches are from the largest larva of this species ever obtained by me; and it is well worthy of remark that in the next to be described, which was fast becoming cryptobranchiate, and which represents the permanent form of Sieboldia and Menopoma, the length was \( \frac{5}{4} \) of an inch less than this, the ripest form of the larva, as such.

Afterwards the creature grows again; but the metamorphosis is attended constantly, I believe, by at least a temporary diminution in the size of the animal.

The mandible of the larval Newt has for its axis a strong, arched, articulate Meckelian rod (fig. 5, ar. c, mk), which has a cylindroidal condyle, and then lessens gradually to its rounded end near the chin; it has a large dentary (d) and a small splenial (spl) investing it; and the articulare (ar) is now a large trough.

The epihyal is suppressed; the ceratohyal (c.hy) is very similar to Meckel's cartilage but is flatter, and its upper end is an elongated tongue and not a condyle. There is no separate basihyal segment; but the first basibranchial pushes between the cornua, which show no hypohyal segment.

The first and second branchial arches (fig. 5) have each a ceratobranchial segment, (c.br), half as long and half as wide as the epibranchial (e.br). These distal parts are like slender phalanges; the proximal segments are flat and falciform.

The series of four epibranchials (e.br) decrease in size backwards, each articulating with the hinder angle of the one before it; the first joins on to the two ceratobranchials, the second to the first epibranchial and its own ceratobranchial; and the two last have only the epibranchial attachments. The last carries no gills; the interspaces
of the arches are formed into a “colander” by interdigitating conical papillae of simple cartilage clothed with epithelium; in the larva of the “Anura” such processes grow into ridges, and become clothed with a rich tufted growth of true internal hypoblastic branchiae.

The basal pieces are two in number, and grow so far back behind their own proper arches as to suggest an ancestry for these types with a much greater number of branchial arches and a more complex “vagus” nerve.

The first piece \((b.br^1)\) is a thick, high bar, rounded and lessened in front, where it joins together the hyoid bars, thick where it joins the first ceratobranchials, and thin again where it conjugates the second ceratobranchials. Under its pointed end the second piece \((b.br^2)\) is articulated; it is a flat bar, becoming wider at the middle, and then fish-tailed at the end; the hinder three fifths is bony.

D. Comparison of the larval Newt’s Skull with that of other Types.

In some respects this skull is on a level with that of the lowest “Proteidea”—*Proteus, Menobranchus, Siren*; in others with more metamorphosed types, such as *Sieboldia* and *Menopoma*.

Like the larvae of some other “Caducibranchs,” e.g. *Spelerpes*, it shows well the formation of the “odontoid” rudiment; and it comes in conveniently to explain the “sphenotic” horn of *Siren*. It agrees with *Siredon*, and not with the Proteidea just mentioned, in having only the ascending process confluent with the endocranium, the lower lobe or “pedicle” proper being free, and articulating with an outgrowth of the basal plate, a parachordotrabeal growth.

This evident preauditory mass, which projects beyond the angle of the parasphenoid, is the counterpart of the cartilaginous facet for the shortened “pedicle” of the adult Frog, and of the postsphenoidal outgrowth (or “basipterygoid”) of *Lepidosteus*.

In each of these types the basis cranii grows out to meet a free pedicle—primarily free in this Urodele and in *Lepidosteus*, but secondarily free in the “Anura.”

Afterwards, as we ascend the scale, the pedicle is absorbed, more or less, and the otic process is developed at its expense; then the pterygoid bones acquire a cartilaginous facet and articulate with the basipterygoids.

Lastly, in Mammals we see these latter processes indifferently ali- or basi-sphenoidal, and having the pterygoid bones applied to them by a squamous suture without the intervention of cartilaginous plates to form a joint.

At present in this larva nearly half the endocranium has a finished floor; the short part in front is a *non-segmented intertrabeal tract*. That azygous element has its least development, and least distinctness, in the Urodeles.
Skull of a "Cryptobranchiate" Larva of Triton cristatus, 2½ inches long.

A. Investing Bones.

The superficial bones are very much larger and stronger in this larva, which has almost lost its gills; it is now in a state very nearly corresponding to that of the adult Sieboldia and Menopoma.

Lengthwise the roof-bones (Pl. XL, fig. 6, f.p) are not much more extended; but they are much broader, so as to overlie the walls well; and thus their form is a shorter oblong.

The fore part of the interorbital region was broader than the hinder; now the reverse is the case; the temporal angles of the parietals are still short and blunt.

On the antero-external angle of each frontal a small triangular bone is now seen close behind the nasal; this is the prefrontal (p.f). The nasals (n) are large crescents now, three or four times as broad as they were in the last stage.

The squamosals (sq) have now a more even breadth downwards, and are much more solid. The premaxillary (px) is much wider on its palatine aspect; and the bony falcate nasal processes (fig. 6, n.px) are broader, and their interspace is filled up under the fossa, in the fore half of the bone. There is a large maxillary (mx) on each side now; each bone is falcate, has an ascending process (fig. 6), and is as long as the median single premaxillary.

The broadly falcate vomers (fig. 7, v) cover more of the trabecular cornua (c. tr), have a more definite notch inside the inner nostril (i. n), and are now perfectly distinct from the palatines (pa). These latter bones are divided from the vomers by a subtransverse suture, and are now parallel with the axis of the skull, and are pointed behind; but they are relatively less than they were in the first stage (fig. 1, pa. v).

The reason of this is that the edentulous pterygoid part (pg) has become segmented off from the tooth-bearing palatine, and has retreated so far back that the fore edge is nearly under the middle of the orbital space.

It is now much broader and shorter than it was when continuous with the palatine; and its fore end has diverged out to some distance from the skull: it is turning outwards, whereas it was directed inwards. The form now is somewhat like the outline of an hourglass; but the hind part is much the broader, and now lines twice as much of the suspensorium; the fore end is ragged; the base is grooved above for a new process of cartilage (e.pg). The palatine bones are not ankylosed with the vomers, but the whole palate is Menopomine.

The parasphenoid (fig. 7, pa.s) is relatively larger. In front it nearly reaches to the fore margin of the intertrabecular notch (c. tr, i.n. c); behind it actually forms part of the foramen magnum (f. m); it has also developed outwards, forming the temporal angles.

None of the inner skull is seen outside it below; and the roof-bones overlap the endocranium above. The bones are altogether stronger and smoother.
THE ENDOCRANIA.

The chondrosteous endocranium is considerably altered; and the basal region is largely losing its cartilage and becoming membranous again, as in the first stage (figs. 1 & 7).

The foramen magnum (f. m) is supero-posterior, the occipital condyles (oc. c) postero-inferior; they also look obliquely inwards, and are pedunculate, with an interspace twice their own breadth for the "odontoid rudiment."

There is a broad superocipital tract of cartilage (oc. r) above, and a smaller tract below; but the ossified sheath of the notochord (c. st) is now coalescing with the upper face of the parasphenoid, and most of the parachordals and parachordal ends of the trabeculae have been absorbed (fig. 7, tr, iv). This is quite like what we see in the adult Proteus and Menobranchus.

On each side the bulbous auditory capsules and the narrow occipital moieties are well ossified from the condyles up to the "sphenotic" projections (sp.o).

Below (fig. 7, vb, st), the floor of the vestibule has in front of the fenestra ovalis an imperfect ring of cartilage, and the large, oval, outturned stapes is also unossified.

The sphenethmoidals (sp.e) have not spread much further fore and aft; but they form stronger walls to the interorbital region.

The trabecular cornua (c. tr), the enlarged nasal roofs (ua), and the ethmo-palatine appendages (ep. a) are now all coalesced together, exactly as in Sieboldia and Menopoma (Pls. XXXVI., XXXVII.). The notch between the cornua is larger; and the intertrabecular bridge (i. n. c) is slightly smaller; and these parts are much more hidden by the superficial bones, both above and below.

A tongue of cartilage has grown from the papilla on the suspensorium; this is the pterygoid foregrowth (e.pg): it has even now become less by yielding its substance to its bony pterygoid floor (pg), but is not cut off as a distinct "epipterygoid," as in Sieboldia and Menopoma (Pls. XXXVI., XXXVII.).

The quadrate bony centre (q) is larger; the rest of the visceral centres are but little altered since the larva was possessed of gills (Pl. XL. figs. 3–5).

c. Comparison of the Skull in the Cryptobranchiate Stages of Triton cristatus with that of other Urodeles.

I have already referred to the conformity of this semitransformed skull with that of the great Cryptobranchiate species, viz. Sieboldia and Menopoma: these three skulls agree marvellously, on the whole; but the epipterygoid is never cut off, even in the adult (Pl. XLI. figs. 1, 4, & 6, pg).

But we catch in this stage of Triton just that condition of the palatine after it has thrown off its new pterygoid limb, ready to become ankylosed to the vomer, from which it was once segmented as a tooth-carrying plate. The epiphyseal elements, however, are entirely suppressed in this kind, as they are in the majority of the Caducibranchs; the stapes also never ossifies in this type.

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As a Urodele, we shall see in the next stage (Pl. XLII.) that this species becomes a culminating type; as a Vertebrate it, in a sense, stands still, and even recedes; we must find another "sucker" before we shall see the blossoming of anything more perfect than the Menopome and the great Salamander show.

The Skull of the adult Triton cristatus.

A. Investing Bones.

The main part of the Newt's skull is nearly oblong, the sides only converging gently from behind forwards; a line drawn completely round it would be a very regular ovoid, the fore half a semiellipse, the hind half a semicircle.

The parietals and frontals (Pl. XLII. fig. 1, p.f) are large, dense, and permanently distinct; and the teeth of the sutures are few and very large. The sinuous hind margin of the dilated temporal part of the parietals does not hide the supraoccipital synchondrosis, nor cover the posterior canals (p.s.c). Each temporal wing has its sinuous outer margin parallel with the axis, and separated from the orbital part by a gently concave space.

There are four or five large sutural teeth on each side, strongly interlocked; and the fore margin of the parietals is hidden by the large "teeth" of the squamous coronal suture.

The frontals (f) have only two definite teeth, right and left, along the frontal suture; these bones are gently convex, oblong, and, in turn, covered by the "teeth" of the overlapping nasals.

The parietals and frontals (fig. 3, p.f) have a moderate orbital downgrowth, equal to the sphenethmoidal wall (sp.e). The nasals (n) are oblong, and are separated by the grooved nasal process of the premaxillary (n.px); their upper surface is convex and rugous, their edges dentate; the fore margin is obliquely notched, to make space antero-laterally for the nasal roof and apertures (na, e.n).

The squamosal (sq) is a strong wedge of bone; it articulates above and behind with the posterior angle of the parietal, bites into the top of the auditory capsule, has a transverse subapical ridge, which sends down from its middle a short crest and a nail-like preopercular process, which, in turn, binds down on the suspensorium as it runs downwards, outwards, and forwards; it overlies the edge of the suspensorium.

Outside the junction of the nasals and frontals there is a supero-lateral bone, the outer ethmoidal or prefrontal (p.f); it is subtriangular and convex, and is wedged in between the upper bones and the maxillary beneath (fig. 3, p.f); the prefrontal is perforated and grooved for the nerves and vessels of the fore face. The whole margin of the premaxillary (px) is now only three fifths as long as that of each maxillary (mx); its palatal face has a considerable breadth behind the marginal belt; its sides are sutured to the maxillaries, and its concave hind margin to the vomers (fig. 2, v).
Above, the nasal process (n.p.x) is large, and wedged in between the nasals; it is
grooved, and a hole behind the groove leads to a passage, the middle nasal passage
(m.n.p), which reappears between the vomers below.

The maxillaries (m.x) are large and falciform: their jugal process reaches three fifths
of the way towards the hinge of the quadrate (q.c); the upper edge articulates with
the lower edge of the nasals and prefrontals (n.p.f).

A small seed-shaped septo-maxillary (figs. 1 & 3, s.m.x) is seen in the narial opening
(e.n) on each side.

The dentary (d) forms full half of the mandible, and nearly reaches the angle behind
the splenial (spl), is very slender, but is more than half the length of the ramus.

The inferior bones form a very elegant floor to the skull; the vomero-palatines
(fig. 2, v.pd) are large trowels, which by their broad vomerine end fill all the fore palate
between the dilated processes of the premaxillary and maxillaries.

The middle nasal passage (m.n.p) is seen in the middle of the vomerine suture; the
internal nostrils (i.n) are half enclosed in a semicircular notch on each vomer.

The palatine portion of each bone (p.p) is a long, sharp style, reaching from the
inner nostril to the widening part of the parasphenoid behind, nearly to the foramina
ovalia (v).

These styles are very straight; their outer edge clamps the outer edge of the para-
osphenoid (p.s); and their inner edge is serrated with small recurved teeth.

The apex of the pterygoid bone (p.g) is now turned outwards, and nearly reaches the
jugal end of the maxillary; this point is far removed from the end of the “mecodont”
palatine, which, after throwing off this its pterygoid process, has grown a new process
parallel with the axis of the skull.

The pterygoid bone is also trowel-shaped; both ends are pointed; and the wide hinder
part is subpentagonal: this part clamps but does not quite cover the condyle of the
pedicle (figs. 2 & 6, p.d); and the “handle” carries the pterygoid cartilage (e.p.g), much
of which it has converted into bone. The pointed hinder end of the pterygoid bone
binds but does not cover the round papilliform otic process (o.t.p) of the suspensorium.

The parasphenoid (fig. 2, p.s) is a large bony scoop, whose bowl is placed behind as
a floor to the hind skull.

The orbito-nasal region of the bone is twice as long as the interauditory part; it is
oblong, rounded in front, and underlain by the vomero-palatines in front and at its
edges; and it has an oblong elevation all along the middle.

The hind part is subcircular, with dentate edges; it is subconvex below, with hol-
lowings towards the sides; above, on its intercranium surface, it has, coalesced with it,
the remains of the ossified “cephalostyle” of the notochord.

There is a general dilatation behind; but the basitormal wings do not project much,
and are at a considerable distance from the joint of the pedicle with the basipterygoid
condyle (fig. 6, p.d, b.p.g).
b. The Endocranium of the adult Newt.

The hinder and middle skull are thoroughly ossified; the fore part or nasal region is soft.

The two sides over the foramen magnum (fig. 4, f. m) are separated by a very narrow tract of cartilage; this part and the crescentic internasal band (i.n. c) are all that keep the two sides conjoined.

The reason of this is that the greater part of the second basicranial bands (parachordals) have been absorbed, and not only these later, but also much of the earlier bands; for the whole of the posterior or parachordal part of the trabecula (tr) has been absorbed also.

Hence there are now only two bones on each side, namely the occipito-auditory mass and the sphenethmoid (sp.e), the latter running along the whole extent of the orbital region, and only separated from the former by a small cartilaginous wedge (fig. 4, tr). Thus the shallow sella turcica and the faint and almost aborted bony cephalostyle are now to be seen on the upper surface of the parasphenoid, the superficial "sucedaneum" of the proper basis cranii.

The foramen magnum (f. m) is very large and obliquely supero-posterior; the arch over it narrows so as to have a very small keystone part of cartilage; at the base there is a wide semicircular emargination for the "odontoid rudiment."

The occipital condyles (oc. c) are obliquely inturned, subpedunculate, reniform, and postero-inferior; the arch itself is narrow, the posterior canal (p. s. c) running very near to the foramen magnum.

The three canals (a. s. c, p. s. c, p. s. c) are large and protuberant, the tegmen tympani (t. ty) scarcely overhanging the horizontal canal.

Cartilage is seen in two places besides the condyles; but only one of these parts belongs to the capsules; this is the stapes (st), which is oval, thick, and almost transversely placed.

The third part of cartilage belongs, like the condylar part, to the basal plate; this is the basipterygoid facet (fig. 6, b.pf), to which the bulbous pedicle (pd) is articulated. The facial nerve (vii) escapes on the inner side of this joint, the ninth and tenth (ix, x) pass out behind the opisthotic edge of the fenestra ovalis (st, vb). The vestibule in front of that opening forms a very elegant crescentic swelling, as much marked as the curved risings on the upper face of the capsule.

The trigeminal nerve (fig. 3, v) escapes at a part of the skull where cartilage still lingers, dividing the prootic from the sphenethmoid; the optic nerve (ii) escapes through a smallish passage in the hinder fourth of the latter bone.

A small anteorbital tract of cartilage in the trabecular wall is seen close behind the perforated prefrontal (sp.e, p.f); the orbitonasal passes through the perforation in the prefrontal. The nasal roofs (fig. 4, na) are nearly as large as the auditory capsules; they are broadly crescentic in form, being deeply notched outside. In this notch the nostrils (e. n) lie; they are wide apart, but not so wide apart as the inner openings
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(fig. 2, i. a). The ethmo-palatine cartilages (e.pa) have coalesced with their hinder margin below; and the palatine bones (pa) show no tendency to apply themselves to them, their proper endoskeletal correlates. The internasal cartilage (i.n. c) is now a narrow truncate band with its convex margin behind, and is much reduced from its former relative size. This retrograde metamorphosis is consonant with that of the parachordals and parachordal region of the trabeculae; at first there is no intertrabecular structure, and only the apices of the trabeculae run to the mid line; afterwards all the hind skull is floored, and a wide internasal band appears in front of the orbits; then, in the adult, the two halves of the endocranium are only held together by a narrow parachordal band behind, and a narrow intratrabecular band in front.

The direction of the suspensorium is what it was at the first, viz. forwards, as well as outwards and downwards; this is extremely unlike what we see in the Frog, where its direction is at first quite forwards, and then changes so as to be directed backwards very considerably.

Indeed the metamorphic range, even in the Caducibranchiate Urodeles, is very small as compared with that of the ordinary Anura: they do not spring from so low a root, by far, and they do not rise so high, by far, as the Frogs and their kindred.

The suspensorium, by its ascending process (fig. 6, a. p), retains its fusion with the alisphenoidal wall; but the pedicle proper (pd) is a bulbous condyle which rolls in the concavity of the basipterygoid plate (b.pg).

The otic process (ot, p) is a thick pedate mass of cartilage, continuous below with the main body of the cartilage, not affected by the quadrate bone (q), which runs forwards into the pterygoid cartilage (e.pg) a narrow filiform process.

c. The Free Arches of the adult Newt.

The hinge (q. c) is a reniform and convexo-concave condyle, corresponding with the sinuous condylar surface of the mandible (figs. 3, 3', ar. c); Meckel's cartilage is persistent; but the proximal part is considerably ossified by the embracing articular bone, in the trough of which it lies.

Only the ceratohyal (fig. 7, c.hy) is developed in the next arch; it is a spatulate bar, rounded above and ossified (more than halfway down); the rest is a flat pyriform region of cartilage, the narrow end of which is attached by a hypohyal ligament to the unossified end of the first basibranchial (b.br1), which alone represents the basihyal segment. This basibranchial (b.br1) is not segmented, but the hinder part of it is left unossified; the whole bar is a strong compressed rod.

The remnants of both the first and second branchial arches (e.br1, c.br1, c.br2) are attached to the soft part, the former to its middle and the latter to its end. The first bar has two, almost equal, ossified segments, and is large; the second arch is a feeble bar, bowed inwards and backwards, and is only composed of the ceratobranchial element (c.br2); it is fastened above to a spur on the lower end of the epibranchial of the first arch.
In the old individual which I have been describing, the whole of the second basis-branchial was absorbed; but in a younger specimen (fig. 7, *t.hy*) I found a spatulate rudiment in front of the larynx (*l.x*).

Recapitulation of the Characters of the Skull of the adult Newt.

As the Common Newt makes a convenient "norma" as a typical "Caducibranch," the characters of its skull may be profitably reenumerated.

A. Investing Bones.

1. The frontals and parietals are distinct, and retain the coarsely dentate frontal coronal and sagittal sutures, as well as the squamous and harmony sutures with the contiguous bones; each pair of bones forms a subequal square territory.

2. The nasals are very similar to the main roof-bones, they keep their distinctness from each other and from the neighbouring bones, cover a quadrangular region, and imbricate the frontals as the frontals imbricate the parietals; the nasals are separated by the nasal process of the premaxillary, as in Birds; the prefrontals are pyriform shells of bone perforated by the orbito-nasal nerve.

3. The trowel-shaped squamosals have, as in the Anura, an upper or temporal and a lower or preopercular region; they articulate, above, with the parietals.

4. The premaxillary is *azygous*; and the maxillaries are subequal: they have ascending and palatine processes; and the latter are a considerable distance from the quadrate, not joined to it by any intermediate bone, where they end in a jugal process; they are dentigerous.

5. The septo-maxillaries are small and seed-shaped.

6. The dilated vomers are confluent with the long styliform palatines; these carry teeth on their inner edge, each row running submesially ("mecodont") and on the basis cranii.

7. The pterygoids are rather small, with a pointed, outturned fore end; they behave as *ectostoses*, and do not remain as *parostoses* like the palatines from which they were segmented.

8. The parasphenoid is a very large, oblong bone, cochleate behind, where it has united (on its upper surface) with the bony cephalostyle; it reaches nearly all the way from the foramen magnum to the middle nasal passage.

9. Of the bony plates of the mandible the hindermost or articular is grafted on the cartilages; it is two thirds as long as the ramus; the splenial is small, and half as long; the dentary large, and runs only a little short of the angle; both the latter are dentigerous.

B. The Endocranium.

10. The hinder and middle parts of the skull are only slightly separated by cartilage; the fore part (ethmonasal) is unossified.
11. The occipital condyles are subpedunculate, and separated by a large notch for the "odontoid rudiment."

12. The halves of the endocranium are only united in front and behind by a very narrow tract of cartilage; most of the basal plate behind, both trabecular and parachordal, has been absorbed; but, right and left, cartilage is seen on the occipital condyles, the stapedial operculum, the basipterygoid facets, and in the alisphenoidal walls.

13. The unossified nasal roofs are wide apart, right and left; but they have coalesced with the cornua trabeculae and the ethmopalatines.

14. Besides its condyle, the suspensorium has much cartilage above; and its narrow pterygoid foregrowth is only partially incrusted into bone; it has no part severed from its root. It is confluent above; but the pedicle and otic process are free: the direction of the suspensorium is unchanged; it looks forwards as well as downwards and outwards.

15. Between the nasals above, and the vomers below, the "middle nasal passage" is permanently visible.

16. The articulo-Meckelian rod is only partially converted into bone, and that mostly on the upper part.

17. There is no epihyal or pharyngohyal element; therefore, as a correlate of the early closure of the tympanic (first) cleft, there is no columella attached to the stapes; and as there is no rudiment of a cochlea, there is no fenestra rotunda.

18. There are no hypohyals; the ceratohyals are large and ossified in the upper narrower part.

19. The branchial apparatus is reduced to a semiosseous first basibranchial; the second becomes entirely absorbed in old age—a first arch with an ossified epi- and cerato-branchial, and an unossified, shrunken, second cerato-branchial.

Many curious minor modifications take different places in "Caducibranchs," as I have shown in my papers in the 'Philosophical Transactions' (1877, pls. 21-29, pp. 529-507) and the 'Transactions' of the Linnean Society (new series, Zool. 1880).

But the most important modifications of the skull in this, the highest, division of the Urodeles have been described and figured by Wiedersheim in his invaluable works.

The Skull of the Adult Triton cristatus compared with other Types.

The skull of the Common Warty Newt, like that of our native Frog, serves well for a pattern to measure others by; it is more transformed than that of an adult Spotted Salamander, which retains a postclinoideal band of cartilage, and exceptionally, like Siren lacertina, has a prenasal rostrum.

Some types of the "Caducibranchs" have a small columella, as I have shown, viz. in Spelerpes and Desmognathus (see Trans. Linn. Soc. 1880, pls. 18, 20, 21); and others, as Ellipsoglossa nivia, Ranodon sibiricus, Desmognathus fuscus (Wiedersheim, op. cit. pl. 5), have, like Sieboldia, an epihyal rudiment confluent with the hinder margin of
the suspensorium; whilst one type, viz. *Ranodon sibiricus* (op. cit. pl. v. figs. 68–70), finishes its suborbital band by confluence of the pterygoid cartilage with the ethmo-palatine, a secondary condition answering to that which is primary in the “Anura.”

But the specialization of the Newt, as a typical metamorphosed Urodele, is quite as noticeable for what is left out as for what is developed: the presence of certain elements in other types is, in them, indicative of a somewhat generalized constitution.

The finished skull of the Newt is similar to and yet very different from that of the Common Frog: it is much more ossified, although smaller, has no cavum tympani, no columella, an open jugal space, but with the quadrate region well ossified intrinsically.

It keeps the main roof-bones distinct, has no postorbital process to the squamosal, whilst, after giving off a pterygoid bone, the palatine coalesces with the vomer, and, instead of applying itself to the ethmopalatine cartilage—its own endoskeletal counterpart—whilst that is transversely placed, the bone runs backwards at a right angle to it, reaching nearly to the auditory region.

Hence we see that under the outward likeness of these two small Amphibian skulls there lie hidden a number of the most remarkable contrasts; these contrasts, however, are not greater than those which exist in the primordial chondrocranium of the larvae of these types.

Passing from the “Elasmobranchs,” in which the placoid dermostoses are not brought under the influence of the slightly calcified chondroskeleton, to the “Ganoids,” in which the larger and more perfect dermal scutes are subjected, in the head and shoulders, to the organic attraction of the parts beneath, we perceive a great difference.

The scutes of the fore part of the animal are manifestly the “serial homologues” of those of the hind part; but in size, number, and form they are greatly changed; some have been selected for one purpose, and some for another.

The principal regions of the brain, the sense-capsules, the apparatus of the mouth, the hyobranchial arches—all these draw unto themselves such scutes as they need for protection, and for the finishing of the mechanism of the mobile arches.

Still many of the scutes are simply a repetition of those on the body, and only a certain number stand out as distinguished from the rest by their size, their form, and their relation to the deeper structures.

These are seized upon by the morphologist as representatives of the superficial bones that, in higher types, have been selected for various functions, that have been completely transformed in accordance with their new relations, and that in those higher forms lose their surface-layers and exist only as subcutaneous bony plates that often combine with the deeper skeletal structures to form the highly compounded skull.

If we make a stride, at once, from such a skull as that of *Lepidosteus* to such a skull
as that of the Newt, we shall find that only those scutes have been retained in the latter
that are always the most constant in the Vertebrata above the Ichthyopsida, altogether.

This fact is disclosed at once when we see that most of the surface-plates in the
Newt’s skull can, in a moment, be named by the same names that their representatives
have received in the highest Birds and in the highest Mammals.

These are they that were at first brought, in the Ganoid Fishes, under the influence
of the brain in its regions, of the sense-capsules right and left of the brain, and
of the apparatus and armature of the mouth.

We see, also, that the Newt has dropped (suppressed), even in its larval state,
the special scutes that protect and amplify the branchial apparatus in the Ganoid
and Osseous Fishes; these are here suppressed at once and for ever (with the slight
exception of a few parts that are retained for new functions) in every ascending branch
of the Great Vertebrate Life-tree.

A list of the superficial bones to be found in the Newt’s skull will seem to be rather
that of some growing Bird or Mammal. They are as follows:—

1, frontals; 2, parietals; 3, nasals; 4, squamosals; 5, premaxillary; 6, septo-
maxillaries (found in certain Birds); 7, maxillaries; 8, vomers; 9, palatines; 10,
pterygoids; 11, parasphenoids (existing in three pieces, early united, in the Bird, and
as two (hinder) ossicles—the “cornu sphenoidalina” in certain Mammals); 12,
dentaries (or mandibular rami); 13, splenials (constant in the Bird class).

In the endocranium the low, and perhaps archaic-selachian, origin of these forms
is indicated by the generalized nature of the truly bony tracts. In the Selachians we
only see the crowding of the superficial calcifications of the cartilaginous structure in
certain parts; here, in the Newt, calcification rapidly passes into ossification, but the
“centres” run riot over two or three morphological territories at once, and do not keep
to proper interneural spaces.

Yet, even thus, the nomenclature is not difficult; the terms merely have to be com-
pound, like the parts they stand for; the “sphenethmoid” is, for example, a bone
answering to the sphenoid and ethmoid of human anatomy.

I have compared Triton with Lepidosteus for the sake of illustration, and not as
seeking to derive the Newt from that or any such Ganoid Fish; I am not speaking of
actual genesis, but of the general order of the specialization of parts.

On the other hand, I am inclined to think that the Urodeles came up from types
that specialized their dermal scutes very sparingly, like the Lipidosiren; whose ancestors
(probably) had simple chondrocrania that had subjected the dermal armature to no
special modification.

Within the limits of this small contribution I have been able to show how remark-
ably the stages of a small high “Caducibranch” correspond with the permanent
condition of large and low types.

But if to this paper we add Dr. Wiedersheim’s invaluable memoirs, and the other
vol. xi.—part vi. No. 6.—January, 1882.
two papers by me which have appeared in the 'Transactions' of the Royal and Linnean Societies, we shall be able to make rather an extended comparison of the skulls of these interesting types.

But the description of the Perennibranchiata form of the Urodelous type of skull, which was given by Prof. Huxley a few years since in the 'Proceedings' of this Society (P. Z. S. Mar. 17, 1874), will for ever remain a model for the morphologist to work by, besides supplying a fuller and more accurate nomenclature of the parts than had ever before been given.

Without lessening the gratitude I feel for all the work that has been done on the anatomy of this group by distinguished anatomists, I nevertheless have not yet seen figures of the skull of the gigantic Sieboldia that have satisfied me.

I am therefore glad that, through the kindness of Prof. Flower (into whose hands the large specimen from the Society's Gardens passed), I have been able to dissect this large skull myself, and to have it drawn, life-size, on stone, both from my own original drawings and from the real object.

The student of these types will have full opportunity for testing the value of this very particular piece of work, as the skull with the rest of the skeleton will be preserved in spirits in the Museum of the College of Surgeons.¹

**DESCRIPTION OF THE PLATES.**

**PLATE XXXVI.**

Fig. 1. *Sieboldia maxima*: adult. The skull, upper view: nat. size.

Fig. 2. The same, side view: nat. size.

Fig. 3. The same, part of mandible, inner view: nat. size.

**PLATE XXXVII.**

Fig. 1. *Sieboldia maxima*: adult. The skull, lower view: nat. size.

Fig. 2. The same, end view: nat. size.

Fig. 3. The same, branchial arches of right side, upper view: nat. size.

Fig. 4. The same, distal part of hyoid arch of left side, upper view: nat. size.

**PLATE XXXVIII.**

Fig. 1. *Menopoma alleghaniensis*: adult. The skull, upper view, ×2 diameters.

Fig. 2. The same, lower view, ×2 diam.

Fig. 3. The same, proximal part of mandible, inner view, ×2 diam.

Fig. 4. The same, section of mandible, ×2 diam.

Fig. 5. *Siren lacertina*: adult. The skull, upper view, ×4 diam.

Fig. 6. The same, lower view, ×4 diam.

¹The first dissection of this skull was made by Mr. W. Pearson, and then passed into my hands, and was afterwards finished by him; this third dissection disclosed the details more perfectly than the second, by me.
DEVELOPMENT OF THE SKULL IN THE URODELES.

PLATE XXXIX.

Fig. 1. *Siren lacertina*: adult. The skull, side view, $\times 4$ diam.
Fig. 2. The same: young specimen. The endocranium, upper view, $\times 5\frac{1}{2}$ diam.
Fig. 3. The same: adult. The lower arches, upper view, $\times 4$ diam.
Fig. 4. *Menopoma alleghaniensis*: adult. The lower arches, left side, upper view, $\times 2$ diam.
Fig. 5. The same, auditory region of the skull, outer view, $\times 4$ diam.
Fig. 6. The same, auditory region of the skull, oblique view, $\times 2$ diam.

PLATE XL.

Fig. 1. *Lissotriton punctatus*: larva, $\frac{1}{3}$ inch long. The skull, upper view, $\times 24$ diam.
Fig. 2. *Triton cristatus*: larva, $2\frac{1}{2}$ inches long. The skull, upper view, $\times 7\frac{1}{2}$ diam.
Fig. 3. The same, lower view, $\times 7\frac{1}{2}$ diam.
Fig. 4. Part of the same, upper view, $\times 14\frac{1}{2}$ diam.
Fig. 5. The same largest larva, 2 in. 11 lines long, the lower arches, upper view, $\times 7\frac{1}{2}$ diam.
Fig. 6. The same: a more advanced larva, with gills almost absorbed, $2\frac{1}{2}$ inches long.
   The skull, upper view, $\times 7\frac{1}{2}$ diam.
Fig. 7. The same, lower view, $\times 7\frac{1}{2}$ diam.

PLATE XLI.

Fig. 1. *Triton cristatus*: adult. The skull, upper view, $\times 6$ diam.
Fig. 2. The same, lower view, $\times 6$ diam.
Fig. 3. The same, side view, $\times 6$ diam.
Fig. 3 a. The same, right mandible, inner view, $\times 6$ diam.
Fig. 4. The same, endocranium, upper view, $\times 6$ diam.
Fig. 5. The same, horizontal section of the nasal region of the skull, upper view, $\times 6$ diam.
Fig. 6. The same, suspensorium, lower view, $\times 12$ diam.
Fig. 7. The same, the lower arches, upper view, $\times 6$ diam.
Fig. 7 a. The same, thyrohyal of a younger specimen, upper view, $\times 6$ diam.

LIST OF ABBREVIATIONS.

The Roman figures in the Plates indicate the nerves or nerve-foramina.

*a. p.* Ascending process.  
*ar.* Articulares.  
*ar. c.* Articular condyle.  
*a. s. c.* Anterior semicircular canal.  
*a. tr.* Apex of trabecula.  
*au.* Auditory capsule.  
*b. br.* Basibranchial.  
*b. hy.* Basihyal.  
*c. hy.* Ceratohyal.  
*c. st.* Cephalostyle.  
*C. 1-2.* Cerebrum (fore and mid brain).
ON THE DEVELOPMENT OF THE SKULL IN THE URODELES.

c. tr. Corru trabeculae.

d. Dentary.
e. Eye.
e.br. Epibranial.
e.hy. Epiphyal.
e. n. External nostril.
e.o. Exoccipital.
e.pa. Ethmopalatine.
e.pg. Epipterygoid.
et.u. Ethmonasal.
f. Frontal.
f. m. Foramen magnum.
fo. Fontanelle.
h.hy. Hyophyal.
h. s. c. Horizontal semicircular canal.
h.s. l. Hyo suspensorial ligament.
i. n. Internal nostril.
i.n. c. Internasal cartilage.
i.tr. Intertrabecula.
i.v. Investing mass.
m.h. l. Mandibulothyoid ligament.
mk. Meckel's cartilage.
m. n. p. Middle nasal passage.
mx. Maxillary.
n. Nasal.
nc. Notochord.
u. n. Nasal process of premaxillary.
oc. c. Occipital condyle.
oc. r. Occipital roof.
od. v. Odontoid vertebra.
ot. p. Otic process.
p. Parietal.
pa. Palatine.
pa.s. Parasphenoid.
p. b.c.f. Posterior basicranial fontanelle.
pd. Pedicel.
p.f. Prefrontal (ectoethmoid).
pq. Pterygoid.
p.g. c. Pterygoid cartilage.
p.h. Pharyngohyal.
p. n. Prenasal cartilage.
p.n. b. Prenasal bone.
pr. o. Prootic.
p. s. c. Posterior semicircular canal.
px. Premaxillary.
pq. Pituitary body or space.
g. Quadrate.
g. c. Quadrade condyle.
s.o. l. Superorbital ligament.
spl. Suspensorium.
s.p.e. Sphenethmoid.
sp-o. Sphenotic.
sq. Squamosal.
s.s. l. Suspensorio-stapedial ligament.
st. Stapes.
sth. Stylohyal.
t.h. Thyrohyal.
v. Vomer.
vr. Vertebra.
v.b. Vestibule.
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XII. On the Structure and Development of the Skull in the Urodèles. By W. K. Parker, F.R.S. (Plates XXXVI.–XLII.) . . . . . . . . page 171

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Continued on page 3 of Wrapper.
XII. Observations on some rare Reptiles and a Batrachian now or lately living in the Society’s Menagerie. By Dr. Albert Günther, F.R.S., V.P.Z.S.

Received December 7th, read December 14th, 1880.

[Plates XLII. to XLVI.]

Chelys fimbriata (Schneid.). (Plate XLII.)

The Matamata is an inhabitant of stagnant waters of Brazil and Guyana. The adaptation of almost every part of this extraordinary creature for its aquatic life, and for the purpose of concealment, is perfect. When this Turtle rests on the surface of the water, or lies half buried at the bottom in the sand, the broad, flat shell with three rough ridges resembles a stone, which by other animals will be readily taken as a place of refuge or rest. The neck is long, broad, and flat, incapable of being retracted within the shell, but can be bent backwards on the right side of the animal. Its sides bear a fringe of broad, dentated tentacles, floating in the water like some vegetable growth. The flat triangular upper surface of the head is enlarged by a skinny postero-lateral lappet overhanging the large tympanum, and terminates in front in a thin flexible proboscis. This enables the animal to breathe without raising the whole head and thus making the ripple on the surface of the water by which other freshwater Turtles betray their presence. The eyes are very small, though clear and perfectly developed. The cleft of the mouth is wide; but the jaws with their horny covering are narrow, feeble, and remarkably flexible.

Naturalists and travellers have left us, singularly enough, very much in the dark as regards the habits of this singular creature. Bruguières tells us that it is eagerly sought for by the Indians for food, that it feeds on the plants growing near the water’s edge, and that he has kept one for some time alive on herbs and bread. As regards its diet, Bruguières probably was mistaken. Schomburgk (Reis. Brit. Guiana, i. p. 326) speaks in words of the utmost disgust of its appearance and intolerable smell. He found it rather frequent on the sandbanks of the river Takutu (ii. p. 29), generally half hidden in the sand in shallow water which barely covered the animal, motionless, and apparently watching for its prey. Without an attempt to escape and without any struggle the Turtles allow themselves to be taken. Schomburgk confirms that they are eaten by the Indians (iii. p. 647).

The specimens which are at present in the Menagerie of the Society fully bear out Schomburgk’s observations as regards the extreme sluggishness of the animal, and the penetrating smell, which, after handling them for a short time only, adheres to the hand for nearly twenty-four hours, and resembles the musky smell of the Alligator.
If we are allowed to make a conjecture as to the principal food of the Matamata, we should be inclined to find it in small fishes, and especially tadpoles. These may be allured to the animal by the waving fringes of its neck and head, and could be readily seized in its feeble jaws, which would be equally ill adapted for cutting off plants or for holding a larger and stronger prey.

Although no good figure of the Matamata has been published, the descriptions are sufficiently detailed to render another description unnecessary. However, there are two points which deserve special notice.

Strauch (Chelonolog. Stud. p. 172) has already stated that authors give different accounts of the extent of the gular plate. In fact, in some specimens the gular plate is short, triangular, and bordered entirely by the postgulars, which form a broad suture together. In other specimens the gular plate is oblong, elongate, reaching the pectorals, and entirely separating the postgulars. This lesser or greater development does not depend on age, as both forms of the gular are found in very young specimens preserved in spirits in the British Museum. Unfortunately the origin of the majority of the specimens which I have had the opportunity of observing is unknown; but such scanty information as I have been able to collect would have led me to the conclusion that the form with the short gular is peculiar to Guiana, and the other form indigenous in the system of the Amazons. In that case the name of *Chelys fembriata* would have to be restricted to the former, and that of *Chelys matamata* to the Amazonian race, so named and figured by Spix. However, the two specimens living at the present moment (November 1880) in the Society's Gardens, which were acquired at the same time and from the same source, show both modifications, and therefore make me hesitate to see in this remarkable difference more than individual variation. Its explanation as a secondary sexual character would be difficult to understand, and open to objection.

The second point to which I would draw attention is the coloration of the young. The shell and soft parts of the adult are almost entirely of a uniform brownish-red colour, resembling that of river-sand. Only on the neck faint outlines mark the position of the spots which are so conspicuous in the young. Specimens preserved dry become darker, brownish-black. The ground-colour of a young individual, the shell of which is 3 inches long, is light reddish, as in the adult, but the areola of each costal scute bears a large black spot; a brown line commences on the occiput, and is continued along the vertebral line to the caudal scute; two brown raised ridges diverge from the frontal region towards each side of the occiput. The lower part of the projecting snout is deep brown. The throat is ornamented with four broad brown longitudinal bars, the two middle occupy the lower side of the throat, and are confluent near the chin, the outer are broader, and run from the angle of the mouth over the

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1 Since these lines were written, the Zoological Society received two other examples, in one of which the development of the gular plate is intermediate between the extreme forms described.
tympanic region along the side of the neck, are confluent with the middle ones behind, and succeeded by some irregular spots. Every scute at the lower side has a broad brown margin with a lateral or subcentral yellow spot. Also the fore legs are ornamented in front with a broad brown longitudinal band.

The largest specimens which I have seen had a shield about 15 in. long; but from the vague descriptions of travellers there is a probability that this Turtle grows to about twice that length.

Of the skeleton, two specimens are in the British Museum, of nearly the same size, the carapaces being respectively 13 and 14| in. long. The most prominent peculiarities of the structure of the vertebral column which are not, or but slightly, referred to by those authors or by Vaillant, the latest writer on the subject (Ann. Sc. Nat. Zool. 1880, p. 80), whose observations otherwise most closely agree with mine.

The cervical vertebrae, which, as usual, are eight in number, show the greatest resemblance to those of Chelodina from Australia. The elongate compressed shape of the centra, the development of broad pleurapophyses, the tendency of the posterior zygapophyses to unite into a single process, and, finally, the mode of articulation are the same in both genera. Like Vaillant, I find simple condyles in all these vertebrae; and not the double convexity and concavity between the sixth and seventh which has been described by Owen. The 1st vertebra is biconcave, the 2nd, 3rd, and 4th opisthocoelous, the 5th biconvex, the 6th procælous, the 7th biconcave, and the 8th biconvex. In the first, traces of the union between neural arch and odontoid elements can scarcely be distinguished, the entire vertebra being similar in form to the second, but shorter and with the posterior zygapophyses wider apart. In the fourth,

![Fig. 1.](image-url)
fifth, and sixth the posterior zygapophyses coalesce, forming a prominent process with a button-like end, the articular facets being at the under surface, and separated from each other by a narrow groove. In the seventh vertebra these zygapophyses are enormously developed into a short high club-shaped process, with the articular sur-

Fig. 2.

faces coalesced into one, and at the lower surface of the bone. The eighth vertebra is distinguished by an extremely compressed centrum, much longer than the short neural arch, by cylindrical pleurapophyses, and by a long coalesced posterior zygapophysis, which is also club-shaped, but much less thick than that of the seventh vertebra. A division into two halves is indicated by a shallow notch at the top, and a deep hollow between the articular facets, which are placed at the sides and not on the lower surface of the process; a deep groove is hollowed out in front of each articular facet.

In connexion with this peculiar structure of the posterior cervical vertebrae it should be remembered that *Chelys*, like *Chelodina*, does not retract neck and head backwards within the shell in the median line of the body, but bends it sideways, so that the head lies either on the right or left forearm.

The number of dorsal vertebrae is eleven, the three hindmost forming a sacrum. Caudal vertebrae 17 or 19.

**Metopoceros cornutus** (Wegl.). (Plates XLIII. and XLIV.)

For many years the single specimen of this Lizard in the Paris Museum, described by Lacépède and Duméril, remained unique, until a living example was presented to the Society in the year 1871; and, singularly, ever since that period the Reptile-House

has rarely been left without one or two individuals of this rare species. The typical specimen is stated to have been obtained at San Domingo; but of none of the specimens received by the Society is the exact origin known.

The description given by Duméril and Bibron applies to our specimens in every particular, except in the following points. The teeth cannot be described as "tricuspid;" the central main cusp is free from denticulation, and two or three small notches indent the margin at some distance from the point of the tooth; towards the front the teeth are simply conical. The teeth are larger than in *Iguana tuberculata*, twenty in each maxillary, six in the single intermaxillary, and twenty-two in each mandible. In the scutulation of the upperside of the head I observe that there are three pairs of scutes interposed between the nostril and frontal horn, the posterior and middle being conically raised. The nasal shield forms a direct suture with the rostral, without any intervening accessory scutes, as described by Duméril.

The skeleton is very similar to that of *Iguana (tuberculata)*. The vertebrae are more slender and depressed, and provided with much shorter and more feeble neural spines; but their number is the same in both species, viz. six cervical, eighteen dorsal, and two sacral. Also the skull (Pl. XLIV.) is built entirely upon the plan of *Iguana*; but it is more massive and depressed, with a prolonged rostral region. The zygomatic arch is very broad; the parietals are horizontally spread out, not vertically as in *Iguana*, forming a broad roof over the occipital region. Again the fore part of the skull shows much firmer and more solid ossifications than in *Iguana*, the floor of the long oval nasal cavity being nearly entirely osseous. The posterior process of the articular of the mandible is short, and much more obtuse than in *Iguana*.

The bones of the limbs do not show any noteworthy difference from those of *Iguana*; but they are throughout shorter. The following are the measurements taken from skeletons of *Metopoceros* and *Iguana tuberculata* which are of the same size, the vertebral column to the first caudal vertebra measuring 10 inches.

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1 List of the Vertebrated Animals, 7th ed. p. 490.
It is obvious from a consideration of these measurements that the limbs of *Metopoceros* are considerably shorter than those of *Iguana*, therefore that its habits are much less arboreal. Probably it lives on rocks near the sea-shore, and has assumed a black coloration, like other reptiles inhabiting similar localities.

The shortening of the limbs is conspicuous in the humerus and femur, less so in the bones of the forearm and lower leg, but most in the distal bones of the fore and hind feet, which are comparatively much more shortened than the proximal.

The largest specimen received by the Society was 44 inches long, of which the trunk and head measured 18 inches.
Tejus rufescens. (Plate XLV.)

Since the publication of the description of this species in Proc. Zool. Soc. 1871, p. 541, no other specimens have come under my observation. Therefore I am unable to add any thing to that description; but after the death of the specimens the late Mr. Ford was enabled to finish in detail the coloured sketches which he had taken from them whilst they were alive. I repeat here the original description:—

On all parts of the body the scales are considerably smaller than either in T. teguexin or T. nigropunctatus. This is especially conspicuous on the temple, where the scales are reduced to the size of granules. The number of transverse series of scales is about one fifth more than in the other species. A stripe of minute scales between the supra-ciliary shields and supra-ciliary edge. A double series, each row formed by five larger scales, above the temple. Only a single mental shield behind the middle lower labial. Posterior part of the tail scarcely compressed, much less so than in T. teguexin. Blackish brown, with brownish red or brownish yellow markings. These markings are in the form of irregular transverse spots on the back, more distinct on the neck, but mottled with brown on the trunk and behind. An interrupted yellowish band proceeds from the tympanum along each side of the neck to the shoulder, where it is lost among the markings of the body. Tail with the alternate black and red rings rather indistinct.
Lower parts brownish red, with irregular transverse blackish spots. Upperside of the limbs with small reddish specks.

In the largest specimen the reddish tinge covers nearly the whole body, whilst in two others of middle size it is confined to the markings and the lower parts. In two young specimens it is not developed, the markings being of a dirty whitish colour.

_Hab._ Mendoza.

_Ceratophrys ornata_ (Bell). (Plate XLVI.)

Of this species a fine male specimen is at present living in the Gardens. Like other species of this genus it bears captivity well, provided it be kept in a temperature which should never be allowed to fall below 65°. Its food consists of other frogs; and it is enabled by the great width of its mouth, the strength of its jaws, and the extensibility of its stomach, to overpower and swallow full-grown specimens of _Rana temporaria_. During the short time of its captivity it has lost much of its timidity, and, opening its mouth, is ready to seize the hand or any other object approaching it. Its bite is powerful enough to leave the impression of its teeth on a pencil or other object. Its movements are awkward, the legs being seemingly hardly long enough to carry the bulk of its body; therefore it passes almost the whole day in a form hollowed out in the turf by means of its metatarsal shovel; it does not seem to be more active during the night. When disturbed it utters loud whining and hissing cries.

In all these points _C. ornata_ resembles much _C. cornuta_, of which two specimens lived for some time in the Gardens in the year 1858. Unfortunately the mode of propagation, the larva, and the young stages after the metamorphosis of these large Batrachians are entirely unknown.

**DESCRIPTION OF THE PLATES.**

**PLATE XLII.**

_Cehlyis fimbriata_, $\frac{1}{3}$ nat. size, with side view of head, and two views showing the variation in the extent of the gular plate.

**PLATE XLIII.**

_Metopoceros cornutus_, $\frac{1}{3}$ nat. size.

**PLATE XLIV.**

_Metopoceros cornutus_, upperside of head, and three views of the skull.

**PLATE XLV.**

_Tejus rufescens_, nat. size.

**PLATE XLVI.**

_Ceratophrys ornata_ $\delta$, nat. size.


2 See Wiegmann’s Archiv, xxvi. p. 39.
XIII. Description of a Specimen of Schedophilus medusophagus, a Fish new to the British Fauna. By Dr. Albert Günther, F.R.S., V.P.Z.S.

Received June 21st, read June 21st, 1881.

[PLATE XLVII.]

In May last I received from my valued correspondent Mr. J. Douglas Ogilby a fish preserved in spirits, with the following notes:—

"The fish was obtained during the second week of August 1878, in a salmon-net, at Portrush, co. Antrim, and came at once into my hands, none of the fishermen engaged in the fishery having previously met with any thing similar to it. It was the most delicate adult fish I ever handled—so much so that, within twenty-four hours of its capture, the skin of the belly with the intestines fell off when it was lifted, and it felt in the hand quite soft and boneless. Its stomach contained herring-fry. I may mention that a few days subsequently to above date I got a fine specimen of a Tunny, also at Portrush."

The fish proved to be a fine example of Schedophilus medusophagus, Cocco, a genus which, as far as is known, has not been previously met with near the British coast.

Originally described from specimens obtained in the Mediterranean, the species was afterwards found in the open Atlantic¹, and quite recently in the South Sea² near Samoa. It is evidently a pelagic form which, at least in the adult state, descends to some depth. The want of firmness in the tissues, well described by Mr. Ogilby, seems clearly to indicate it as a deep-sea fish. But we have no evidence as to the exact depth to which it may descend, which probably does not exceed a hundred fathoms.

As in other deep-sea fishes, the young of this species are more frequently found near the surface than the adult, which are very rare. They accompany floating objects, chiefly for real or fancied protection, or for the sake of animalcules which congregate round every object floating on the surface of the sea; this is what induces these little fish to follow Medusæ. The idea expressed by the specific name of our fish, viz. that it follows Medusæ in order to feed on them, cannot be correct, as the fish could draw but little nourishment from those animals. The specimen obtained by Mr. Ogilby probably followed one of the shoals of fry of Clupeoids which annually travel from the open sea towards our coasts, and are followed by a number of southern fish which prey upon them and in their turn are pursued by larger pelagic fishes such as Tunnies and other Scombroids.

The specimen is 9\frac{1}{2} inches long, and in good condition, with the exception of the lower part of the abdomen, which is lacerated and shrunk in consequence of the loss of the intestines. All parts of the body are in that state of softness which is peculiar to many deep-sea fishes.

The body is strongly compressed, of an elongate ovoid shape, its depth being contained twice and two thirds in the total length, fins not included. The head is small, as deep as long, and less than one fourth of the total length (without caudal). Interorbital space convex, broader than the diameter of the eye, which is situated immediately below the upper profile of the head, nearly as long as the snout, and one fourth of the length of the head. Snout obtuse, with projecting lower jaw and oblique mouth. Mouth of moderate width, the cleft extending to below the front margin of the eye. Maxillary rather narrow, but widening towards its extremity. Teeth minute, implanted in a single series on the sharp edge of the jaws. The palate is toothless.

The préopercular margin is armed with short spines, which upwards become a little longer on the posterior margin; these longer spines have an oblique dorsal direction. Also the interoperculum is spinous, the suboperculum less so. Operculum membranous; its upper portion shows radiating osseous striae, which project beyond the margin.

The gill-rakers of the outer branchial arch are long, narrow, and rather widely set. Gill-openings very wide.

The dorsal fin commences above the root of the pectoral, and terminates at a short distance from the caudal, the caudal peduncle being about as deep as long. This fin is rather low, the longest rays, behind the middle of the fin, being not erectile into a vertical position. The rays are slender, fragile, 50 in number\(^1\). The anal commences a little behind the middle of the length of the fish, and is formed by 27 rays\(^2\). The caudal fin (slightly injured) has a rounded margin, and is rather shorter than the head.

The pectoral fin has a broad base, is more than half as long as the head, and has the upper rays longer than the lower. Ventrals rather small, close together, and inserted in advance of the pectorals.

The entire fish is covered with minute cycloid scales; on the head they appear to be present on the cheek only. The upper part of the head is covered with a thick spongy skin, as in Centrolophus.

The colours of a fresh fish are a pale greenish olive marbled with darker, the markings being in the form of spots on the upper, and of irregular longitudinal bands on the lower half of the body. Also the vertical fins are spotted with blackish. The iris is nearly white; and a ring of small white pores encircles the orbit.

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\(^1\) In other specimens 45–47 have been counted.  
\(^2\) 28–29 in other specimens.

Received March 12th, read April 5th, 1881.

[Plates XLVIII., XLIX., L.]

Of late years numerous specimens of the Californian Sea-lion (Otaria gillespii) have been brought alive to Europe and exhibited in the Zoological Gardens and Aquaria of England and the Continent. A pair, the male of which has lately died, lived long at the Brighton Aquarium, and on two occasions bred, one of the cubs being now a fine adolescent male. Another pair were received in the year 1877 at the Southport Aquarium. Of these the female was killed accidentally some fifteen months ago, as already noticed in the Society's 'Proceedings' (1879, p. 460). Unfortunately no further use seems to have been made of her body, though the skull was exhibited at one of the Society's meetings, and determined by Prof. Flower as belonging to this species (l. c. p. 551). The male did not long survive his partner, but, gradually pining away, died last spring. Mr. C. L. Jackson, the Superintendent of the Aquarium, having forwarded this animal after its death to Prof. Flower, our President, being at that time much occupied with other duties, was kind enough to hand it over to me for examination and dissection.

Till within a few weeks ago our knowledge of the Californian Sea-lion was extremely limited, all that was known about it being contained in Mr. J. A. Allen's account of the species in his article on the "Eared Seals" (Bull. Mus. Comp. Zool. ii. pp. 69-73, 1870-71). At that time his only materials, as regards the present animal, were two skulls and a skeleton; and for his description of the skin he had to depend upon Schlegel's (i.e. Temminck's) account of Otaria stelleri in the 'Fauna Japonica,' which at that time, following Dr. Peters's identification, he regarded as being in reality O. gillespii.

¹ Mr. J. A. Allen, in the second of his valuable memoirs mentioned below, uses the name Zalophus californianus for the present species. I am not yet prepared to split up the, in many ways, very natural genus Otaria into several genera, founded, as these are, almost entirely upon cranial characters. As regards the genus Zalophus, it may be noted that Mr. O. Thomas has lately noticed a skull of Otaria jubata with the same number of molars as are supposed to characterize that genus (P. Z. S. 1881, p. 4).

As regards the specific name, the Otaria californiana of Lesson was based, as Mr. Allen states, on a drawing published by Choris in 1822, which is called by Mr. Allen himself "a rather poor figure," and has hitherto been referred to O. stelleri. As there can be no doubt as to the species intended by MacBain's name gillespii, and as that name, too, has hitherto been used by nearly all writers on the subject, I think it will be better to retain it.
Since the subject of the present paper passed through my hands Mr. Allen's elaborate 'History of North-American Pinnipeds' (Washington, 1880) has been published, and our knowledge of *Otaria gillesii* much increased thereby, Mr. Allen having been able to examine many skins and skeletons of the species, as well as to give full details of its habits in a state of nature. A good figure, however, of this species still remains a desideratum. The drawings accompanying this paper having been made from the fresh animal by Mr. Smit (under my own supervision), their publication will, by filling up this blank, tend to still further complete our knowledge of this animal. The detailed measurements and description of the adult male examined will also still further supplement Mr. Allen's account, whilst the notes on the anatomy of the soft parts, hitherto unknown in this species, will perhaps also be acceptable, as confirming, or adding to, our knowledge of these parts as described in Dr. Murie's elaborate and exhaustive treatise on *Otaria jubata*.

The animal examined by me was a male, perhaps adult, but by no means aged, as may be seen from the condition of its teeth and skull, now preserved in the College of Surgeons. The Brighton animal, already alluded to, was probably somewhat older, as I am informed by Prof. Flower.

The following measurements were taken, by means of calipers, on the unskinned animal:—

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<td>From nose to prominence in shoulder-joint</td>
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<tr>
<td>Greatest breadth of pelvic limb, when the fin is expanded</td>
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<tr>
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<tr>
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<tr>
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<td>4:75</td>
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<tr>
<td>&quot; from chin to angle of mouth</td>
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<tr>
<td>Depth of muffle</td>
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<tr>
<td>Breadth of ditto</td>
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ANATOMY OF THE CALIFORNIAN SEA-LION.

There are four mammmæ, abdominal in position. The posterior pair, situated about 2 inches from the middle line, are 5.75 inches in front of the opening for the penis; the anterior ones, which lie about 3 inches from the middle, are 10.25 inches in front of these.

There is no true scrotum; but a bare patch of dark, rugose skin surrounds the anus for about 4 inches each way. This did not in the least hang down; neither did the testes project into it at all, though possibly at certain times of the year they may descend into this sort of rudimentary scrotum, or the descent may even be regulated by the condition of the animal.

No such distinct, Balanoptera-like pectoral plaits of skin as those figured by Dr. Murie in Otaria jubata (l. c. pl. lxix. fig. 7) could be made out here. There a few indistinct lines of folding in the region of each axilla; but their presence seems due to the "lie" of the hairs, and not to any real growing or elevation of the skin, their situation probably depending on the position of the body.

No underfur could anywhere be found. The skin itself, where hair-covered, is pale flesh-coloured.

The following description of the pelage was taken from the animal as it lay, after having been thoroughly dried for a day or two.

The general tint is dark umber-brown, darkest and blackest on the neck, brownest on the back, and lightest on the chest. The muzzle is lighter brown. On the chest and pectoral limbs the coat is very glossy; on the pelvic limbs it is less so. The hairs of the head and neck are chiefly deep black-brown, tipped with pale brown; mingled with these are numerous white ones, which are most numerous on the sides of the head, and on the sort of crest along the top of the head, the hairs here being rather longer than elsewhere. The space round the eyelids is slightly reddish; and there is a pale spot above the eyes. Between the eyes the hairs are shorter, and of a reddish-brown colour. The eyebrows are represented by three, or, on the right side, two small curved hairs of pale colour, slightly marked with darker; the median hair is much the longest. Round the nose the hairs are brown and dirty white. The sides of the face below and above the lips, as well as the chin, are pale rufous-brown; but the margins of the lips themselves are everywhere dark. In the region whence the whiskers arise the cheeks are mottled with dark brown and dirty white hairs. The whiskers are about thirty-five in number on each side, arranged pretty regularly in six horizontal rows. The uppermost row of these contains only three whiskers, all small and short; but below and posteriorly they increase in size and number. The longest row has about seven whiskers. The greater part of the whiskers are white, including all the longer ones; but some three or four on each side are blackish.

The ears are covered with shorter, dirty white and grey hairs. Behind the shoulders, along the back and upper parts, the tips of the hairs get lighter brown; and mixed with
them are numerous entirely pale-brown ones; so that in these regions the general colour of the coat becomes much lighter, inclining to a mottled yellowish-brown tint.

The sides of the neck are darker in colour than any other part of the body, the hairs here being very deep black-brown, with very few pale ones intermixed. These latter hairs increase in number towards the head, whilst posteriorly the hairs get shorter, paler, and more tipped with yellow, so that the dark colour of the neck passes gradually into the greyer tint of the head and the browner hue of the back.

On the flanks, belly, and lips the yellowish-brown hairs and tips disappear, and the general colour in consequence becomes a dark rich brown, with a vinous tinge in some lights, particularly observable on the anterior parts of the pectoral limbs. The tail is rich brown in colour. On the chest and between the pectoral limbs the hairs become much shorter and yellowish-grey in colour; but both the shortness of the hair and the colour are, I believe, accidental, caused by the wearing-away of the hairs here by the animal's position when in repose.

The pectoral fins (Pl. L. fig. 1) are above covered with closely appressed, short hairs, which are black for the greater part of their length. There are no light-tipped hairs at all on the "fin" below the humerus. The thickened convex radial margin, from halfway down the first metacarpal for a breadth of about an inch, as well as the ulnar side from two inches above the last nail, are naked; the line of hairs runs along some little way proximad of the nails, leaving the rest of the "fin" naked. Below, the flippers are quite naked from a transverse line extending across a little proximad of the carpal joint; the bare skin is marked by numerous, subparallel, wrinkle-like lines.

On the hind limbs (Pl. L. fig. 2) the hairs extend above along the ridges of bone nearly to the nails; the margins for some way, as well as the skin between and below the nails, are naked. Beneath they are naked from nearly the base of the free part.

The accompanying Plate (XLVIII.) represents to the right the male specimen from the Southport Aquarium, from a drawing by Mr. Smit, taken from the animal when thoroughly dried. The attitude and position, however, are from a sketch made by him of the adult specimen of the same species at the Brighton Aquarium, taken a few weeks before its death. The figure to the left represents the female specimen at Brighton, and is also taken from life; it represents the animal, however, when wet. The smaller size and different coloration of this sex are well shown in it, as well as the difference in the contour of its head, due to the non-development of the great sagittal crest, which is such a conspicuous feature of the male. The small distant figure in the same Plate represents the male animal with its coat wet. On the second Plate (Pl. XLIX.) the head of the male Southport specimen is represented of half the natural size.

As regards the visceral anatomy, it, as might have been expected, conforms closely to that of Otaria jubata, with some few minor differences. I did not examine the brain, which is now mounted in the College of Surgeons' Museum.
The tongue is bifid at the apex. There are only three large, pitted, circumvallate papillae, arranged in the usual reversed V; the radix linguae behind these is covered with many free papillae or processes. The stomach is much like that of Otaria jubata, as depicted by Murie (l. c. pl. lxxxi. fig. 65), but is less globular and more elongated. Internally the mucous membrane is soft, and raised up into numerous well-defined rounded rugae, which are very irregular in disposition, curving about in all directions. In the pyloric part these folds quite disappear. When undistended, the greatest transverse length of the stomach is 16·5 inches, and its depth, opposite the pylorus, 8·75 inches. Along the greater curvature it is 29 inches. The pyloric part, which is bent back towards the cardiac part, is 4·5 inches long, measured from the angle it makes with the rest of the organ. At the pylorus the stomach is about 2 inches across. All these dimensions, except the extreme length, are a little smaller than Dr. Murie's corresponding figures (l. c. pp. 560, 561).

The small intestine is quite without rugae of any kind, but is covered with very minute villi. The large intestine has only a few slight longitudinal rugae, but is otherwise smooth. The cæcum is as in Otaria jubata, a short, simple, conical prominence, projecting backwards for \( \frac{3}{4} \) inch. The length of the small intestines is 106 feet 11 inches; of the large, 6 feet 7 inches. In the Otaria jubata dissected by Murie the total length of the intestines was only 65 feet 2 inches.

The great size of the vena cava and hepatic vein causes the comparatively small liver-lobes to be, as it were, developed round them. All the six lobes of the typical mammalian liver can be clearly made out, they being much separated from each other by the great development of all the chief fissures. Thus the umbilical fissure extends for at least three fourths the depth of the liver; and the cystic fissure is nearly as well developed, almost completely dividing the right central lobe into two. The lateral lobes are not united by any hepatic tissue at all to the central lobes, but are simply connected to them by means of the great vessels and connective tissue. The right lateral, the two parts of the right central, and the left central lobe are all comparatively long and narrow, the last particularly so; the left lateral, on the other hand, is of an irregularly square shape. The caudate and Spigelian lobes are small compared with the others, and are very freely attached. Both are of irregular shape, the caudate being somewhat forked externally; they are nearly, though not quite, united by a very thin bridge of hepatic tissue developed between them over the broad vena cava. The round and suspensory ligaments are well developed. The gall-bladder is elongated, and appears on the superior aspect of the liver. As compared with Dr. Murie's figure (l. c. pl. lxxxii. fig. 72) of the liver in Otaria jubata, that of the present species differs chiefly in the more regular outlines of its lobes, and the much smaller development of additional sulci on its inferior aspect, in these respects more resembling the liver of ordinary Mammalia, and presenting less approximation to the greatly complicated liver of the Seals.
The pancreas is compact, and of a creamy-red colour. From its extremity it measures 9.75 inches to its “head,” and 11.75 inches to its “tail.” The duct, as far as could be ascertained, opened into the ductus choledochus as the latter perforated, in a very oblique direction, the wall of the small intestine.

As regards the vascular system, the aorta gives off the great vessels in a way different from that described and figured by Murie in Otaria jubata. In the latter species the aorta gives rise successively to a right innominate, a left carotid, and a left subclavian, as in Man and many other animals. In Otaria gillespui an innominate gives off both left and right carotids close together, continuing on as the right subclavian, which then gives off two smaller trunks, which are apparently the right internal mammary and vertebral arteries; the left subclavian arises independently from the aortic arch, just beyond the origin of the innominate, and also gives off, not far from its origin, two corresponding branches. The ductus arteriosus is conspicuous.

The trachea is very wide, measuring about $2\frac{1}{2}$ inches transversely, and is somewhat dilated at the bronchial bifurcation, being here about 3 inches across. From the right main bronchus, 4 inches below its origin, is given off an extra third bronchus to the uppermost lobe of the lung on that side. Each lung is divided into three distinct lobes, of which the lowermost of each side is the biggest, whilst the middle ones are the smallest. The left upper lobe is deeply divided anteriorly. There is a distinct azygos lobe in addition, of subtriangular shape. The epiglottis hardly exists as a free organ; it has tumid margins, and a median sulcus. The arytenoid and thyroid cartilages are much produced superiorly.

The spleen is flattened and elongated, with one end slightly broader than the other. It measures 13$\frac{3}{4}$ inches in length, and 3 inches across. The thyroid glands are the size of Brazil nuts, and are quite separate from each other.

The kidneys are compound, and are composed of about forty quite distinct papillae, in each of which the cortical and medullary parts are as distinct as in Murie’s beautiful figure of the same organs in Otaria jubata (l. c. pl. lxxxi. fig. 70).

The male generative organs have been preserved as a preparation in the College of Surgeons; so I have not been able to examine them thoroughly. The testes, as already stated, did not lie in any distinct pedunculated scrotum, but were situated in the groin, close to the naked skin round the anus. There is apparently a small prostate, like that in O. jubata (l. c. pl. lxxxii. fig. 73); but both vesicula seminales and Cowper’s glands are absent. The penis (Pl. L fig. 3) has a large os, which is bifurcated at the apex. This bone in the glans is only covered by a thin coating of pale mucous membrane, which is continued also onto the prepuce. The length of the glans, from the reflected prepuce to the apex, is 2-8 inches; the notch between the superior and

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1 Not having been able to dissect the larynx, which is now mounted in the College of Surgeons, I am unable to describe its internal structure. There are, however, small laryngeal pouches, connected with the lateral ventricles, and opening in the same position as those described by Murie in O. jubata (l. c. pl. lxxx. fig. 59).
inferior ends of the bifurcated os is slightly filled up by the coating of mucous membrane, the urethra opening just behind the lower end of the os, on the inferior aspect of the glans. About an inch from the apex of the penis the mucous membrane is developed into a sort of reflected corona of loose skin; if this is expanded it forms on each side a sort of triangular flap, attached dorsally and ventrally to the median lines of the penis (vide fig. 3 a, Pl. L.). This description differs in several particulars from that given by Dr. Murie; but his specimen had sustained a fracture of the penis, and consequent damage to the glans, so that the discrepancies of the two may be due to accidental causes.

Until examples of other species and more specimens of these animals have been dissected, it will be impossible to say how much taxonomic importance ought to be attached to certain differences between Otaria jubata and O. gillespii, indicated in the present communication; but at present the anatomical evidence seems to be in favour of retaining the two forms under a common generic title, as is here done.

DESCRIPTION OF THE PLATES.

PLATE XLVIII.

Fig. 1. ♂ Otaria gillespii, from the specimen lately in the Southport Aquarium (coat dry).
Fig. 2. ♀ Otaria gillespii, from the specimen formerly living in the Brighton Aquarium (coat wet).

PLATE XLIX.

Head of ♂ Otaria gillespii: ½ natural size.

PLATE L.

Fig. 1. Pectoral fin of O. gillespii: ½ natural size.
Fig. 2. Pelvic fin of O. gillespii: ½ natural size.
Fig. 3. Glans penis of O. gillespii: about natural size.
Fig. 3 a. The same, viewed from the front.
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Continued on page 3 of Wrapper.

Received October 19th, 1881, read January 3rd, 1882.

[Plates LI. to LVIII.]

§ 1.

Of no species of Dinornis have I received so complete osteological evidence of one and the same individual as in the case of the subject of the present communication. Along with the skeleton were found the ossified rings of the windpipe (Pl. LI. figs. 10–12) and some of the smoothly rounded pebbles from the gizzard.

This rare specimen, the sole evidence of its species which has hitherto come to my knowledge, was discovered, during the construction of a road, in a cave about forty miles north-west of Nelson Town, South Island of New Zealand; and the parts, being collected with unusual care, were transmitted, through W. J. Upton, Esq., to the British Museum, and purchased by the Trustees.

The same confluence of the constituent bones of the tarso-metatarsal segment of the leg which supported the inference of the specific distinction and full size of Dinornis didiformis¹, is manifested in the present evidence of the still smaller species; and every other part of the skeleton testifies to the full growth of a mature if not aged individual.

§ 2. The Skull.

Although the reference of skulls respectively to species of Dinornis in former 'Parts' was based on grounds which left little doubt of accuracy, of no species have I had the good fortune to receive the certainty which attaches in this respect to that of which the skeleton was found entire and undisturbed under the circumstances above narrated.

The skull of Dinornis parvus, the subject of Pl. LI., lacks only the portion of the osseous palate contributed by the vomerine, palatal, and pterygoid bones, the dinornithic disposition and proportions of which bones have been described and figured in former Memoirs, and probably did not materially differ in the present species, in which the palatal processes of the maxillary (ib. 2r') and premaxillary (ib. 2p') closely agree with those parts in the undercited species².

The figures in Pl. LI., being of the natural size, dispense with a note of dimensions. Of the skulls of species of Dinornis already figured which are nearest in size to that of

¹ Transactions of the Zoological Society of London, 4to, vol. iii. 1843, p. 244, pl. xxxvii. fig. 6; Memoirs on the Extinct Birds of New Zealand, 4to, 1878, pp. 80–82, pl. xxvii. figs. 3–6, pl. xxviii. figs. 3, 4.
D. parvus, D. crassus\(^1\) differs in the minor breadth across the zygomatic arches (ib. 27,27) in proportion to the length of the skull, which exceeds that of the present species, and differs more markedly in the broader and more obtuse premaxillary, and in the minor breadth and capacity of the temporal fossae; the coronoid process also rises higher, but has less basal extent. Dinornis gravis\(^2\), with equal length of skull, has greater breadth across the postfrontals, with less breadth of the temporal fossa. Dinornis casuarinus\(^3\), with equal length, has a shorter extent of the premaxillary part of the upper beak, and a narrower nasal process of the same bone.

In the occipital region (Pl. Lxxii. fig. 4) the paroccipitals (4,4) are shorter and narrower, or less obtuse, than in D. rheides\(^4\); the occipital tubercle (1) is larger in D. parvus; the ectotympanic processes of the mastoid (8') are rather shorter in D. parvus. The upper transverse superoccipital ridge, to which the parietal (7) and mastoid (8) also contribute, is more strongly marked than in D. rheides. The masto-paroccipital wall (ib. fig. 1,4,8) has a less arched border than in D. rheides; the basioccipital mammillloid tuberosities (fig. 4, a, a) are relatively larger than in that species, indicative of greater power in downward strokes of the bill. The posterior wall of the Eustachian canal (ib. fig. 3, e) is less developed than in D. rheides; this canal shallows as it advances, and is lost on the plane of the basis cranii opposite the pterapophyses (9). The chief character of the basisphenoid, and to me the most interesting, is the well-marked longitudinal channel and foramen (fig. 3, 5, 5; see also D. ingens\(^5\) and D. elephantopus\(^6\)), which I take to be residuary indications of the upward embryonal production of the primary mouth, subsequently becoming, or communicating with the conario-hypophysial tract, which crosses vertically the brain, by the 'third ventricle,' between the pros- and mesencephalon. The pterapophyses (fig. 3, 5') are relatively larger (longer in proportion to their breadth) than in Dinornis ingens and D. elephantopus.

The presphenoid is not carinate below, or is less so at its mid extent, than in D. gravis, D. elephantopus (ib. ib.), and D. ingens, where the keeled part is longer. The presphenoid in D. parvus is not compressed at its mid third, as in D. gravis\(^7\), and is not expanded there as in D. robustus\(^8\).

The alisphenoid is indicated, as usual, by the 'foramen ovale,' as is the orbitosphenoid by the larger 'foramen opticum:' the original divisions of these cranial neurapophyses are soon obliterated, and their bases become confluent with their

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1 Trans. Zool. Soc. vol. vii. pl. xi. figs. 2, 3; Memoirs, vol. i. p. 266.
2 Ibid. vol. vii. pl. xiv. fig. 3; Memoirs, vol. i. p. 250, pl. lxxxi.
3 Ibid. vol. vii. pl. xiii. fig. 1; Memoirs, vol. i. p. 278, pl. lxxvii.
4 Ibid. vol. vii. pl. xii. fig. 2; Memoirs, vol. i. p. 271, pl. lxxv.
5 Ibid. vol. vii. pl. xv. fig. 3, 8'; Memoirs, vol. i. p. 281.
6 Ibid. vol. vii. pl. x. fig. 4, 8'; Memoirs, vol. i. p. 282.
7 Ibid. vol. vii. pl. xiv. fig. 4.
8 Ibid. vol. v. pl. lxxiv., pp. 344-355.
respective centrumis, the ali- and orbito-sphenoids, in all birds. Anterior to these the
confluence with the prefrontals is marked in D. parvens by the outward extension of a
triangular plate of bone, indicative of the original base of the prefrontal neurapophyses,
which have coalesced into a single vertical plate, again expanding on each side to give
support to the bifid neural spine, or nasal bone. The upper expansions of the coalesced
prefrontals likewise undergo ankylosis with the posterior turbinals. The inferior
turbinals coalesce with the maxillaries, but remain free from the intervening part of
the presphenoid.

On the upper surface of the skull (Pl. LII. fig. 2) the sutural limits of the parietal
bone are obliterated. Laterally a low ridge defines the upper boundary of the temporal
fossa; and the fore part of this ridge is continued forward and outward to form the
posterior angle of the three-sided, conical, downbent, obtuse postfrontal process. The
prosencephalic part of the conical roof does not rise above the level of the calvarium,
as in D. rheides; the postfrontal terminates less obtusely than in that species. The
temporal fossa is relatively wider and better defined, by a continuous ridge extending
backwards to the mastoid, than in any of the before-described skulls of Dinornis. The
rostral part of the premaxillary has nearly the same shape and proportions as in
D. rheides, being in both species relatively shorter than in D. robustus and D. ingens;
but it is longer than in D. casuarius. The concave hind margin of the premaxillary
septum is excavated to receive the fore end of the presphenoidal rostrum, here forming,
or confluent with, the fore end of the septum narium (Pl. LII. fig. 1, s). The lateral
grooves of the rostrum are continued nearer to the trenchant margins of that part than
in D. rheides.

The upper median tract (ib. fig. 2, 2') is impressed at its middle third by a
narrow longitudinal furrow; beyond this it expands laterally and thins off vertically, the
lamelliform hind portion fitting into the corresponding channel of the coalesced
nasals, which, in advancing forward, pass beneath the beginning of the nasal process
of the premaxillary.

From the short maxillary diverge the malar process (fig. 1, 21) and the palatal process
(fig. 3, 21). The malar process, the malar bone (26), and the zygomatic or squamosal (27)
have, as usual in birds, coalesced to form a styliform zygoma, 21\frac{1}{2} inches in length.
The malar presents a low angle to the postfrontal; but the interval, or unossified hind
border of the orbit, is 4 lines in extent. From the inner side of the hind end of the
squamosal projects the tubercle adapted to the articular cavity on the tympanic. This
bone is relatively longer than in Dinornis crassus, and has a longer orbital process (k).
There is a large foramen pneumaticum on the inner (mesial) side of the articular

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2 Ibid. vol. vii. pl. xv. fig. 1.
3 Compare with pl. xi. fig. 6, Trans. Zool. Soc. vol. vii.
4 Ibid. vol. v. pl. xi. fig. 1, 22.
5 Ibid. vol. vii. pl. xiii. fig. 1.
6 Compare with pl. xi. fig. 6, Trans. Zool. Soc. vol. vii.
process ascending to the mastoid. Of this bone the production descending outside of the above articular process gives strength to the joint.

The mandible (Pl. III. figs. 5, 6, 7), 4 inches 9 lines in length, repeats, with slight specific modifications, the characters of the bone described and figured in the volumes of the Zoological 'Transactions' already cited. There is no closer approach in the present small species of *Dinornis* to the cranial characters of *Apteryx* than in any of the larger kinds of Moas. The entire osteology of *D. parvus* helps greatly to exemplify the well-defined character of the group of wingless birds of New Zealand to which the generic term *Dinornis* is applied.

§ 3. Vertebrae.

In the best-preserved, or least incomplete, skeletons of *Dinornis* already described, the "dorsal series" of vertebrae, defined as commencing by the first or foremost "retaining its pleurapophyses as movable elements," was preceded by not more than fifteen vertebrae, showing no costal articular cup; and these accordingly were reckoned as "cervicals." But the slight degree of difference as to size or structure in the mid extent of this series would allow of easy coarticulation of such vertebrae without appreciable indication of one or even more being absent.

From the circumstances under which the present skeleton was found, and the singular care in the collection of its several parts, it shows a number of cervicals, as above defined, not fewer than twenty-one (Pl. LVIII. 21).

To these succeed six rib-bearing vertebrae (ib. ib. D) not confluent with the sacrum, the last forming, in the present species of *Dinornis*, the twenty-seventh vertebra, counting from the occiput. Eighteen following vertebrae are confluent with each other and with the contiguous pelvic elements (Pl. LIV. 1-18), including those which in most Mammals and Reptiles would be reckoned as posterior dorsals, lumbars, and anterior caudals. Of free caudal vertebrae there are, eleven (ib. figs. 2, 3) in the present skeleton, of which the two hindmost have coalesced. Thus there are not fewer than fifty-six vertebrae in the 'axial skeleton' of *Dinornis parvus*.

The first or foremost vertebra consists in this, as in other Moas and birds generally, of the hypapophysis (Pl. II. figs. 2-4, *hy*) and neural arch (ib. *n*), which have coalesced to form the so-called 'atlas.' The second vertebra (ib. figs. 5-9) includes, with the hypapophysis (*hy*), the centrum of the first vertebra (*c*), as well as its own (*c*'), and the neural arch (*n*), thus constituting the so-called 'axis' or 'vertebra dentata.'

In Part XXI. (*Dinornis*) three views (upper, under, and front) are given of the atlas of *Din. maximus*¹. The extreme length of this vertebra is 26 millim., the greatest breadth is 32 millim., the height is 35 millim., the transverse diameter of the cavity for the occipital condyle is 15 millim.

In Part IX. (*Dinornis*, pl. liii. figs. 4, 5, 6²) three views (front, back, and side) are

² Ibid. vol. v. 1864, p. 357.
given of the atlas of *Dinornis robustus*, of the natural size. In this species the greatest length of the vertebra, at the base of the neural arch, is 15 millim., the greatest breadth at the same part is 30 millim., the height of the vertebra is the same; the diameter of the cup for the occipital condyle is 15 millim. In *Dinornis parvus* the corresponding admmeasurements are 10 millim., 20 millim., and 10 millim. respectively (Pl. LI. figs. 2, 3, 4).

The proper centrum (ib. figs. 5, 6, 7, e) has coalesced with that of the second vertebra (ib. e), its anterior convexity forming the 'odontoid process,' and projecting into the canal formed by the confluent hypapophysis and neural arch of the atlas. The hypapophysis (ib. fig. 2, hy) is, as usual, wedge-shaped, with the base downward, as in *Ichthyosaurus*; the apex is truncate, and deeply emarginate, to receive the odontoid process. At the back part of the transversely extended and flattened base (ib. fig. 4) is a feeble rudiment of the more developed process in *Dinornis robustus* (loc. cit. pl. liii. fig. 6, hy). The postero-lateral extensions give confluent attachments to the slender columnar processes of the neurapophyses (ib. fig. 2, n) which bound outwardly the large vertebrarterial foramina (ib. figs. 3, 4, v). The fore facet of the hypapophysis is deeply cupped (ib. fig. 3) for articulation with the occipital condyle. The hind facet (fig. 4, hy) gives a smooth, almost flat transverse surface to the corresponding anterior facet of that of the axis (ib. fig. 8, e).

The base of each neurapophysis of the atlas has coalesced with the hypapophysis, and there sends mesiad a short pointed process, tending to circumscribe the atlantal cup below and the wide neural cavity above. Each neurapophysis then curves upward, outward, and inward, coalescing with its fellow above the neural canal (n'), over which it arches. From the hind part of the base of each neurapophysis extends a short strong process, developing a tuberosity externally (z') and a flat, articular, subcircular surface mesially, which joins the prezygapophysis of the axis. The roof of the neural arch is a broad bridge-like plate of bone, without trace of neural spine. In this respect it resembles that part in *Dinornis maximus*, but differs in shape and extent. The mid line of the bridge in *D. maximus* equals one half of the transverse extent; in *D. parvus* it equals one third. The fore border of the bridge is straight in *D. parvus*, but is convex in *D. maximus*. The hind angles supporting the postzygapophysial surfaces (z) are relatively more produced in *D. maximus*, the upper surface of the atlas presenting a horse-shoe figure.

In *Dinornis robustus* the marked difference from both the above species is seen in the non-union of the sides of the neural arch, leaving a longitudinal fissure at the upper mid line (loc. cit. pl. liii. figs. 4, 5, c); it is possible that the specimen yielding those figures may have come from an immature individual. The more complete ossification of the vertebra in *D. parvus* is one of many similar evidences of the maturity of the bird yielding the subject of the present description.
Of the axis vertebra, the following are the relative dimensions in *Dinornis parvus* and *D. maximus*:

<table>
<thead>
<tr>
<th></th>
<th>millim.</th>
<th>millim.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>23</td>
<td>60</td>
</tr>
<tr>
<td>Breadth</td>
<td>25</td>
<td>58</td>
</tr>
<tr>
<td>Height</td>
<td>28</td>
<td>60</td>
</tr>
</tbody>
</table>

The base of the centrum in *Dinornis parvus* develops a feeble submesial longitudinal ridge; its smooth fore ‘preaxial’ articular surface is adapted to the hind surface of the atlas, but is transversely concave in the same slight degree in which that is convex; it is not divided by a non-articular depression, as in *Dinornis maximus*, from the convex articular undersurface of the odontoid (c). The ridge on the fore part of the hæmal surface of the hypapophysis is not developed in *D. maximus*, but is so in *Struthio*, and in a greater relative degree in *D. parvus*. The fore surface of the ‘centrum proper’ is confluent with the hypapophysis and with the centrum of the atlas (odontoid process). The hind ‘postaxial’ articular surface of the second vertebra is convex transversely, concave vertically, the transverse convexity becoming feebly concave at the lateral borders, making a minor approach to the angular outline than in *D. maximus*. The hypapophysial process of the proper centrum of the axis resembles in shape and proportions that in *D. maximus*.

The neural canal (figs. 8, 9, n) is two thirds the length of the entire vertebra, and its width is one third of the breadth; the anterior outlet is subcircular, 8 millim. in diameter; the posterior outlet is transversely elliptical, 10 millim. across, and but 6 millim. vertically. In *D. maximus* the two diameters of this outlet are each 18 millim. The parapophysis (ib. fig. 9, p) has not the same relative lateral extension as in *D. maximus* (loc. cit. fig. 7, p), the centrum of the axis in *D. parvus* being there relatively narrower. The rudiment of the pleurapophysis developed from the middle of the outer surface of the vertical bar completing the vertebrarterial canal in *D. maximus* (ib. figs. 5, 6, pl) is not present in *D. parvus*. From the diapophysial plate completing that canal, the small prezygapophysis is developed with an articular surface looking outward and slightly upward; the postzygapophysis (fig. 9, z') differs chiefly in size from that of the atlas. The neural spine is a strong and seemingly simple process; but its summit is wanting.

The succeeding cervicals retain the generic characters of those in *Dinornis*. But the main difference, as already remarked, is shown by their superior number, at least in the complete skeleton of the present diminutive Moa.

The third cervical has a large compressed hypapophysis; but this abruptly subsides to a low ridge in the fourth, and disappears in the succeeding cervical, to give place, as it were, to the parial inferior processes which begin to be developed from the parapophyses of the fifth cervical.

In the third and several following cervicals the neural spine is represented by a pair
of short, compressed processes, which may be distinguished, gradually subsiding and diverging, to the fourteenth, where they appear as a forward projection from the rising of the neural arch, which expands and projects as the postzygapophysis. A short mesial prominence, like a rudimental neural spine, intervenes in the twelfth and succeeding cervicals between the bases of the lateral homologues of the bifid spine in the fifth to the eleventh vertebrae. But these homologues increase in size and height of the intervening part from the fourteenth to the nineteenth vertebrae are represented in the twentieth by a pair of low tuberosities on the summit of a subquadrate strong process 8 lines in anterior height, while in the twenty-first vertebra the spine assumes in its loftier and subcompressed form the longer and larger, superiorly truncate neural spines of the free dorsals.

The cervical vertebrae very gradually increase in size from the fifth to the ninth, but show scarcely an appreciable increase of size in the four following, beyond which they gradually, as before, gain in size to the twenty-first vertebra.

As compared with the third cervical in Dinornis maximus\(^1\), the centrum beyond the pleurapophyseal processes is shorter and broader, and has no hypapophysis. The hyperapophyses are relatively lower, and the neural spines shorter; the interzygapophysial foramina are present, but are relatively smaller. In the sixth cervical the shorter and broader proportions of the hind half of the centrum are well marked.

The parial hypapophyses commence as low tubercles from the parapophyses of the seventh cervical, as in the sixth of D. maximus\(^2\), and gain in size, as the pleurapophyses do in length, in the succeeding cervicals as far as the thirteenth. In the sixteenth cervical the lengthened hypapophyses converge, but do not meet; in D. maximus they diverge from an almost common base. In the following cervicals they are represented by a single median subcompressed process. Both the twentieth and twenty-first cervicals resemble the last (fifteenth) in the subject of Dinornis maximus described and figured in the undercited memoir\(^3\).

The base of the hypapophysis in D. parvus is not extended lengthwise as a low ridge, nor is it so circumscribed or relatively so small as in D. giganteus; but the pair of low tuberosities mark here, as in the huge species\(^4\), the hind border of the lower surface of the centrum. The interzygapophysial ridge ceases in the nineteenth cervical of D. parvus. The pneumatic foramen is present beneath the zygapophysial expanse of the neural arch in the eight binder cervicals. A tuberous metapophysis is developed from the diapophysial part of the costal or lateral arch in all the cervicals beyond the seventh. The parapophysis rises external to the preaxial articular surface in the fifth and following cervicals. The articular surface of the postzygapophysis begins to change a downward for a lateral aspect at the sixteenth vertebra, the change increasing to the last cervical.

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\(^1\) Loc. cit. p. 152, figs. 8–11.

\(^2\) Loc. cit. p. 155, fig. 14.

\(^3\) Loc. cit. p. 159, figs. 18, 19.

\(^4\) Loc. cit. p. 162, fig. 24.
In the twenty-second vertebra (first dorsal) the diapophyses are relatively shorter and broader than in *D. maximus*, the postzygapophysial prominence is much narrower, both neural spine and hypapophysis are relatively shorter. The hypapophysis is longer and narrower than in the preceding (last cervical) vertebra.

The base of the hypapophysis extends so as to form a ridge coextensive with the length of the undersurface of the centrum in the third dorsal. The parial tubercles below the postaxial articular surface in the last cervical gradually subside, and disappear in the third dorsal, in which the hind end of the hypapophysial ridge begins to broaden and project. In the fourth dorsal the fore and hind hypapophyses project as distinct processes, but are subequal; the anterior one is not produced and curved forward as in the fifth (!) dorsal of *Dinornis maximus*¹. The anterior hypapophysis is suddenly reduced in the fifth dorsal of *D. parvus*, and disappears in the sixth, where the posterior hypapophysis resumes the transversely parial character, and this part of the centrum is more produced backward. The neural spines gradually lengthen after the third dorsal, but lose in fore-and-aft diameter. Both fifth and sixth dorsals show three pneumatic foramina on each side of the neural arch.

The length of the vertebral column, as composed of the foregoing twenty-seven segments, with those inclusive which compose the skull, is 3 feet.


The vertebral ribs are in nine pairs, the seven anterior ones having free articulations with their respective segments, the two posterior pairs being ankylosed therewith. The first three pairs have no corresponding sternal ribs; and those of the seventh and eighth do not attain the breast-bone. The ninth pair (Pl. LIV. fig. 1, *pl 3*) like the first are short, straight, and terminate in an obtuse point. The third, fourth, and fifth pairs of vertebral ribs (pleurapophyses) retain their diverging appendages (Pl. LVIII.). The hemapophyses of the fourth, fifth, and sixth pairs, ossified as in the rest of the class, join the 'sternum,' both articular extremities admitting of the movements affecting the capacity of the thorax; they progressively increase in length, and are termed 'sternal ribs.' The haemapophyses of the seventh and eighth pairs lose length, and terminate freely.

§ 5. *Sternum.*

The part of the skeleton of *Dinornis* which, after the skull, differs most from that of *Apteryx*² is the sternum (Pl. I.V.). It is true that the character of a pair of posterior notches with coextensive mesial and lateral boundaries, and the general relations

¹ Loc. cit. p. 163, fig. 30.
of breadth to length of the body of the bone are preserved; but the deep anterior
emargination of the Kivi's breastbone is not indicated in any species of Moa of which
the sternum is known; nor have any of them shown the unossified spaces observed in
the body of the sternum of some individuals of *Apteryx*, as in that described in the third
volume of the 'Transactions' of the Zoological Society, and figured in pl. xxxix. fig. 2.
But, on the whole, the sternum in *Dinornis* has a closer essential resemblance to
that in *Apteryx* than to that of any of the existing Struthious or flightless birds, as
will be shown in the following comparisons.

In previous Memoirs "On Dinornis," descriptions and figures of the sternum have
been given in the 'Transactions' of the Zoological Society. From a mutilated
specimen, referred to *D. giganteus*¹, characters were deduced, especially of the anterior
and lateral borders, differentiating the bone from that of the Kivi (*Apteryx australis,
ib. fig. 8), and from the sternums of the known existing genera of large wingless birds
(ib. figs. 4–7). In a later Memoir² are given a description and figures of a less mutilated
and smaller sternum, repeating the generic characters of the preceding, but differing in
the minor breadth as compared with the length; this subject was chiefly valuable as
verifying the conjectural outline restoring the form of the entire bone in *D. giganteus
in a previous Memoir. I am still unfurnished with grounds for positive determination
of the species to which the subjects of pl. iv. of the undercited volume can be referred³.
In size it accords with that of *Dinornis didiformis*. The third modification of dinornuthic sternum was shown by an entire specimen of that of *D. rheides*⁴; the fourth by
a somewhat mutilated specimen of the sternum of *D. elephantopus⁶*; a fifth by an entire
one of *D. robustus*, and a sixth by that of *D. maximus*.

Of these modifications of the dinornuthic type of sternum that (Pl. L.V.) of *Dinornis pærus* most resembles the subject referred to in note 2. It is absolutely smaller, and
is longer in proportion to its breadth, thus making an approach to the form of that of
*D. rheides*, in which the character of length is in excess.

In the breadth and terminal integrity of the mid production of the hind border
(ib. figs. 1, 2, *g*), the sternum of *Dinornis pærus* resembles that of *D. elephantopus*;
in the minor degree of divergence of the side processes (ib. ib. *h*, *h*) it resembles that
of *D. rheides*. From this it differs in the greater relative breadth and minor length
of these parts of the hind border of the sternum, in the relative length and breadth
of which parts *D. pærus* more resembles *D. giganteus*. But the indication of the
terminal notch of the mid process (*g*) is very feeble in the diminutive species; and
the foramen above the deeper mid notch of that part in *D. rheides* is wanting in
*D. pærus*. With the figures of the breastbone of the present species (Pl. L.V.) of
the natural size, statement of dimensions may be dispensed with.


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The curve of the anterior border (ib. fig. 3) is limited to the slight concavity upward or dorsad (a) as it extends from one "costal angle" (d) to the other; in relation to a longitudinal axis the border is straight (figs. 1, 2, a), as it is in the preceding species. The coracoid fossae (fig. 3, c, c) show the usual small and shallow proportions; they are relatively smaller even than in Aptyeryx, and thus are indicative of a still greater reduction of the scapular arch.

The costal border presents, as usual, three articular depressions. The anterior one (fig. 4, o1) is smooth and shallow, to which the short and straight anterior sternal rib (fig. 1, s1) appears to have been connected by ligament. The second costal pit (fig. 4, o2) is better defined, is chiefly extended transversely, and receives the correspondingly extended sternal end of the second sternal rib (fig. 1, s2) by a distinct synovio-cartilaginous articulation. The third costal pit (fig. 4, o3) has a similar shape, but is of smaller size; it offers the same articulation to the third sternal rib (fig. 1, s3). The foregoing articular surfaces are limited to the anterior fourth part of the lateral length of the sternum.

The inferior or haemal convexity of the sternum (ib. fig. 1) is slight, but is rather more pronounced along the mid fourth of the surface than in D. maximus, or D. rheides.

On the concave or neural surface (fig. 2) the pair of deeper hollows (p, n) at the base of each costal process (d) are less marked than in D. rheides, and the foraminal indications of extensions into the substance of the bone, of either vessels or air-cells, are much fewer and smaller.

The lateral borders of the sternum continued from the costal tracts (o, o) are obtuse, and in the side processes (h) narrow to an edge mesiad. The side borders of the mid process (g) are similarly trenchant.

The retention of the dinornithic type of sternum under all its minor modifications puts the generic distinction of the wingless genus Aptyeryx, still existing in New Zealand, in a strong light. Yet the sternum of that bird differs in a much more marked degree from the keelless breastbone of the larger known existing Ratite of Nitzsch than do these from one another1.

Nevertheless the differences which the sternum of the Ostrich (Trans. Zool. Soc. vol. iii. pl. lvii. fig. 4) presents, in the manubrial prominence from the fore border and the side processes from the hind border, from that bone in Rhea (loc. cit. fig. 3), and the greater difference exemplified by the median notch in the fore border of the sternum of Casuarius (loc. cit. fig. 6) with the limitation of the coracoid grooves, which almost meet in Struthio, to the outer third parts of that border in Rhea and Casuarius, together with the more marked modifications in the hind limbs of these flightless birds, and the modifications of the syrinx2 testify to the artificiality of Nitzsch's order—a condition

1 Trans. Zool. Soc. vol. iii. pl. xiii.
which exaggerates the departure from a 'natural system' when such 'order' is posed as a group equivalent in value to all the rest of the class of birds.

From the indications of the coracoid notches in the sternum of *Dinornis parvus*, a diminutive pair of scapulo-coracoid bones may have escaped the notice of the finder of the present skeleton; they would appear to have been proportionally smaller than the subjects of pl. lxiv¹, taken from *D. robustus*.

§ 6. Pelvis.

Of the pelvis of *Dinornis* more or less complete examples have been described and figured in former Memoirs².

The least incomplete specimen of the subjects of pl. xix. of the undercited volume³ afforded a comparison with the pelvis of the Ostrich, the difference from which in that of the equally large or larger terrestrial bird is detailed in pp. 253–258 (tom. cit.), and exemplified in figs. 2 & 4. The close resemblance, in the proportions of the pre- and post-acetabular parts of the pelvis, to that of the *Apteryx*⁴ is exemplified in the side view of the part in *Dinornis dromioides* (pl. xx. fig. 2) and in the under or haemal view of the pelvis of *Apteryx australis* (pl. lv. fig. 1) and that of *D. dromioides*. A side view of a more complete specimen of the pelvis of *D. didiformis* is given in pl. xx a. fig. 1, of the natural size. A less complete pelvis is described and figured in connexion with the skeleton of *Dinornis elephantopus*⁵; it agrees in general characters with that of the previously described species of the genus. The least incomplete pelvis already described and figured is that of the skeleton of *Dinornis robustus* preserved in the Museum of the Philosophical Society of York, and forming the subject of pp. 388–390, pl. xcvi. of the 'work.' But the only perfect example of a dinornithic pelvis which has hitherto come to hand is that of *Dinornis parvus*, the subject of Pls. LIII. & LIV., and represented more reduced in the view of the entire skeleton (Pl. LVIII.).

The following are dimensions of the pelvis:—

<table>
<thead>
<tr>
<th>Description</th>
<th>in.</th>
<th>lin.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>&quot; anterior to acetabula</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>&quot; posterior to acetabula</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Breadth (between ends of pelvic bones)</td>
<td>5</td>
<td>10</td>
</tr>
<tr>
<td>&quot; (across back part of acetabula)</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>&quot; of ischium from acetabulum</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>&quot; of pubis from acetabulum</td>
<td>4</td>
<td>9</td>
</tr>
</tbody>
</table>

² In the 'Work,' locis citatis at p. 91.
⁴ *D. struthioides*, and xx a. (D. didiformis).
⁶ Ibid. vol. iv. pls. xlvi., xlvi.
Breadth (across fore end) ...... 2 7
" (across hind end) ...... 2 2
Depth, or vertical diameter, anteriorly .... 3 0
" posteriorly, including ischium and pubis .... 4 3
" of ischium, distal end ...... 2 0
Vertical diameter of acetabulum .... 1 6
Horizontal diameter, including trochanterian surface .... 2 1

The pelvis includes, as in other birds, the parts corresponding to sacrum, ilia, ischia, and pubes in mammals, but all coalesced into one mass or bone.

The sacrum includes eighteen vertebrae.

The ribs of the first or foremost (8 1) have not coalesced with the centrum and neural arch; the articular surfaces for these elements are distinct on each side. The ribs of the second sacral (Pl. LIV. fig. 1, pl. 2) are confluent by both head and tubercle; and the body of the rib arches outward and downward for an extent of 2 inches 9 lines from the tubercular confluen.

The ankylosed ribs (ib. pl. 3) of the third sacral vertebra project freely for about 5 lines from their coalesced tubercle. The pleurapophyses of the fourth, fifth, and sixth sacrals consist of the 'head' and 'neck' only, the fourth terminating in a slightly prominent ridge, the others expanding at both ends, one confluent with its parapophysis, the other with the ilium. The pleurapophyses of the sixth and seventh sacrals have coalesced into one short and thick process, slightly expanded at the distal end, which blends with the confluent acetabular or proximal ends of the ischium and pubis.

In the eighth, ninth, and tenth sacrals the parapophyses and costal elements are absent; they abruptly reappear in the eleventh and twelfth sacrals, and coalesce with each other at their respective distal extremities; the proximal ones are coextensive with the two centraus, the distal ends expand into a thick mass abutting against and confluent with the inner or central surface of the posterior or trochanterian tract of the acetabulum.

A plate of bone extends from the hind border of the thirteenth pleurapophysis, and expands as it extends outward and backward to coalesce with the mesial and under margin of the ilium. The pleurapophyses of the fourteenth to sixteenth sacrals have a similar course, outward, backward, and slightly upward, with similar expanded abutments against the ilium, increasing in thickness and decreasing in length as they recede in position. The corresponding coalesced processes of the two last (seventeenth and eighteenth) sacral vertebrae are the shortest and thickest; and their distal, sutureal, iliac connexions are not wholly obliterated.

The breadth of the first sacral centrum (Pl. LIV. fig. 1, s 1) midway between its articualr ends is 1 inch; this dimension gradually increases to 1 inch 5 lines in the fifth sacral (ib. 5); it suddenly diminishes to 11 lines in the eighth vertebra (ib. 8),
augments to 1 inch 2 lines in the eleventh (ib. 11); thence this dimension gradually decreases to the breadth of 7 lines in the seventeenth sacral (ib. 17), slightly increasing in the eighteenth (ib. 18), which presents the characters of a coalesced caudal vertebra. The neural spines of the sacrals are confluent throughout; that of the first, 2 inches 2 lines in length, has part of its summit (Pl. LIII, fig. 2, s 1) exposed at the angle of divergence of the ilia (ib. 62); the following ten spines have coalesced with each other and with the upper or neural margins of these bones; the succeeding similarly coalesced sacral spines do not reappear until the divergence of the ilia (ib. 62') at the eleventh sacral vertebra. The summits of the neural spines thence to the fifteenth vertebra are exposed to form a flat horizontal plate (ib. a, s), the side borders of which coalesce with mesial ones of the diverging ilia; this coalescence ceases at the spine of the fifteenth sacral, whence the coalesced flattened summits of the rest converge to the eighteenth, terminal vertebra (ib. 18). The thick pleurapophyses (ib. pl) of the last three sacrals are exposed at the interspaces between their spines and the iliac bones.

The outer surface of the anterior two thirds of the ilium (ib. fig. 1, 62) is smooth, moderately concave, marked by a few vascular grooves; it forms the upper three fourths of the acetabulum (ib. 6), and the surface (b) for the femoral trochanter continued thence from backward and upward; this surface is feebly concave vertically, convex lengthwise. The outer surface of the ilia behind their divergence is bent downward at a right angle with the horizontal flattened part; the extent of the downbent part (62) is 4 inches, its vertical diameter is 1 inch; but this part of the bone is triedral, the third and inner surface inclining downward and inward to receive the coalesced ends of the abutting processes of the fourteenth to eighteenth vertebrae inclusive. The dimensions of the pelvis give the chief ones of the iliac bones.

The ischium (63), after contributing part of the lower and hinder wall of the acetabulum, contracts to a subcylindrical bar of 6 lines diameter and of like length; it then expands with the lower border almost in contact with the pubis (64), the opposed rough surfaces indicating a fibrous union there 6 lines in extent, defining the hole (q) for the passage of the tendon of the 'obturator internus' muscle. Beyond this the ischium loses thickness and gains in breadth, attaining that of 2 inches at its free hinder end (6v); this is 1 inch distant from the ilium above, and ½ an inch from the free end of the pubis below. The ischia bend slightly inward towards their expanded ends, which are 3½ inches apart at the upper angle, and 5 inches at the lower angle of the bone.

The pubis (64), contributing the lower and fore part of the acetabular wall, contracts to a thickness of 5 lines, and assumes beyond the obturator foramen (q) a subtriedral figure, flattened on the outer facet, and slightly expanding at its terminal upcurved extent of one inch and a half to a depth or breadth of 8 lines (6v), with an interspace between it and the ischium of 5 lines.

The cavity of the acetabulum (a) presents the usual circular form, with a diameter
of the outlet of 1 inch 3 lines, and one of the inlet of 10 lines; through the latter the bodies of the tenth, eleventh, and parts of the ninth and twelfth vertebral centra are visible.

Thus the pelvis of the smallest known species of *Dinornis* repeats, in the main, the characters of that part of the skeleton in the larger species above referred to. It includes the same number of vertebrae as that of *Dinornis giganteus*¹. As in this species and *D. robustus*, the pelvis is broader in proportion to its length than in the *Apteryx*, but in most other respects resembles the pelvis in that bird more than it does that of any other known avian genus. The pelvis is equally divided lengthwise at or by the coalesced pleurapophyses of the seventh and eighth vertebrae, giving origin to the ischia, whereas in *Struthio*² the part of the pelvis behind this origin is twice as long as the part in front. The terminal junction of the ischium with the pubis, which does not take place in *Dinornis parvus*, is more extensive and complete in *Struthio* than in *Apteryx*³; and the pubis in *Struthio* is extended much beyond that junction, where the ischium terminates. It need hardly be remarked that the produced pubes bend downward and inward, expanding to a symphysial union in the Ostrich, since this mammalian character is peculiar to it among birds.

It appears that in *Dinornis robustus* the terminal junction of ischium and pubis is as well marked as in the *Apteryx*, and that the distance between the ischium and ilium, posteriorly, is less. In *Dinornis parvus*, as in *D. robustus*, the terminal expanse of the ischium is relatively greater than in *Apteryx*, and the interspace between it and the ilium is less; and this narrowing is increased in *D. robustus* as compared with *D. parvus*.

If the anterior end of the pelvis of *D. parvus* (Pl. LIII. fig. 3) be compared with that of *Aptornis*, the preaxial surface of the first sacral is less extended transversely, the hypapophysis is wanting, and the neural spine springs more abruptly from between the prezygapophyses in the present Moa.

If the same view be compared with that of *Cnemiornis*, the vertical contraction of the preaxial surface in the latter is still more marked; the difference in the origin of the long neural spine is the same as in the comparison with *Aptornis*. In this genus, as in *Cnemiornis*, the ischiadic notch is converted into a foramen by confluence of the ischium with the ilium; and such confluence is greater in *Aptornis* than in *Cnemiornis*³.

As the osteology of *Didus* is recorded and illustrated in the 6th and 7th volumes of the 'Transactions' of the Zoological Society, I may here add to the comparison of *Dinornis* with other genera of extinct birds deprived of the power of flight, that of *Didus* in relation to the pelvis. It includes sixteen coalesced vertebrae, with which the

iliac bones are continuously confluent. The ischium, receding from the acetabulum, expands vertically, and converts the ‘ischiadic notch’ into a foramen by junction with the ilium; near its acetabular origin it sends down a feeble prominence to denote the hind boundary of the ‘obturator foramen,’ which is thus a mere notch widely communicating with the space between the ischium and pubis, beyond which the latter bone extends for some distance in both the Dido and the Solitaire.

§ 7. Caudal Vertebrae.

The free, or proper, caudal vertebrae of Dinornis parvus are eleven in number; but the tenth has coalesced with the eleventh (Pl. LIV. figs. 2–7). The first caudal resembles the last sacral in the vertical extent and general thickness of the transverse processes; but these have not the length of those of the otherwise similar vertebrae in which such processes are confluent with the ilia. The under surface of the centrum is irregularly grooved lengthwise, not smooth as in the antecedent vertebra; the neural arch sends off a pair of short, thick, obtuse processes, representing a bifid neural spine, which seems to have had ligamentous junction with the hind part of the neural arch in advance, a median prominence of which has been continued by ligament into the interspace of those processes.

The centrum of the second caudal vertebra shows the same irregular inferior grooving as the first; the loss of size in the second is chiefly due to the minor development of the transverse processes, from each of which slightly project a diaphysial and parapophysial prominence. The neural arch here also sends off a pair of short, but more divergent, obtuse processes, defined by an anterior notch. The third caudal loses breadth; but this dimension continues the same to the seventh caudal inclusive. The transverse processes gradually diminish; and the indication of their double nature disappears at the sixth caudal; the short stumpy bifid character of the neural spine is continued, with slight diminution of size, to the eighth caudal inclusive. In the ninth it is represented by a single tubercle; in the tenth it disappears and the neural canal is there closed. A fine vertical line descending from a puncture, which may have transmitted a nerve-filament from the end of the neural axis, and a transverse pair of notches on the under part of the centrum are the indications of the primitive development of the seeming terminal vertebra from two cartilaginous rudiments. The ossified confluent result exceeds in length that of any of the antecedent caudals, and, besides the absence of neural spine, gradually narrows to a rough termination of 2 lines inferior breadth; the sides of the eleventh vertebra converge to an upper ridge (ib. fig. 3).

The base of the terminal coalesced vertebrae (ib. fig. 7, 10, 11) is more rough and irregular than in the two antecedent caudals; in the rest of these vertebrae a similar
or double-ridged character of the centrum (as shown in figs. 4, 5 and 6) is indicative of the attachment of depressor muscles.

The caudal vertebrae in natural articulation curve slightly downward at the terminal third of the series. The length of this series following such curve is 5 inches 3 lines.

In the skeleton of Dinornis elephantopus\(^1\), described and figured in Trans. Zool. Soc. vol. iv., nine caudal vertebrae were definable, most of them more or less mutilated, but the last one sufficiently preserved to show the absence of the characteristic modifications of that part of the tail-skeleton in most birds of flight\(^2\). The caudal vertebra of Dinornis maximus, described in the Memoir (part xxii. fig. 36) as the second of the series, corresponds in the main with the second in D. parvus; but the divisions of the neural spine, or divergent processes from the roof of the neural arch, are relatively longer than in D. maximus, and the interspace is consequently deeper and wider. In the three coalesced terminal caudals of, probably, Dinornis crassus, described p. 180, loc. cit., and figured (figs. 38, 39), the better-marked indications of the line of confluence of the penultimate and last vertebra bear out the interpretation of the corresponding feeble ones in D. parvus; but the parapophysis of the last vertebra in D. crassus is not developed in the smaller species. The foramen indicative of the exit of the hindmost nerve is relatively longer in D. crassus, and is repeated on both sides. The antepenultimate caudal in D. crassus is relatively shorter than in D. parvus. Of the three sides of the terminal coalesced caudals in D. parvus, the lower one is the narrowest, not the broadest as in D. crassus. The penultimate centrum of D. parvus has not the excavation of the lower surface which is described and figured in that centrum of D. crassus. But all the essential modifications of this part of the skeleton in the present extinct wingless genus of birds are repeated in Dinornis parvus, and are manifested with slight modifications in the caudal vertebrae of Apteryx\(^3\).

§ 8. Femur.

Notwithstanding the extreme difference of size, the femur of Dinornis parvus (Pl. LVI. figs. 1–6) presents the generic characters of the bone as well marked as in Dinornis maximus\(^4\), and as clearly differentiated from those of the femur of Apteryx australis. The only trace of a transition is in the slight degree of relative slenderness of the shaft to the length of the bone as compared with that in the taller species of Moa; but all the characters connected with muscular power or work are as strongly marked in D. parvus as in any of the larger forms of the genus. The thickness of the wall of

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\(^1\) Memoirs, &c., 4th, 1878, p. 223, pl. lx. Ibid. p. 233.

\(^2\) In Chauna chavaria the caudals precede the coalesced group of four, the foremost of which barely surpasses in height the preceding free caudals. (See the excellent and exhaustive work by Eyton, 'Osteologia Avium,' pl. 25. fig. 3).


the cavity of the shaft and the expanse of the distal end of the femur are dinornithic.

In carrying out comparisons with previously determined species of the genus, I find that, the least diameter of the shaft being one seventh the length of the femur in D. parvus, the entire bone is relatively less thick than in Dinornis geranoides\(^1\), and the distal end is relatively less expanded than in Dinornis didiformis\(^2\). The trochanter (Pl. LVI. figs. 1, 2, c) shows rather less relative height than in D. didiformis, but presents equal breadth. The distal end has greater relative breadth, especially of the rotular concavity (ib. fig. 1, r), compared with the length of the femur and the diameter of the shaft, than in Dinornis geranoides. The muscular ridges are as strongly developed on the hinder or popliteal aspect of the shaft (fig. 2), and the popliteal space (ib. figs. 2 & 6, a) is as deeply excavated, as in any other species of Moa.

The rough, deep, oval depression (ib. fig. 2, g) reappears at the same part above the outer condyle (e). The outer surface of the great trochanter (fig. 4, c) shows a broad longitudinal angular depression, beneath which the distal part of the narrowing trochanter is indented by a narrower and shallower longitudinal one (fig. 4, h). From the fore border of this depression is continued the intermuscular ridge (fig. 1, i), which runs straight down the middle of the fore part of the shaft to within one third of the distal end of the bone.

The full, oval, flat, rough surface (fig. 1, d) on the fore part of the femur, midway between the head of the bone and the trochanter for the insertion of the ‘iliacus internus’ muscle, is well defined; it is nearer the middle of that part of the bone than in the femur of Dinornis elephanto\(\)pus. The oblong rough surface at the hind part of the base of the great trochanter for the insertion of the strong tendon of the ‘obturator internus’ is also well marked\(^3\). From this a linear rising or ridge (ib. fig. 2) descends along the inner side of the shaft parallel with the anterior ridge. On the outer and back part of the trochanterian enlargement are two oblique parallel ridges extending downward and backward; the lower one is the strongest and longest. Two linear ridges extend down the back of the femoral shaft, converging, and terminating in a single ridge at about one third of the length of the femur from the distal end.

The medullararterial canal (fig. 2, k) opens, as in other Moas, between the hinder ridges a little way above their confluence, at the mid length of the bone.

In the femur of Dinornis ingens and in that of D. struthio\(\)ides, at the middle of the back of the neck of the femur, a seemingly vascular foramen, bigger than the rest thereabouts is figured. A foramen in the corresponding position is relatively larger, more marked, in D. parvus (fig. 2); it might be taken for a ‘foramen pneumaticum,’

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\(^2\) Ibid. vol. iii. 1843, p. 249, pl. xxiv.

\(^3\) The muscles in relation to the above femoral characters are determined from the analogy of Apteryx australis. See Trans. Zool. Soc. vol. iii. 1842, p. 291, pls. xxxii., xxxiii.
but is of very small size; it leads, however, to a more expanded cavity, and may probably have given passage to one air-cell, penetrating for a little way into the neck of the femur. At the distal end of the bone (fig. 6) the articular production separating the tibial from the fibular articular surface on the outer condyle is more ridge-like, and is less produced backward, than in *Dinornis didiformis*.


The tibia of *Dinornis parvus* (front view in figure of skeleton, Pl. LI., oblique back view, ib. Pl. LVIII.) shows the chief generic characters of the bone in the great relative breadth and height of the rotulare or epicnemial plate, in the wide concavity between this plate and the proximal articular surfaces, in having the same direction and relative extent of the ridge for the attachment of the fibula, and in the completion by an oblique bridge of bone of the canal transmitting the tendon of the 'extensor tibialis anticus'.

The large, slightly concave, articular surface for the inner condyle of the femur is divided from the small convex surface for the inner side of the intercondyle by a well-marked smooth wide groove. The prominence closing the outer end of that groove is less developed than in *Dinornis gravis* and most of the larger species. The procnemial ridge subsides within 3 inches of its summit, and is not continued, as in *D. gravis*, to the groove for the extensor tendon. The ectocnemial process has a similar extent. The fibular ridge subsides, as usual, at the entry of the medullarterial canal, beyond which a rough narrow tract, not rising above the surface of the bone, indicates the continuation of the ligamentous attachment of the slender distal half of the fibula to the tibia. On the opposite side of this bone commences, at 3 inches from the distal end, a well-marked, rough, slightly depressed surface, gradually widening to 7 lines across, where it terminates \( \frac{1}{2} \) inch above the distal border of the inner ('tibial') condyle.

The anterior part of the distal articular surface of the tibia has not the mid rising interrupting the transverse concavity as in *Dinornis gravis*. For the rest, the distal articular and other characters of the leg-bone closely conform to the dinornithic type.

I may remark that in comparison with the Bustard (*Otis tarda*), to which *Dinornis parvus* is little superior in size, the tibia is thicker relatively to its length, and, with other osseous characters of the legs, is indicative of the more powerful actions and varied uses to which the Moas of New Zealand applied their feet.

Both proximal and distal epiphyses are as thoroughly confluent with the diaphysis in the present small species as in the tibia of the largest Moas.

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1 Compare fig. 6, Pl. LVI. of the present Memoir with fig. 3, pl. xxxv. Trans. Zool. Soc. vol. iii. pls. xxv., xxvi.
3 Ibid. vol. viii. pl. lix. fig. 1, g.
4 Tom. cit. pl. lix. fig. 2, v.
In the immature individuals of *Dinornis*, not much exceeding in size the present mature example of *D. parens*, the proximal epiphysis is seen to consist chiefly of the epicondylar process with the upper portions of the procenial and ectocnemial ridges; the epiphysis, also, includes the outer of the two tuberosities for the attachment of the intercondylar ligaments. The broad articular surface for the inner femoral condyle, and the tuberosity for the outer one, are formed by the diaphysis.

The distal epiphysis of the tibia includes both condyles of the articular pulley, including the whole articular surface, and also that portion of the shaft which forms the outer (fibular) wall of the canal for the extensor tendon, including the tuberosity giving attachment to the same end of the ligamentous bridge, which subsequently becomes ossified. A foramen marks the remnant of the outer (fibular) part of the suture between the diaphysial process of the epiphysis and the rest of the shaft of the tibia. The anterior extension of the epiphysis, for a considerable extent upon the diaphysis, is shown in fig. 4, pl. lix. of the Memoir on *Dinornis gravis*¹, and negatives the homology of this characteristic avian epiphysis with the 'astragalus,' or other proximal tarsal bone in Reptiles. From the distal epiphysis is developed the groove and bridge for the tendon of the 'tibialis anticus.'

§ 10. *Patella*.

Only in the present complete skeleton have I found the patella of a *Dinornis* preserved (Pl. LVIII., bones of the right leg). It is an oblong triedral bone, the outer or front side being the broadest, slightly convex, and rather rough; the other two sides are smooth, as if originally coated by cartilage. The surface next the outer femoral condyle is moderately sinuous; that next the inner condyle is flat transversely, concave lengthwise at the proximal two thirds, convex to the deflected small end. The length of the patella is 1 inch 1 line, its breadth 7 lines.

§ 11. *Fibula*.

The proximal end of the fibula (Pl. LVI. fig. 7) contributes, as in other birds, to the articulation with the outer femoral condyle; its breadth is 1 inch 4 lines. On its inner (tibial) side the articular surface (ib. a) is continued upon the shaft for an extent of 4 lines. Below this part the bone rapidly contracts, takes on a triedral form, the hinder and inner angle articulating with the fibular ridge of the tibia. On the opposite side of the bone is an elongate rough surface for the origin of the 'peronæus medius' muscle². Beyond the tibial conjunction the fibula more rapidly contracts, and termi-

brates in a point. The entire length of the bone is 9 inches 6 lines (see Pl. LVIII., of the skeleton).

§ 12. Metatarsae.

The form and dimensions of this bone are given in Pl. LVII. figs. 1–4; and the degree in which it resembles in its proportions the metatarsae of previously described species may be inferred from the subjoined Table of Admeasurements of Metatarsal Bones in the Genus *Dinornis*:

<table>
<thead>
<tr>
<th></th>
<th>Length</th>
<th>Breadth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Middle of shaft</td>
</tr>
<tr>
<td>1. Dinornis maximus</td>
<td>20 0 in. lin.</td>
<td>3 in. lin.</td>
</tr>
<tr>
<td>2. giganteus</td>
<td>18 6</td>
<td>2 in.</td>
</tr>
<tr>
<td>3. robustus</td>
<td>15 9</td>
<td>1 10</td>
</tr>
<tr>
<td>4. ingens</td>
<td>13 6</td>
<td>1 7</td>
</tr>
<tr>
<td>5. gracilis</td>
<td>12 9</td>
<td>1 10</td>
</tr>
<tr>
<td>6. struthiouides</td>
<td>12 0</td>
<td>1 6</td>
</tr>
<tr>
<td>7. dromioides</td>
<td>10 0</td>
<td>1 3</td>
</tr>
<tr>
<td>8. elephas topos</td>
<td>9 4</td>
<td>2 6</td>
</tr>
<tr>
<td>9. crassus</td>
<td>8 9</td>
<td>1 9</td>
</tr>
<tr>
<td>10. casuarinus</td>
<td>7 9</td>
<td>1 7</td>
</tr>
<tr>
<td>11. gravis</td>
<td>7 7</td>
<td>2 0</td>
</tr>
<tr>
<td>12. didinus</td>
<td>7 6</td>
<td>1 6</td>
</tr>
<tr>
<td>13. didiformis</td>
<td>6 11</td>
<td>1 3</td>
</tr>
<tr>
<td>14. parvus</td>
<td>6 3</td>
<td>1 1</td>
</tr>
<tr>
<td>15. geranoides</td>
<td>5 11</td>
<td>1 11</td>
</tr>
<tr>
<td>16. curtus</td>
<td>5 0</td>
<td>1 0</td>
</tr>
</tbody>
</table>

From this Table it will be seen that *Dinornis parvus* is intermediate between the slender sorts, represented by *D. giganteus* and *D. struthiouides*, and the thicker sorts, represented by *D. elephas topos* and *D. gravis*, in the proportion of its metatarsal bones.

The entocondylar surface (Pl. LVII. figs. 1, 2, a) is, as usual, deeper and narrower than the ectocondylar one (b); the intercondylar rising (c) terminates anteriorly in a well-marked lever-prominence, over which the tendon of the 'tibialis anticus' glides prior to its insertion at the rough depression (fig. 1, k), which is relatively less, but deeper and better-defined, than in *Dinornis geranoides*. The entocampilan process (ib. fig. 2, n) rises higher than the entocampilan one (p). The ectogastrocnemial tract (fig. 4, h) is more ridge-like and shorter than usual; the entogastrocnemial surface (fig. 3, g) is more distally placed, is roughened, but not raised, for the insertion of that muscle. Neither ento- nor ectointeroseal canals are marked, or open, on the back surface of the bone (fig. 2), as in *Dinornis gravis*; but the antointeroseal depression is

1 Trans. Zool. Soc. vol. viii. pl. lviii. fig. 2.
indicated by a single small foramen (fig. 1, d). The hallucial surface (fig. 2, q) is barely definable. Along the distal half of the fore surface of the bone the mid metatarsal shows a recognizable prominence. The distal end of the bone closely adheres to the dinornithic type; the depressions ii', iv', figs. 3, 4, are well marked; the condyles ii, iii, iv have the usual dinornithic proportions and relative positions. The digits ii, iii, iv have the usual phalangial formulae; the mid toe (iii) is longer in proportion to the metatarsae than in Dinornis robustus\(^1\), but is shorter in proportion to the digits ii, iv; the ungual phalaux of each toe is rather sharper and more decurved than in the larger species.

\(\S\) 13. Phalanges.

For comparison of the foot-bones of Dinornis parvus with those of Dinornis rheides, reference may be made to plate iii. of Memoir, part iv. Trans. Zool. Soc. vol. iv. 1851, and with those of Dinornis dromoides to plate ii. of the same part and volume. It will be seen that the smaller species under description shows intermediate proportions of the toes in regard to thickness and length.

In the absence of any definite indication of an articular surface for the innermost toe, it might have been inferred that Dinornis parvus, like some larger species, to which I therefore originally limited that generic appellation, had lacked that part of the foot—a part which, being better developed in other species, led to their being referred to a genus Palapteryx. But the degree in which the digit i (Pl. LVII. figs. 8, 9) may be reduced without being wholly lost, is significantly demonstrated by the subject of the present 'Part,' owing to the care with which the bones of the individual, dying in the cavern most probably a natural death, were collected.

\(\S\) 14. Conclusion.

If the skeleton of Dinornis parvus (Pls. LI. & LVIII.) be compared with those of D. maximus, D. robustus, D. crassus, D. rheides, D. gravis, D. didiformis, D. gracilis, and D. casuarinus\(^2\), it will be seen that the smallest species (Pl. LVIII. of the present Part) has proportionally the largest skull. The modifications of the frame accompanying augmentation of bulk in the genus, are chiefly manifested by greater proportional length and strength of the terrestrial limbs. If the peculiarly nutritious roots of the common ferns of New Zealand contributed, with buds, foliage, or other parts of trees, to the food of the gigantic race, the concomitant gain of power in the locomotive and fossorial limbs seems not to have called for a proportional growth of brain or of bill.

\(^1\) Trans. Zool. Soc. vol. iii. p. 47, pl. i.

\(^2\) Memoirs on the Extinct Wingless Birds of New Zealand,' 4to, vol. ii. 1878, Is. xcvii., xcvii., cviii.-cxii
DESCRIPTION OF THE PLATES.

PLATE LI.

*Dinornis parvus*.

Fig. 1. Front view of skeleton, reduced; see 'scale,' Pl. LVIII.
Fig. 2. Side view of the first cervical or 'atlas' vertebra.
Fig. 3. Front view of the same vertebra.
Fig. 4. Back view of the same vertebra.
Fig. 5. Side view of the second or 'axis' vertebra.
Fig. 6. Upper view of the same vertebra.
Fig. 7. Under view of the same vertebra.
Fig. 8. Front view of the same vertebra.
Fig. 9. Back view of the same vertebra.
Figs. 10-12 a. Different views of ossified tracheal rings of *D. parvus*.

Figs. 2-12 a are of the natural size.

PLATE LII.

Skull of *Dinornis parvus*: nat. size.

Fig. 1. Side view.
Fig. 2. Upper view.
Fig. 3. Under view.
Fig. 4. Back view.
Fig. 5. Mandible, upper view.
Fig. 6. Left ramus and symphysis, under view.
Fig. 7. Inner surface of left ramus.

PLATE LIII.

Pelvis of *Dinornis parvus*.

Fig. 1. Side view.
Fig. 2. Upper or outer view.
Fig. 3. Front surface: nat. size.
Fig. 4. Hind surface: nat. size.

Figs. 1 & 2 are two thirds of the natural size.

PLATE LIV.

Pelvis and caudal vertebrae of *Dinornis parvus*.

Fig. 1. Under view of the pelvis.
Fig. 2. Side view of the caudal vertebrae.
Fig. 3. Upper view of the caudal vertebrae.
Fig. 4. Under view of the first caudal vertebra.
Fig. 5. Under view of the fourth caudal vertebra.
Fig. 6. Under view of the seventh caudal vertebra.
Fig. 7. Under view of the four terminal (eighth to eleventh) caudal vertebrae.

All the figures are of the natural size.

PLATE LV.

Sternum of Dinornis parvus: nat. size.

Fig. 1. Front or under view, with the sternal ribs.
Fig. 2. Back or upper view.
Fig. 3. Anterior margin.
Fig. 4. Side view.

PLATE LVI.

Femur of Dinornis parvus: nat. size.

Fig. 1. Front view.
Fig. 2. Back view.
Fig. 3. Inner (tibial) side.
Fig. 4. Outer (fibular) side.
Fig. 5. Upper view of proximal end.
Fig. 6. Under view of distal end.
Fig. 7. Inner (tibial) side of upper two thirds of the fibula: nat. size.

PLATE LVII.

Bones of the left hind foot of Dinornis parvus: nat. size.

Fig. 1. Front view.
Fig. 2. Back view of metatarses.
Fig. 3. Outer side of metatarses.
Fig. 4. Inner side of metatarses.
Fig. 5. Inner (tibial) side of phalanges of inner or second toe (ii).
Fig. 6. Outer side of phalanges of outer or fourth toe (iv).
Fig. 7. Outer side of ungual phalanx of inner toe (ii).
Fig. 8. Metatarsal and ungual phalanges of innermost, or first, or back toe (i), side view.
Fig. 9. Upper or outer surface of the same parts.

PLATE LVIII.
Oblique side view of the skeleton of *Dinornis parvus*. Reduced to scale annexed of 3 feet (English).
DINORNIS PARVUS.
DINORNIS PARVUS
XVI. On Dinornis (Part XXIV.): containing a Description of the Head and Feet, with their dried Integuments, of an Individual of the species Dinornis didinus, Owen. By Professor Owen, C.B., F.R.S., F.Z.S., &c.

Received June 11th, read June 20th, 1882.

[PLATES LIX.—LXI.]

The subjects of the present Part tend to complete, in an unlooked-for degree, the characters of a Moa almost as they might be studied in a living or recent specimen.

I cannot refrain from expressing the pleasure I have experienced in being spared to make such closer acquaintance with a subject of an early communication to the Society¹, which has given admission, with liberal illustrations, to so many successive contributions to the natural history of the great extinct terrestrial birds of New Zealand.

The parts now before me consist of the head and a continuous part of the neck, with the trachea, enclosed and covered by the dried integument; also of the bones of both legs, with the feet, covered by their dried skin, with the claws, and some feathers, of a species of Moa, of about the size of Dinornis didiformis, but with differences in comparable parts leading me to refer it to a nearly allied species, Dinornis didinus.

These specimens were obtained by Mr. H. L. Squires, at Queenstown, South Island of New Zealand, and are briefly noticed, as parts of one individual, in a number of the 'Tuatara Times,' published at Otago, November 1878, but without an indication of the place where or the person by whom they were discovered. They were transmitted by Mr. Squires, May 29th, 1882, to the British Museum. With the head are attached, by tegument or ligament, fourteen cervical vertebrae.

The length of the skull (Pl. LXIX. figs. 1–3), from the tip of the upper mandible to the indication of the occipital crest, is 4 inches 10 lines (=122 millim.); that of the lower mandible, from its fore end to the indication of the angular process is 4 inches (=100 millim.). The dried tegumentary nostril (ib. n) has a longitudinally ovate form, gradually contracting forward, and inclining obliquely inward, to within 10 lines (=22 millim.) of the tip of the beak; the fore border is not defined; but the orifice, or nostril, to the extent to which the integument is preserved, shows a length of 9 lines (=20 millim.), with an extreme vertical breadth of 5 lines (=10 millim.); the inter-space between the outer nostrils, taken at their mid length, is 6 lines (=12 millim.). From the beak-tip to the fore part of the tegumentary orbit (ib. o) is 2 inches 9 lines

¹ Transactions of the Zoological Society, vol. iii. p. 29 (1839).
(≈70 millim.); to the back of the palpebral opening is 3 inches 6 lines (≈86 millim.); the longitudinal extent of that opening is 9 lines (≈20 millim.). From the beak-tip to the hind border of the ear-aperture (ib. e) is 4 inches 8 lines (≈120 millim.) The length of the tegumentary aperture is 9 lines (≈20 millim.); its vertical diameter is 7 lines (≈15 millim.).

The sclerotic bone-ring of the dried eye-ball projects from the left orbit; a few of the ossicles are exposed (ib. fig. 2); their total number seems to have been twelve. The relative size of the organ of vision, as compared with that in Apteryx, favours the assumed diurnal habits of Dinornis, in which also it accords with the relative size of the optic lobes indicated by their fosse in the bony walls of the brain-case.

The head is preserved with the mouth widely open; the length of the gape is 3 inches.

Not any of the feathers are preserved on the cranial integument, but their pits of insertion are manifest, slightly increasing in size toward the occiput and upon the cervical integument, where the pits become prominent.

Within the mouth may be seen the hypobranchial elements of the thyrohyals, each 1 inch 8 lines (≈43 millim.) in length; the dried remains of the tongue anterior to these bones are preserved, including the antroverted ceratohyals and the basihyal (ib. fig. 4). From the beak-tip to the fore border of the palato-nares is 2 inches 2 lines (≈54 millim.).

The upper larynx, with the trachea, as far as the ninth cervical vertebra, is preserved. The tracheal rings are bony and entire, showing a full oval diameter of the windpipe, 7 lines (≈16 millim.) by 6 lines (≈14 millim.) (ib. fig. 5); each ring shows a breadth of nearly 3 millim., with a thickness of nearly 1 millim. They are not quite the size of the smallest tracheal ring (fig. 10, a–c, pl. xlvii. Trans. Zool. Soc. vol. vii. 1870) referred, with a ?, to Dinornis rheides; but they give welcome confirmation to the ascription of those and larger tracheal rings found detached in different New-Zealand localities to species of the genus Dinornis.

Of the skulls ascribed to species of the genus, figured in former volumes of our 'Transactions,' that of the present species comes nearest in size and shape, so far as can be determined through the integument, to the subject of figs. 1, 2, & 6 of pl. xiii. of the under-cited volume, referred (p. 139) to Dinornis casuarinus; and, like that skull, the present shows a close resemblance to the skull of the Emu (Dromæus novaehollandiae), with similar proportions, positions, and relative size of the narial, orbital, and auditory apertures.

In the transmitted parts of the hind limbs of Dinornis didinus the tibæ and fibulæ are bare, the bones of the feet more or less enclosed in their integuments.

The proportions of the tibia and metatarsal of the present subject do not accord with those of the corresponding bones of *Dinornis casuarinus* given in "The Table of Admeasurements" (Trans. Zool. Soc. vol. viii. 1873, p. 370)\(^1\).

The following dimensions, which I have been able to take of the tibia and metatarsal of the present acquisition, may be compared with those in the volume above cited:—

<table>
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<tr>
<td>Breadth of distal end</td>
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<td>Breadth of middle of shaft</td>
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<table>
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</tr>
<tr>
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<td>2</td>
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<tr>
<td>Breadth of middle of shaft</td>
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In a comparison with the 'admeasurements' quoted above, it will be seen that the present species accords best with *Dinornis didiformis*\(^2\). But there are differences; and what I regard as a significant one is the indication, in the present species, of the larger proportional size of the phalanges supporting the back toe (\(i\)).

The instances in which evidence of that toe had been recognized by an indication of the surface for the ligamentous joint of its metatarsal with the tibia led me in 1872 to abandon the ground on which a genus *Palapteryx* had been separated from that called *Dinornis*, and to include both under the same generic term.

The short and feeble metatarsal of digit \(i\) was subsequently recovered in connexion with a tibia in which the joint-surface in that bone was inconspicuous. But no specimens of the metatarsal and phalangial bones of the back toe had indicated the functional development and strength manifested in the subjects of Plates LX., LXI.

Were it not for the comparative shortness of this toe, the foot, now recovered with its integument and claws, might be suspected to be that of a huge raptorial bird, rather than of a terrestrial phytophagan deprived of wings.

The length of the back toe (\(i\)) including the claw, where the toe projects from the tegument of the foot, following the convex curve, is 3 inches 10 lines; the corresponding admeasurement of the mid toe (\(iii\)) is 10 inches 6 lines. The accompanying figures of the right, and best-preserved, foot being of the natural size, other admeasurements are omitted. The proportions of the digits \(ii\) and \(iv\) are those of the genus.

The best-preserved claws are subobtuse, canaliculate beneath, the wide and shallow

\(^1\) *Dinornis*, Part xviii. (1872).

groove being bounded by raised margins, sharpest at the outer (fibular) side of the groove; these margins, losing sharpness, are continued along the borders of the claw’s concavity to near its base. Each claw phalanx shows the lateral vascular grooves. That on the inner (tibial) side of the phalanx (Pl. LX. fig. 1 i) is deeper but shorter than that on the opposite side (Pl. LXI. fig. 1).

The proportion of the toes (ii, iii, iv), as to relative length, are closely those of the species of *Dinornis* of which the toe-bones are described and figured in the fourth volume of the Zoological Society’s ‘Transactions’ (1851). In robustness, or the proportion of thickness to length, the toe-bones of *Dinornis didinus* are intermediate between those of *Dinornis rheides* and *D. dromioides*.

From the osseous structure of the foot, especially the strength and curvature of the ungual phalanges of the digits ii, iii, iv, it was inferred that the hind limbs of the Moas might have been put to the work of uprooting the ferns which, from the unusual proportion of nutritious matter their roots contain, are peculiar to New Zealand, and still afford the material of a favourite bread of the Maoris. This deduction receives support from the additional knowledge of the foot of a *Dinornis* now acquired.

The dried remains of the sole-pad show the thick and smooth integument; and this smoothness is continued to near the proximal end of the metatarsae. The lateral and dorsal, or anterior, parts of the metatarsal integument show numerous pits for insertion of feathers, of which some of those attached to the proximal and also near to the distal ends of the metatarsal segment are preserved.

These feathers (Pls. LX. & LXI. fig. 2) vary from 2½ inches to 1 inch in length; the barbs are loose, filamentary, directed at an angle with the shaft, which gives a breadth of half an inch at the proximal third of the feather, where the barbs are about a quarter of an inch in length; beyond the basal third the barbs incline more to the tip, and the feather becomes narrower. The colour of the basal part is lighter than that of the apical two thirds of the feather, deepening from a greyish to a reddish brown colour, which latter, as in the larger kinds of *Apteryx*, may probably be the prevailing hue of the entire Moa. There is no trace of an accessory plume, or of any basal down, in the preserved small feathers of the foot of *Dinornis didinus*.

If, as is most probable, a character of the genus may be inferred from parts of the species here described, *Dinornis* differs from *Apteryx*, as from all the large existing Struthionidae, in having the metatarsae (or ornithological ‘tarsus’) feathered down to the toes. From *Apteryx*, *Dinornis* (or at least *D. didinus*) also differs in the greater relative size of the hind toe. Indeed, a foot of the proportions above described must have possessed a certain grasping-power; and this may have been exercised in pulling their fern food up by the roots, after these had been exposed and loosened by the strong

1 *Dinornis robustus* (p. 188, pl. xlix. fig. 1), *Dinornis rheides* (p. 195, pl. i. fig. 1), *Dinornis dromioides* (p. 194, pl. li.).
2 Loc. cit. p. 103.
3 Mr. Forbes informs me that feathers have been seen on the metatarsal of a young Rhea.
fossorial anterior digits. But such aliment was doubtless varied by other nutritious substances.

After close comparison of the dried head of *Dinornis didinus* with those in the existing Struthious birds, the characters of which are so admirably given in the illustrations of Mr. Sclater's excellent memoir in vol. iv. of the 'Transactions' of the Zoological Society, pls. lxvii. a–lxxvi., pp. 353–364, the Moa is found to repeat most closely, in the form and proportions of the beak, and in the shape, relative positions, and dimensions of the narial, orbital, and auditory apertures, the Emus of the Australian continent.

**DESCRIPTION OF THE PLATES.**

**PLATE LIX.**

Head of *Dinornis didinus*.

Fig. 1. Head, with dried integument and portion of neck, left-side view.

Fig. 2. Head, with dried integument and portion of neck, right-side view.

Fig. 3. Head, upper view.

Fig. 4. Hypobranchial tongue-bones, and portion of dried tongue.

Fig. 5. Area of tracheal ring.

**PLATE LX.**

Foot of *Dinornis didinus*.

Fig. 1. Tibial side view of the foot.

Fig. 2. A metatarsal feather from the same side.

**PLATE LXI.**

Foot of *Dinornis didinus*.

Fig. 1. Fibular side view of the foot.

Fig. 2. A metatarsal feather from the same side.

(All the figures are of the natural size.)
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P. L. SCLATER,
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Continued on page 3 of Wrapper.
XVII. *On the Structure and Development of the Skull in the Crocodilia.*

*By W. K. Parker, F.R.S., F.Z.S.*

Received October 15th, 1881, read January 17th, 1882.

[Plates LXII. to LXXI.]

*Introduction.*

SEVERAL years ago I received from my friend Mr. David Bartlett several ripe young embryos of a Crocodile, the species of which was undetermined. Other ripe embryos of *Crocodilus acutus* (from St. Domingo) were about the same time given to me by another friend, Mr. Henry Power, F.R.C.S.

For about twelve years no further addition was made to my collection, nor further observations recorded than such as were done, partially, soon after receiving these treasures.

But early in the summer of 1879 I received from my talented young friend, Mr. Henry F. Osborn, of Princeton, U.S., a box of the eggs of *Alligator mississippiensis*. These had been laid quite recently, and contained nothing sufficiently advanced for my purpose; but soon afterwards, when this failure had been made known to Mr. Osborn, I received another box of eggs. These reached me on August the 8th; they were twenty-six in number, and all but one of them yielded me embryos.

These have served me for my earlier and most important stages; but the largest embryos were scarcely half ripe.

Shortly afterwards I received a large number (several dozen) of embryos of *Crocodilus palustris*¹, from Dr. Kynsey, P. M. O. of the Hospital, Colombo, Ceylon, who took great pains for me, employing his native assistant, Mr. S. Waytialingam, to collect them. This zealous service I owe to the influence of Sir Joseph Fayrer. An account of the nest-rifling of these “fearful wildfowl” has already appeared in the ‘Proceedings’ of this Society (1880, pp. 186, 187). There were about eighty of these embryos, ranging from 1½ to 10 inches in length; they were most carefully preserved and tabulated.

I have no *dates* in the case of the embryos of the Alligator, and I can therefore only give *measurements*; but in the Crocodile embryos the time is given in each case, and this in specimens taken from two places, namely, Vadunakaloo and Talavaikal; the eggs from both these sources were evidently laid about the same time. Mr. Waytialingam says that they are laid as early as June; and as the smallest specimen measured nearly 2 inches in total length, and was taken on the 16th of July, it is probable that both the nests were filled by the middle of June. They were ripe on the 8th of September,

¹ See Günther’s ‘Reptiles of British India,’ p. 61, pl. 8, fig. a. I must here call the reader’s attention to the extreme beauty of the plates (by G. H. Ford) both in that work and in Dr. Gray’s paper referred to on the next page.

*Vol. XI.—Part IX. No. 1.—October, 1883.*
so that three months may be given as the full time required for the development of the embryo, which is probably one third longer than is required in the case of the Brush-Turkey (Talegalla).

Bibliography.


The skulls of other reptiles worked out by me (the Snake, Phil. Trans. 1878, part 2; the Lizard, Phil. Trans. 1879, part 2; and the Green Turtle, 'Challenger' Reports, Zoology, vol. i. part 5) are not of themselves sufficient for comparison with that of the Crocodile; that of the Bird and of the Mammal are quite necessary before its meaning and uses can be understood.

Moreover, as the Sairopsida are built upon the foundation of the Amphibia and Fishes (Ichthyopsida) it is before all things necessary that the skull in one or the other of those Branchiate types be taken as a measure or pattern with which to compare that of this highly specialized Abranchiate form.

For now, in the ascent of the types, the more or less ossified chondrocranium is almost buried under the well-compacted framework of superficial bones, and the once capacious respiratory pharynx is reduced to a funnel-shaped vestibule of the digestive

1 In this list I make no pretension to completeness. The works and papers are just such as served me in my special research.

Since this paper was read, an important memoir has appeared on the anatomy of the Crocodile, viz. "Recherches sur l'oreille moyenne des Crocodiliens et ses communications multiples avec le pharynx," by Edouard van Beneden (Archives de Biologie, vol. iii. plates 20-22. pp. 487-560; 1882).
tube. The only permanent “cleft,” the first of the series, scarcely opens externally, and serves merely as the rudiment of the tympanic labyrinth of the adult; it never takes on any respiratory function.

Thus the cranium, proper, and the visceral arches are greatly modified from what we see in such a good fundamental type as the Skate, the cranium being “cribbed, and cabin’d, and confined” within the fast-growing masses of the outer bones, whilst the arches are arrested early, and then wrought into fitness for new physiological uses.

Yet masked and curtailed as the elements of the skull are in so high a vertebrate type, they are not too modified nor too fragmentary for interpretation; the parts can, besides their relative and functional names, have a terminology given them that shall perfectly correspond with that which has been given to those of the pure chondro-cranium of the “Elasmobranchs,” with its complex lattice-work of branchial arches.

Thus, in the present paper, whilst I shall try to name every part by its own proper morphological designation, I shall not disturb the old anthropotomical terms with which the anatomist is familiar.

I need scarcely say that all that is purely morphological in the present paper is based on embryological facts; and that whilst I would wish to make clear to the student fresh from his human anatomy the structure and fitness of a skull so different from that of Man, yet, on the other hand, the whole work of interpretation must be done so as to commend itself to the mind of the embryologist.

As the Crocodile is known to be one of the most ancient types inhabiting this terraqueous globe, his development is full of interest in relation to those countless Reptilian forms that have succumbed to secular changes of the earth, and have “left neither son nor nephew” in the regions where they once were dominant.

In the great structural conformity of the skull, in its early stages largely, and to a wonderful degree also permanently, to that of the Bird, there is much both to admire and to stimulate inquiry. The copious development of air-cells in the tympanic labyrinth is extremely like what we see in a Hornbill or a Toucan; but the “final purpose” of such a conformity is a dark riddle. On the other hand, fresh from the study of the development of Lepidosteus, I find no difficulty in imagining a “Ganoid” descent for the Crocodile. “I do read some tokens” of the gigantic forms of that older group “in the large composition of this” Reptile.

The skeleton of the head is composed of all the three embryonic layers—epiblast, mesoblast, and hypoblast—only in its hinder half; the front part, from the pituitary body forwards, is devoid of the lower layer.

Therefore, in any comparison of the head with the trunk, this must be borne in mind; the notochord only reaches to the “infundibulum,” which receives the pituitary graft, and the hypoblastic lining of the throat ceases inside the mandibular arch; thence, above and below, the whole structure is composed merely of the upper and middle layers.
Thus in the axial and neural regions we have a parachordal tract with a prochordal tract in front of it; whilst, below, we have the postoral (visceral) arches, the foremost of which, the mandibular, is finished in front by super- (or pre-) oral outgrowths. Moreover, the visceral arches must not be confounded with the costal arches; these latter are found in the outer layer of the body-wall, the "somatopleure," whilst the visceral arches are developed in the inner layer, or "splanchnopleure." The fact that these two layers are only separate for a short time in the pharyngeal region, does not alter their real nature; the difference between the two sets of arches is fundamental, and only in the lower types (Ichthyopsida) do arches arise in the superficial layer of the pharynx.

1st Stage. *Embryos of Alligator mississippiensis, Daudin, 11 lines long* (head 3, body 5, tail 3).

My smallest Crocodilian embryo, measured along its coils, was less than an inch in length, and served well for comparison with the early embryos of the other Reptilian forms already figured and described. The mesencephalic flexure was perfect, the visceral clefts visible, more than fifty somatomes were developed, and the limbs were in the condition of trowel-shaped paddles (Pl. LXII. fig. 1). The ventral laminae were imperfect, so that the heart (h) protruded below the throat, and the umbilical vessels (u. v) came from an open abdomen. The divisions of the brain were clearly seen from the outside; the hind brain (C') was large and long, the mid brain (C") large and protuberant and ending the axial line, and the fore brain had already given off the rudiments of the hemispheres (C', C").

The nasal sacs, eyeballs, and auditory capsules (ol, e, an) were already formed, and the involution of the latter (aq.e) was visible. There were four pairs of visceral folds behind the mouth, the mandibular, hyoid, and first and second branchial (mn, hy, br1-2); these were separated by three clefts (el-3), the first of which was short, crescentic, and obscure, and the other two large and open. Already the first and second visceral folds had gained largely on the other two, being thick and solid, whilst the two branchial folds were very slender and small, ready to lose their distinctness in the folds of the neck.

Seen from below (Pl. LXII. fig. 2), the mouth (m) is bordered behind by the solid mandibular folds (mn); behind these are the hyoid folds (hy), which have an opercular fold, as in fishes. There is a wide open space between them and the first branchial fold, and then a smaller cleft, right and left, between the first and second branchials (br1-2). The open oral space (m) has, right and left of it, a solid semioval fold, the maxillo-palatine (mx.p), then there is a clear chink on each side, and, in front, a fau-shaped lobe, cleft in the middle, and, flanking each lobe, the right and left olfactory sacs (ol); this double middle fold is the "fronto-nasal process" (f.n.p).

When the inferior (postoral) arches are removed, and the head viewed from below (Pl. LXIII. fig. 1) the form of the folds that finish the face in front is better seen.
These parts—the fronto-nasal and maxillo-palatine folds (f.n.p, m.x.p)—are in front of the hypoblastic layer of the embryo, and therefore have to be considered, *in the present state of our knowledge*, merely as additions or outgrowths to the true visceral folds, which are lined with the lower embryonic layer.

In the preparation figured, the myelon (my) has been cut through, and also the notochord (nc) and investing mass (iv); also the mandibular folds and hyoid arches (mu, hy); these arches are now becoming cartilaginous. The notochord can be seen shining through the hinder part of the floor of the head; in front of it there is an opening partly filled by a sort of glandular structure—the rudimentary pituitary body (fig. 2, py). From the middle of the mandibular fold, right and left, a membranous fold appears with a free sinuously emarginate hinder edge, this fold, which runs up to the fronto-nasal fold, is the *epiblastic* lining of the palate; the higher stratum of mucous membrane behind it is composed of hypoblast, which reaches in front to the notch in which the pituitary body lies, and on each side passes into the first cleft (cP'). In front of the first cleft the hypoblast unites with epiblast, ending there. The second cleft (cF') is seen behind the hyoid fold (hy); the other folds and clefts were not figured: these parts had been cut away.

Inside, the solid maxillo-palatine folds (mx.p), right and left, are thick and bulbous; these swellings are the rudiments of the lower or hard palate, which is so greatly developed afterwards. When the mucous membrane and palatal skin had been removed (Pl. LXIII. fig. 2), then the rudimentary chondrocranium was displayed; the mandibular arches only (mn) were left in section in this preparation. The notochord (nc) seems to be a straight, horizontally placed rod, but its position is really oblique (see 2nd stage, Pl. LXIII. fig. 7, nc). It lessens gradually to its fore end, where it is somewhat bulbous, and shows but little tendency to become moniliform. On each side of the notochord the parachordal cartilage (investing mass, iv) is becoming solid; it is almost regular in width, but is indented by the corresponding auditory capsule (anu), itself now just becoming hyaline.

The front margin of the basal plate is emarginate, bounding, as it does, the pituitary body behind; from each moiety a small horn of less consistent tissue is seen to grow forwards with an outward curve; this bovicorn structure is the prochordal part of the basis cranii, in rudiment; the horns are the "trabeculae cranii." Here the structure is quite like what is seen in the Axolotl (Phil. Trans. 1877, pl. 22. fig. 1), except that in that type the "horns" solidify first; this is also the case in the larval Lamprey. At this stage the trabeculae are very slight additions to the proper axial skeleton; they just help to support the first vesicle of the brain.

2nd Stage. *Embryos of Alligator mississippiensis, 1 ½ inch long (head 4 lines, body 6, tail 8)*.

At this stage the embryo has not only taken on the pentadactyle character, it is also
evidently a reptile, and nearly half its length is due to the growth of the coiled tail. The number of somatomes has greatly increased, and the lobes of the face are now confluent; yet the mesocephalic flexure is still perfect, throwing the huge mid brain (Pl. LXII. fig. 3, C) forwards, as though it were the end of the embryo. The hemispheres (C\(^2\)) are very much elongated in front of the pineal region (pl); the hind brain (C\(^3\)) is still very long and thinly covered.

The prenasal beak is now definitely formed, and projects considerably beyond the brain, so that the outer nostrils (ol, e.u) are carried away from the eyeballs; these latter are immense, and are fitted with well-margined sockets.

The auditory capsules (au) are still evident as ovoidal swellings on the outside, and the involution (aq.v) is evident as a lipped slit; a curtain hangs down over the closed first cleft.

The mouth (figs. 3, 4, m) is now well formed and has large angles; the mandibles (mn) are still short as compared with the upper or maxillo-palatine margin of the mouth; the hyoid (hy) lies some distance behind the mandibles, and the clefts are nearly closed. When the inferior arches are removed, and the head is viewed from below (Pl. LXIII. fig. 3), we see how much the palatine region has developed in front of the pituitary involution\(^1\) (py).

At the mid line, where the faucial and palatine territories meet, there is a sagittal form recess, in the centre of which the pituitary rudiment is to be found.

The hinder tract is short, and passes right and left into the clefts, the first of which (el\(^1\)) only is figured; it lies within and behind the mandible (mn). The epiblastic mucous membrane in front of this pair of clefts is now greatly elongated, narrows towards the front, and then widens again somewhat. In each angle, in front, the lacrymal "involutions" (l.i) are seen. Right and left, the club-shaped maxillo-palatine folds (mx.p) are growing inwards, especially in front, and these inner lobes contain the rudiments of the hard palate. The upper palatine skin shows a median seam when the two sides have grown together. The nasal sacs and their openings (ol, e.n) are still quite inferior in position, and the lobes of the fronto-nasal process (f.n.p) are growing small; they now form the anterior margin of the palate, where the promaxillary teeth will be.

When the palatal and faucial skin has been removed, then the hardening basis cranii is exposed (Pl. LXIII. fig. 4); in relation to the early chondrocranium of the Vertebrata, generally, this is a very important dissection.

At present the notochord (ne) is half as long as the whole basal tract; it was two

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\(^1\) In my earlier papers I have been in the habit of calling certain passages about in front of the mouth, as well as the mouth itself, by the term "clefts." Now, and for the future, I shall only call those passages clefts that lie behind the mouth, and in which the epiblast unites with the hypoblast. In the mouth, pituitary rudiment, lacrymal, and nasal passages, the whole tract, outside and in, is merely epiblast; these will be called "involutions."
thirsd the length in the first stage (fig. 2), and it will be relatively much shorter than now. Although it appears to be straight in this aspect, it is really bent forwards near the end, and hooked downwards at the end (figs. 7, 8, ne), where it is slightly bulbous. This is like what I found in the same stage in Chelone viridis (op. cit. pl. 2. fig. 4).

The parachordal cartilage grows up into the recess under the mid brain (C⁰) much further than the notochord, so that, already, that rod has retreated from its first position between the moieties of the investing mesoblast; the ascending plate of cartilage is the "posterior clinoid wall" (p.cl.), a part which is developed much more in the Sauropsida than in the Ichthyopsida.

The folding over of the notochord at its end is the counterpart, in the skeleton, of the folding over of the mid brain; both the fore skull and the fore brain appear to be outgrowths from the proper end of the skeletal and neural axes; the arrest of the hypoblast at this point favours such a view; this view would also put the optic and olfactory nerves out of the normal category¹.

The parachordal plate, which is still distinct from the auditory capsules, has very sinuous outlines, for it is pinched in by the pressure of those capsules and by the cranial nerves.

Behind (Pl. LXIII. figs. 4, 6, oc.o, iv) the occipital condyles are being formed, and the plate of cartilage in front of them is pierced by the hypoglossal nerves (xii), and notched by the glosso-pharyngeal and vagus nerves (ix, x).

Also the growth of the cochlear (chl) towards the mid line causes the parachordals to become very narrow, thence they widen out and get in front of the auditory capsules (au), and at this, their widest part, they are notched by the large Gasserian ganglia (v).

As seen from below (fig. 4, iv) these plates seem to end in the postpituitary region, on this lower plane; but the upper view (fig. 6) and the sections (figs. 7, 8) correct this view.

The two plates ascend under the hind brain (C³) into the large space within the folded mid brain (C²), and grow, right and left, into large wings; these wings are the alisphenoids (a.s); they grow from the "posterior clinoid wall" (p. cl). The base of each wing grows round the fore edge of the hind skull, and the tip of each touches the hind corner of the adze-shaped orbito-sphenoid (o.s); the upper surface of these wings is sinuous, and fits to the swellings of the overlying membrano-cranium.

The basal plate looks outward, right and left, at the fore end, and is notched (for the notochord, ne) in the middle. Between these points the trabeculae (tr) arise; they are very thick, short, pointed "horns," curving towards each other, but kept apart in front by the thick intertrabecular bar (figs. 4-6, i.tr). Above (fig. 6) the trabeculae lie on

¹ The reader will observe, if he compares this with former papers of mine, that my views are becoming more and more in harmony with those of Prof. Huxley and Mr. Balfour. The truth of the matter is this, that I am gradually placing my work on an accurate embryological basis.
the same plane as the investing mass from which they arise; but below (figs. 4 & 5) they project, being thick, oval in section, or compressed.

Behind and below they would seem to be articulated to the moieties of the "investing mass;" but they are really continuous, and do not form so distinct a joint as in Chelone ("Turtle's Skull," op. cit. pl. 2. figs. 6, 7). This apparent distinctness of the trabeculae as seen from above and below is partly due to the fact that the internal carotid artery (i.e) is entering the skull at that part.

Yet these inferior projections may be taken as the apices of the trabeculae, and these projections backwards into a cartilaginous "lingula" (see "Fowl's Skull," Phil. Trans. 1869, pls. 81, 82, ly) is for the purpose of forming a root, from which may grow the copious periosteal laminae that form each "anterior tympanic recess."

The fore half of the chondrocranium is not finished by the trabeculae. I have just spoken of an intertrabecular bar (i.tr); this large and important element is nearly as distinct in the Crocodile as in the Green Turtle (op. cit. pl. 2. figs. 6, 7, i. tr, pn). This agyous preputitary element helps the winged trabeculae to finish the foundations of the skull in front; it is a solid subfalcate plate or bar, with its convex margin above, and its concave outline below. The lower edge is thick, but subcultrate behind, where it is jammed in between the trabeculae; it projects a little into the pituitary space (py). In front (figs. 4 & 5, i.tr) this bar has become lessened, and it curves downwards behind the frontal wall of the head, as the prenasal rostrum (pn; see also "Fowl's Skull," pl. 81). The trabeculae do not end at the part where they embrace the intertrabeculae, but run along its upper part as thin laminae, and then break out, right and left, as the large adze-shaped orbito-sphenoids (Pl. LXIII. figs. 5, 6, and Pl. LXIV. figs. 1, 2, tr, i.tr, o.s).

These "anterior sphenoidal wings" form nearly half of the lateral part of the skull; they touch the small "posterior wings" (als) by their more extended hinder wing-tip, and by the lesser front tips they grow up to the nasal sacs (ol), walling in the "rhinencephalon" (fig. 6, C") on the outside. These elegant wings are convex above, near the middle, but become sinuous externally, their margin is convex above, before and behind it forms a concave line.

The large optic nerves (ii) escape behind the orbito-sphenoids, close to the part where the trabeculae flatten themselves against the intertrabecular wall.

The pituitary body (py) is still a racemose mass, behind which we see the hooked notochord (nc), the emarginate ascending wall of the investing mass (p.cl), and behind this the basilar artery (b.a).

The nasal capsules (Pl. LXIII. figs. 3, 4, and Pl. LXIV. fig. 1, ol) are scarcely cartilaginous as yet; but the auditory sacs have a more solid wall (Pl. LXIII. figs. 4, 6, 8, Pl. LXIV. fig. 4, and Pl. LXVIII. fig. 8, au); this is still distinct from the investing mass (iv). Each capsule is now of a pyriform shape, broad in front, narrower behind, and lobate on the inner face, whence the membranous labyrinth is giving off the rudimentary cochlea (chl). The horizontal and posterior canals can be seen from below, shining
through the walls (Pl. LXIII. fig. 4, h.s.c. p.s.c), and the anterior canal can be seen, partly, in the sectional view from the inside (fig. 8, a.s.c) in front of the “meatus internus” (viii).

In this stage we can thus trace the original elements of the chondrocranium; they are—(a) the basal plate (parochordals) and notochord, (b) the three prochordal bars, and (c) the olfactory and auditory sense-capsules; the eyeballs are not counted, because of their freedom from the rest of the skull, yet they affect its form very much by their bulk and shape.

The skull is finished above by a huge membranous roof (fontanelle), for even in the occipital region there is, at present, no solid cartilage above.

The ventral walls of the head are very contracted (Pl. LXII. figs. 3, 4), and only the first and second visceral arches are well developed, for the third has merely distal rudiments.

The first arch or mandibular (Pl. LXIII. figs. 3, 4, Pl. LXIV. figs. 1–4, and Pl. LXVIII. figs. 1 & 9, q, mk, ar) is composed of an epi- and a ceratobranchial element; but these parts are very large.

The first cleft (cl), seen in these dissections and sections, runs (already) in two directions, namely, obliquely inwards and outwards; inwards to form the rudiment of the complex system of Eustachian passages, and outwards to form the cavity of the drum—"cavum tympani."

At present the Eustachian opening is a mere lipped crescentic slit, with its concave border looking towards the postero-internal surface of the mandible (mn); its position in the throat is shown in the vertical section (Pl. LXIII. figs. 7, 8, cl); and its actual form and extent in the subhorizontal sections (Pl. LXIV. fig. 4, and Pl. LXVIII. figs. 1–3, cl).

Below the mouth, in some of these sections (Pl. LXIV. figs. 1, 2, and Pl. LXVIII. figs. 7, 8, mk), the free mandible is seen to be a solid, somewhat flattened, rod in all its fore part; but behind (Pl. LXVIII. figs. 5, 6, 9, ar) it is considerably dilated to form the articular head and the angular process. On that process the main part of the next arch, the "ceratohyal" (c.hy), rests, and not only rests, but is already fused with it, so that at this point the two arches are continuous. Below this conjunction (Pl. LXVIII. figs. 6 & 9, ar, c.hy) the angular process is seen to be short, and reflected downwards.

The quadrate cartilage, or mandibular pier (Pl. LXVIII. fig. 9, q), is very large, and its main part is crescentic, hooking in a falcate manner over the first cleft and the hyoid arch, along the fore part of the auditory capsule.

The hinder, concave, bevelled edge is already forming the front boundary of the tympanic cavity; its lower end is the solid rounded condyle for the lower jaw (ar, mk); but its front margin is developed into a thin and somewhat bilobate process, this is the "orbital process" so familiar to us in Chelonia and Birds; it is the common rudiment VOL. XI.—PART IX. No. 2.—October, 1883.
of the "pedicle," "ascending process," and "pterygoid cartilage;" the falcate postero-superior part of the quadrate is the "otic process" (ot. p).

I find no rudiments of the "ethmo-palatine," such as are seen in other Sauropsida; they are probably, when present, merely detachments of the "pterygo-quadrate," and not rudiments of a preoral arch.

The hyoid arch (Pl. LXVIII. fig. 9) is scarcely one fourth the size of the mandibular; it is also much more segmented, and corresponds very closely in its divisions with a branchial arch.

A side view (Pl. LXVIII. fig. 9) shows that there are four pairs of segments besides the basal rudiment, and of these, one, the "suprastapedial," is a special hyoid element not found in normal branchial arches; moreover, the distal piece of such an arch, the "hypohyal," is not distinct in the Crocodilia from the common basihyo-branchial plate. The uppermost segment or columella (co. = part of "pharyngo-hyal") is like a drumstick; its height is about three times as great as its thickness; it is narrow in the middle, and dilated at each end. The next is a short oval nucleus, the "suprastapedial" (s.st); this is a special Crocodilian segment. The third, or "epihyal" (e.hy), unites the pharyngo-hyal with the main piece; above, this small curved rod is attached by ligament to the uppermost piece 1.

The main bar, or "ceratohyal" (c.hy), is like a rib, with its "capitulum" and "tuberculum," and, like its proper homologue in the herbivorous Mammalia, carries the ephial; it is also tied to the columella; it lessens downwards, becoming terete, and is thoroughly fused below with the mandible, close behind the articulation with the quadrate (fig. 9, c.hy, q, ar); it is a gently sinuous bar. The rest of this arch, at present, is merely a median hyo-branchial tract (Pl. LXVIII. fig. 7, b.h.br); the hyoid part of which lies in front of the "first ceratobranchials" (c.br1), or paired "thyrohyals."

These segments are to be seen in the subhorizontal sections; in one which takes the notochord and investing mass through their common plane (Pl. LXIV. fig. 4), the relation of the mandibular and hyoid arches to the tympanic cavity (first cleft) and auditory capsule is well shown. The cavity widens as it passes forwards between the quadrate (q) and the auditory capsule (aw); a lesser space is seen passing behind at an acute angle from the front parts, and running behind the quadrate and the joints of the hyoid arch. A thin shaving of the columella (co) or pharyngo-hyal is seen running inwards so as to touch the auditory capsule; thus the top of the main part or ceratohyal (c.hy) is seen, and behind it the small ephial (e.hy) is cut through.

Another very similar section (Pl. LXVIII. fig. 3) is still more instructive; it is a little higher up, and the columella (co) is seen fitting into the side of the auditory capsule exactly as its counterpart (the hyo-mandibular) does in the Selachians. Here the "suprastapedial" (s.st) is cut across above the top of the ceratohyal (c.hy).

1 This separate "suprastapedial" has not turned up in any other type.
Part of a section, much like this, is figured in Pl. LXVIII. fig. 2; here the columella (co) dents the auditory capsule (au), the epihyal is just missed, and the head and shoulders of the ceratohyal (c.hy) are cut obliquely across.

But another section from a higher plane (Pl. LXVIII. fig. 1) is the most instructive; here the columella or pharyngo-hyal fits into a hole, the fenestra ovalis, which opens into the vestibule (vb); on the inside that cavity is growing into its cochlear diverticulum (ehl). Here the small curved epihyal (e.hy) is cut across, and also (outside and below it) the head and shoulders (obliquely) of the ceratohyal (c.hy). The fore part of the investing mass (iv), the body of the quadrate (q), and the first cleft (cP) are seen, as cut across, in this figure.

In a lower section (Pl. LXVIII. fig. 4) the quadrate cartilage is seen sending its long orbital process inwards and forwards; behind it the ceratohyal (c.hy) is cut across. In another figure (fig. 6) the ceratohyal (c.hy, ar) is seen as cut across at its junction with the angular part of the mandible.

In a still lower section (Pl. LXVIII. fig. 7) Meckel's cartilage (mk) is cut across, and behind it, at the middle of the floor of the face, we see the basihyo-branchial plate (b.h.br) with the rudimentary first ceratobranchial (c.br1); these are gently curved, rounded rods of cartilage. In the lowest of these sections (Pl. LXVIII. fig. 8) the larynx (la) is cut along; and here the curved thyrohyal or first ceratobranchial is cut in its curve so as to look like two pieces.

The very ichthyic condition of these arches seen in this stage will be found to be greatly transformed in the stages that follow.

The next stage will illustrate the further growth of the chondrocranium and visceral arches, and the first definite appearance of the investing bones.

3rd Stage. *Embryos of Crocodylus palustris, from 1 1/2 inch to 2 1/2 inches.*

a. *Chondrocranium.*

This stage (Pl. LXII. figs. 5–9, Pl. LXIV. figs. 5–11, and Pl. LXVIII. figs. 10, 11) follows very closely upon the last, but belongs to another species and genus.

I shall give all the details of the chondrocranium in the next stage, but in this the main things will be noticed; the cartilaginous framework is already perfectly formed.

The notochord (Pl. LXIV. figs. 5–8, nc) is now closely embraced by the parachordal tracts, behind, and the cartilage has formed a semilune, below, half embracing it; this is the transversely oval occipital condyle (oc.c). Then for three fifths of its extent the notochord is naked below, but it gains a superior position in front, the basal (parachordal) tracts having coalesced again beneath it. It escapes once more at the end, where it projects, inwards and upwards, into the neat circular pituitary space (py). The basal cartilage is dilated behind and in front of the auditory capsule, but is greatly

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pinched-in in the middle by the ingrowth of the cochlear pouches (chl). The large pre- and postauditory nerve-passage (v, ix, x) are very similar, and besides a pair of passages for veins, there is a small posterior hole, right and left, for the hypoglossal nerve (xii). In the fore half of the hind skull the cartilage is burrowed on its lower face by the converging internal carotid arteries (i.e.), which pass into the skull through the pituitary space on each side of the apex of the notochord. This space is at present filled with the gland-like racemose mass of the pituitary body (py); one of the “acini” is much larger than the rest, and is in the centre of the mass.

The lingular processes of the trabecula (tr) end as solid rod-like bars with bulbous and somewhat inturned ends, some distance outside the pituitary space. These rods converge, are separated by a space only equal to their own width, and then become flat and vertical, and run straight forwards. The space between them is filled by the solid rounded end of the elongating intertrabecular bar (i.tr); this bar is, indeed, a vertical plate, the orbito-nasal septum, and ends, in front, in the rounded (prenasal) rostrum (p.n); this median element grows lower down than the lateral bars.

The trabeculae only run up to the front third of the intertrabecula; they thicken a little, become thinner again, and are then enlarged into a solid wedge-like mass; these lobes are the “cornua trabeculae,” the “super-vomerine laminae” of my paper on the Fowl’s Skull (op. cit. pl. 83, fig. 4, s.v.l). The occipital and nasal roofs (Pl. LXIV. fig. 9, s.o, na) are now chondrified; the former are bounded by the auditory capsules (au), which appear on the upper surface, right and left.

b. Visceral Arches.

The mandibles and their piers are rapidly increasing in size (Pl. LXIV. figs. 8, 10, 11, and Pl. LXVIII. fig. 10, q, mk, ar); and the hyoid arch (Pl. LXVIII. figs. 10, 11) is now complete, and bears the same relation, in size, to the mandibular arch, that the branchial arches, proper, in Ganoid and Teleostean fishes do to the hyoid and the mandibular; but this sudden arrest of the postmandibular arches is attended with new specializations of the lessened elements; and the tracts of cartilage that do appear serve every purpose of the new functions to which they are dedicated.

The quadrate (Pl. LXVIII. fig. 10, q) has now developed an angular projection from the fore corner of its huge otic process (ot. p) above; the “orbital process” also is much more developed. The condition of this process here is very instructive; it is a well-formed rudiment of both the “pterygoid cartilage” (pg.c) and the “pedicle”—such a pedicle as exists in Triton and Salamandra, where the articular part of the pedicle does not coniclec with the basis cranii, but is merely a facet on the inside of the “ascending process.” Here the ascending process (a.p) is arrested as a flat triangular flap; in the ordinary Lizard it is a distinct, long, terete rod of cartilage (“Lizard’s Skull,” pl. 41. fig. 3, e.py), which afterwards ossifies as the “epipterygoideal columella.” In *Hatteria* (Günther, Phil. Trans. 1867, pl. 1. figs. 3, 4) it is a large flat piece; in both it has
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exactly the same position, and general anatomical relations, as the permanently non-segmented and unossified counterpart in the "Urodeles."

In the Turtle (Skull of Chelone, 'Challenger Reports,' vol. i. pt. 5, pl. 10. fig. 7) the small epipterygoid is at first a flap of cartilage hanging down from the apex of the orbital process of the quadrate, which afterwards becomes segmented and ossified; it corresponds with such a remnant of cartilage as is often seen on the pterygoid bone in adult Urodeles.

To any one familiar with the rich development of the visceral arches in Fishes, and aware that the mandibular is merely a highly modified visceral or branchial arch, these modifications will present no real difficulty. Morphologically speaking, the quadrate is an epibranchial, and the articulo-Meckelian rod a cerato-branchial element. Any separate cartilages developed between the antorbital and postorbital regions of the palate are merely to be looked upon as segments or dismemberments of the epibranchial piece—the quadrate. Above the Fishes, I know of no other segment in this arch that can with safety be called pharyngo-branchial, except the epipterygoid of the Lacertilia; I am doubtful even that of the Chelonia, which is developed differently; but the "ethmo-palatine" and "post-palatine" rudiments so well seen in the Axolotl ("Skull of Urodeles," Phil. Trans. 1877, pl. 24. figs. 1–3) are all (I now consider) to be looked upon as remnants of the huge "pterygo-quadrate" of the Shark.

The lower or articular part of the quadrate of the Crocodile is now closely embraced behind by the cerato-hyal (Pl. LXVIII. fig. 10, q.c, ar, c.hy), and the articular head of the mandible sends backwards a large, notched, angular process.

The hyoid arch (Pl. LXVIII. figs. 10, 11) is now perfect; the uppermost piece (or pharyngo-branchial element) has now become a long "columella;" it is only partially distinct from the cartilaginous operculum (base of "stapes") of the auditory capsule; in this the Sauropsida differ from the Amphibia, which have the stapes and medio-stapedial separate. Yet, as I have shown in my former papers on the Reptilian skull, the ring of thin cartilage embracing the dorsal end of the uppermost hyoid segment is partially a separate tract of cartilage, whose cells are much flatter and less characteristic of that tissue. I shall soon show that a separate bony centre is formed in the stapedial end of the columella (Pl. LXIX. figs. 2, 3); these parts are special developments of the hyoid.

As in the branchial arches, proper, of the Sturgeon, this pharyngo-hyal piece is subdivided; the proximal segment forms the base and stem of the columella (st, m.st), and a process to which the suprastapedial (s.st) is attached; the distal piece is the extrastapedial part.

The columella is comparable both to a pruning-hook and a scythe; it has two side handles, and ends in a broad blade with a thickened convex back. The back is turned outwards and upwards (fig. 10, e.st), and overlies the concave bevelled postero-superior edge of the quadrate cartilage; and the sharp concave edge looks upwards and inwards.
The shaft of the columella (medio-stapedial, *m/st*) turns inwards and a little backwards, and the dilated stapedial end fits into the oblique fenestra ovalis (see Pl. LXV. figs. 3 & 8).

Over the temporary and imperfect joint of the columella, but arising most from the upper part, we see a triangular ascending process (*s/st*) on which the large reniform *suprastapedial* (*s/st*) rests, and from the lower side, in front of the segmentation, the extrastapedial gives off a small curved spur, which is hooked backwards; this is the *infrastapedial* process (*i/st*). Attached to the descending process of the extrastapedial (infrastapedial) we see a small curved segment of cartilage; this is the “epihyal” (*e.hy*), a distinct piece, a distinct centre in the Ganoid and Teleostean Fishes.

This small epihyal conjugates the distal pharyngo-hyal piece, or extrastapedial, with the main hyoid bar, the ceratohyal (*c.hy*); it is attached to its “shoulder.” The main bar then descends as a considerable cartilage, but less than a fourth the bulk of the quadrate, and is fused with the mandible behind its articulation with the quadrate; this bar follows the curve of the quadrate.

We can describe the distal part of the hyoid arch in the next stage (see Pl. LXV. fig. 4), where it will be seen to be greatly developed as compared with what is seen in the second stage (Pl. LXVIII. fig. 7).

I shall take up the stapedio-hyoid chain again after describing the other parts of the skull in their various changes. But it will be necessary to reexamine the metamorphosis of this curiously modified *branchial arch* when I come to summarize the whole.

**c. Investing Bones.**

Before describing the investing bones I will call attention to the structure of the palate, as displayed in the lower view of the head of an embryo 2½ inches long, the lower arches of which had been removed. In this state (Pl. LXIV. fig. 7) the membranous palate has become very extensive, but the right and left selvedges have not formed a perfect seam. The hinder third is open, and in the front part of this open space the middle (or internal) nasal opening (*i.n*) can be seen, right and left of the fold of skin that covers the base of the orbital septum.

The hinder third of the notch is notched again; here the posterior narial opening passes into a rounded narrow median space, in which the right and left tympanic clefts (*cl*) meet. These sigmoid passages can be seen to terminate externally behind the quadrate cartilage (*q*).

Here we have the rudimentary condition of the double tympano-Eustachian labyrinth of the adult Crocodile. The Eustachian openings have melted into one at the mid line as in the "Batrachia Aglossa" (see Günther’s "Batrachia Salientia," 1859, p. 1, and my "Batrachian Skull," part 2, Phil. Trans. 1876, pl. 59. fig. 2). In the earlier stages (Pl. LXIII.) the Eustachian openings (*cl*) are far apart, as in the Batrachia, generally.
When the head, at this stage, is carefully peeled and stained, fine reticulations of young bone-cells can be traced (Pl. LXIV. figs. 8–11); these lie along the appointed lines, and can be named accordingly.

The brim of the cranial basin is pyriform, the narrow end being in front (Pl. LXIV. fig. 9); narrow, reticulated strips of young bone now lie along the rim and also further outwards.

The parietals are half the length of the frontals (f, j); the latter are sigmoid and the former crescentic. Outside the parietals we see the postorbitals and the squamosals (pt.o, sq), and in front of the eyeballs the small arcuate prefrontals (p, f). Over the nasals sacs (na) the small nasals (n) lie; they are pyriform, with a sharp end in front; outside these are the oblong maxillaries (mx), and margining the fore face the premaxillaries (px).

The two latter pairs of bones are also well seen from below (fig. 8); within the boundary formed by these we see a pair of fine curved styles that lie behind the middle or inner nares (in); these are the vomers (v), their convex outline is inwards.

So also is that of the much larger palatine bones (pa), whose thick fore end is turned outwards towards the maxillaries; the transpalatines (t, pa) and the pterygoids (pg) bound the hinder margin, externally and within, of the subocular palatine fenestra. The transpalatines are angular and apiculate; the pterygoids are thick in their inner part, and falcate. Outside the sharp fore end of the transpalatine, lies the sharp jugal style (j), and overlapping it the smaller quadrate jugal (q, j). Bony traces resting on the maxillary below and in front of the eyeball form the rudiment of the lacrymal, and five tracts of young bony tissue are appearing on each free mandible (figs. 10, 11, d, sp, cr, s.ag, ap); the two first of these, the dentary and splenial, are the longest; the coronoid, supraangular, and angular are shorter, and invest the high hind part of the bar.

I have not succeeded in finding any more investing bones than these, in the more advanced stages, except the “basitemporals,” and I have not found any endocranial centre at this date; therefore the investing bones appear first, and are almost exactly synchronous. These bony tracts would weigh, together, scarcely more than a grain; they are sufficient, however, to form the seed-plots, as it were, of the “osteoblasts” that are needed to develop the heavy bony vegetations that become the outwork of the skull of the adult Crocodile.

4th Stage. Embryos of Crocodilus palustris, 3½ inches long.

a. Chondrocranium.

In this stage I am able to show the perfected chondrocranium before ossification sets in and the visceral arches with that process just begun.

The hind skull is now only half as long as the prochordal part; this is mainly due to the rapid elongation of the intertrabecula and the nasal capsules (Pl. LXV. figs. 1–4).
The single occipital condyle (oc.c) is an elegant crescent, embracing the notochord (nc); much of that rod is naked behind on the lower surface, but is invested in front, and is only seen again at its apex in the back of the round pituitary space (py). The whole of the hinder chondrocranial walls are very distinct from the larger lobulated auditory capsules (au). Here the hypoglossal nerve (xii) passes through the "posterior condyloid foramen" (Miall).\(^1\)

The cochlear diverticula of the auditory capsules (chl) have coalesced with the basal plate (iv); but laterally, and above, the occipital arch is quite distinct from them, and where the ninth and tenth nerves (ix, x) emerge there is a large oval open space. Above, the supraoccipital cartilage roofs in three fourths of the hind skull, forms a flange on each side to the back of the auditory capsules, has concave lateral edges and then spreads out again, but to a lesser degree, in front of the capsules. The ascending fore end of the double basal plate is now a continuous slanting wall of cartilage leaning over the pituitary space behind (fig. 1, p.cl, py). From this wall a flying buttress is thrown across, right and left, and this buttress passes into the thickened coping of the alisphenoidal wall (al.s). That thickening is developed behind into a crescentic horn, which embraces the front outer corner of the auditory capsule; this process is very thick and strong below (fig. 2), and the two hold, like opened tongs, the swollen front lobes which have the anterior ampullae (a.s.c) inside. The thick top of the alisphenoidal wall (al.s) runs beyond that limited part, and curving round, passes into the hind corner of the orbitosphenoid (o.s); thus there is below a large "orbito-alisphenoidal fenestra" (o.al.f). Below each flying buttress, sent out from the postclinoideal wall, there is a large recess; it has the auditory capsule above and outside it, and the basal plate (iv) bounding it below and towards the middle; this is the huge primary "foramen ovale" (v) for the trigeminal nerve and Gasserian ganglion. In front and below, the alisphenoid (al.s) grows downwards, margining the pituitary cup above, and by a thick inturnd process uniting with that cup as a partial rim. There is, then, inferolaterally, a lesser crescentic fenestra, the "lower or alisphenoidal fenestra" (al.f); this transmits the lesser preauditory cranial nerves. The rest of the alisphenoid is a narrow convex band, which runs forwards and inwards, and is confluent with the postero-inferior angle of the orbitosphenoid (o.s); where these two bands converge to join the orbitosphenoids, there, on the upper surface, we see the foramina for the optic nerves (fig. 1, ii); these are separated by the sharp top of the intertrabecular bar (i.tr).

The long rod-like structure which forms the base of the prepituitary region of the skull encloses the front and sides of the circular pituitary space, below, by its forks; these short forks are mamillated at their end, and project from the general surface of the cartilage. They converge rapidly to embrace the intertrabecular bar, which is

\(^1\) In my former papers on the skulls of the Sauropsida, led by the analogy of the Mammalia, I have considered the anterior condyloid foramen as the passage for the hypoglossal nerve. I suppose that dissection would show that I have been in error.
now more than twice as long as the parachordal tract. The whole base gradually lessens forwards, but at its middle, in the ethmoidal region, the lateral elements (trabeæ, tr) cease. The intertrabecula then enlarges somewhat, gradually lessens again, and ends in front of its own crest, the septum nasi, in a spearpoint-like process, the prenasal rostrum (p.n), which turns a little downwards, and projects slightly beyond the nasal labyrinth.

The flattened trabecula, after giving off the orbito-sphenoidals (o.s), swell into a short solid wedge; the two wedges fill in the space between the hind lobes of the nasal capsule below: they are the cornua trabeculae (c.tr). These cornua in short-faced forms, such as the Amphibia, spread into the forehead; here, in the race of growth, they are left midway by the fast-growing intertrabecular bar.

The trabecula almost touch each other above, where they give off the orbito-sphenoidal wings (fig. 1, o.s); these together form a lozenge-shaped hammock for the fore brain to lie on, and, whilst ending in a sharp point on each side in front, are tied by strong cartilaginous tapes to the posterior wings, or alisphenoids (al.s).

The large pyriform anterior fenestra, and the small oblong fenestrae behind them, bring this skull very near that of the Lizard ("Skull of Lacertilia," Phil. Trans. 1879, pl. 43). The ethmo-nasal crest of the middle bar (p.e) is exposed in its hinder part, in front of and between the orbito-sphenoids; it there forms a sort of "crista galli" between the olfactory lobes, that rest upon a concave part of the roof of the nasal capsules. This hinder, more swollen part of these capsules corresponds to the ethmoidal region in the Mammal, but is very simple within. After a sudden contraction the nasal roof and walls are enlarged again, sinuously, but, on the whole, are gently lessened up to their fore end. The olfactory nerves pass through a single hole on each side behind the higher part of the roof in the front of the rhinencephalic recess. The walls in the true nasal, as well as in the ethmoidal, region, pass across, below, and form a very complete floor, becoming confluent (as I shall show in the next stages) with the intertrabeculae for some extent.

In front, they are bulbous below, and the semi-distinct alæ nasi (al.n) form two upper bulbs twice as large as those below; these latter are perforated in their middle (above). This crescentic passage, with its horns looking backwards, is the external nostril (e.n). Here the connate, circular, valvular fold is so specialized as to open on the upper surface of the head, whereas the primary position of the opening is below.

The auditory capsules (au) are only confluent with the rest of the chondrocranium below; they are very large, and have lost much of their original ovoidal shape. The semicircular canals (a.s.c, h.s.c, p.s.c) are large and shine through the unossified cartilage; so also do the other processes of the membranous labyrinth. A large pyriform tract of each capsule is seen on the upper surface of the skull; its narrow end is in front, and that part projects outwards, and is produced into an angle.
Below (Pl. LXV. figs. 2, 3), the sigmoid cochlear rudiments (chl) grow towards the notochord; seen obliquely (fig. 3), there are two fenestrae, both oval in shape; that which is on the inside opens into the cochlea ("fenestra rotunda," f.r), and that which is on the outside opens into the vestibule (f. ovalis, f.s.o); the narrow tract of cartilage between these passages is afterwards ossified by the "opisthotic bone."

Before the anterior semicircular canal opens into the posterior it enlarges (fig. 3, a.s.c, p.s.c), so as to have the appearance of one large arch with an "ampulla" at each end.

b. Visceral Arches.

The inferior arches (Pl. LXV. fig. 4, July 24th, and Pl. LXVIII. figs. 12, 13, 14, July 20th) are now well developed, and bony shafts are forming in some of the rods on each side. The anterior angular process of the quadrate (Pl. LXV. fig. 4, g) is still larger, and so is the orbital process, which is now at its fullest development—in this type; it shows a rudimentary ascending process and pterygoid cartilage (a.p, pg.c). The main body of the quadrate is now elegantly scooped, from the solid part to the hind border, so as to form a crescentic hollow, enlarging the tympanic space. The rounded lower part above the condyle is enringed with an ectosteal tract, the quadrate bone; the condyle is hemispherical at present. The joint was dislocated in the specimen figured, and the columella appears too low down; the other figures (Pl. LXVIII. figs. 12, 13) of a younger embryo correct this. The saddle-shaped facet on the lower jaw is well formed, and there is a considerable angular process. The Meckelian rod (mk) gradually lessens to half the thickness it has, proximally, and then turns outwards, and is somewhat flattened at the end; it is long and gently arcuate. Between the right and left rods, in front, there is a wedge of cartilage interposed, the most distinct basal piece ("basimandibular") I have yet seen1, except in the Green Turtle (see Turtle's Skull, op. cit. pl. 3. fig. 6).

Noting a long facet of cartilage on the outside of the descending plate of the pterygoid bone (Pl. LXV. fig. 8, pg.c'), I suspected that it would have its counterpart in the mandible: it has (see Pl. LXV. fig. 4, cr.c). This is the rudimentary "coronoid cartilage," a large structure in the Lepidosteus and in Amia calva, but in them it forms part of the mandibular rod. The "pterygoid cartilage" (pg.c') or facet on the descending plate of the pterygoid bone is another equally instructive segment; besides this separate piece the lower horizontal fork of the quadrate (pg.c) shows a continuous remnant of the large forth-growth pterygoid process of the Urodeles and the Selachians. The oval patch attached to the inner face of the coronoid bone (see Pl. LXVI. fig. 2, cr, cr.c) plays upon the patch above. The stapedio-hyoid chain is shown in situ in Pl. LXV. fig. 4; it is figured from a somewhat younger embryo, and detached (Pl. LXVIII. figs. 12, 13, 14); in that dissection I was able to make out a true

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1 My friend Mr. Charles Stewart long ago pointed out to me this conjugation and dilatation of the distal ends of the mandible in the embryo Crocodile.
“cartilaginous annulus tympanicus” \(a.ty\), with long cells, however, like those of the stapedial base of the columella. This is quite like that found in \textit{Chelone viridis} (“Turtle’s Skull,” \textit{op. cit.} pl. 10. figs. 10, \(a.ty\)).

The main part of the hyoid arch, the ceratohyal \(e.hy\), is still perfectly continuous with the mandible, and immediately in front of its confluence, on the outside, a diverticulum of the tympanic cavity is growing downwards into the substance of the articular cartilage; this is the “siphonium” \(sph\), forming, already, the large air-cell of the lower jaw. There is still a joint between the ceratohyal and epihyal \(e.hy\), below; and between that small, curved, normal segment and the extrastapedial \(e.st\), above. That part of the columella is still distinct from the mediostapedial \(m.st\), which, contrary to rule, gives off the suprastapedial stem. This latter process \(s.st^1\) is a flat triangular blade, with its broad end outwards, and is, now, confluent with the suprastapedial segment \(s.st\); the seam is still visible. The suprastapedial is a bilobate thick flap, notched above, and its outer edge ribbed. The extrastapedial \(e.st\) is a large falcate plate with a thickly ribbed edge above. The mediostapedial and this thick edge is turned almost directly outward, so as to make this part seem like a mere rod. But this is only the back of the upper part, for the plate grows inwards and backwards, and ends below and behind in a notched angle; to this posterior notch the epihyal is articulated; the long, convex, postero-internal part of the extrastapedial has a neatly thickened selvedge; the top of the extrastapedial is somewhat dilated.

At present the mediostapedial shaft, only, is ossified, \textit{not the base}; the bony tract stops, distally, where the suprastapedial is given off: this bone corresponds to the “hyomandibular” of a Teleostean or a Ganoid fish; the unossified proximal end is always a separate cartilage \(stapes\) in the Amphibia; it is never differentiated in Fishes so as to fit into a “fenestra,” although the hyomandibular pushes far into the side of the auditory capsule in the Sharks (see Gegenbaur, plates 11 and 12).

5th Stage. \textit{Embryos} of Alligator mississipensis, 4\(\frac{1}{2}\) inches long, and of Crocodilus palustris, 4\(\frac{1}{2}\) and 5 inches long.

\textit{a. Endocranium.}

Again, before describing the endocranium, I may point out the progress made in the development of the tympano-Eustachian cavities. In the palatal view, with the inferior arches removed (Pl. LXV. fig. 5), we see that the seam along the middle of the palate is just becoming perfect; it is open, however, behind, and the posterior nares \(p.n\) open, still, scarcely behind the middle of the head; but in the back of the recess into which they open there is a neat round hole with a swollen edge, before, and at the sides. Looking well within this hole we see three lesser passages, one in front and one right and left. A bristle is shown passing from one of the side holes.
over the mucous membrane obliquely, outwards and backwards; it reappears in a
curved hole behind the quadrato hinge (q.e); these passages are the median and lateral
Eustachian tubes and the tympanic cavities (m.eu, l.eu, cl').
In the sectional views (Pl. LXV. figs. 6, 7) the air-cavity in the hind part of the
basisphenoid (b.s) is shown, but not the opening below, as the section is more than half
of the head; in fig. 6 the opening into the tympanic cavity (ty.c) is shown. These
passages will be illustrated in their further development in the later stages.
The chondrocranium (Pl. LXV. figs. 6, 7, 8) is very similar to what has been described
in the last stage; but some of the main bony tracts have appeared in the hind skull.
The first of these is the basisphenoid (b.s), which reaches more than halfway from the
condyle to the pituitary space (py), but leaves a considerable tract of cartilage, behind,
untouched.
The exoccipitals also (Pl. LXV. figs. 7, 8, Pl. LXVI. fig. 3, e.o) are now climbing up
the sides of the occipital arch; they are a good distance yet from the basal piece (b.o),
reach nearly to the top of the foramen magnum, and just touch the opisthotic region
in front; the supraoccipital and the periotic regions are not ossified.
The next bone is the basisphenoid (b.s); this occupies the bottom of the pituitary
cup, and runs backwards a little below; it is not of greater extent than the sphen-
occipital synchondrosis behind it, and it does not reach far into the "postclinoid
wall" (p.cl).
The description just given of the chondrocranium of the last stages might serve also
for this, except that the passages for the lesser cranial nerves are more perfectly
bounded by cartilage (Pl. LXV. figs. 7, 8, between ii and v); in this stage I have
studied the skull by sections. Here, also, I have figured the auditory capsules on
the outer and inner sides, in lateral views (Pl. LXV. figs. 7, 8), and the nasal capsules
have been worked out both by dissections and sections. The auditory capsules
(Pl. LXV. figs. 7, 8) are quite unossified; they form relatively very large pyriform
masses, with sinuous surfaces arising from the form of the membranous labyrinth
within.
On their inner face (fig. 7) where the anterior canal dilates at its junction with the
posterior, there is a crescentic aperture whose concavity looks upwards and backwards;
this is the remnant of the original involution (aq.e). In front of this there is a large
arched swelling caused by the anterior canal, and behind it another of less extent
called by the posterior canal; these are also seen on the outside (fig. 8, p.s.c). A
gently sulcate tract separates the arched part on the inside from the swelling caused
by the "sacculus;" then comes the shallow meatus internus, with one upper and two
lower passages; the foremost of these latter is for the facial nerve (vii), the others for
the auditory (vii). Mesiad of these there is the swelling caused by the cochlea, best
seen in the outer and lower views (Pl. LXV. fig. 8, and Pl. LXVI. fig. 3, chl) The
large pre- and postauditory nerves (v, ix, x) pass through deep foramina, fore and aft;
DEVELOPMENT OF THE SKULL IN THE CROCODILIA.

a deep groove runs down inside between the fore edge of the capsule and the out-turned selvedges of the hooked, overlapping alisphenoid (al.s). In section (Pl. LXVII. fig. 8) the auditory capsule is seen to be very distinct from the wide, swelling plate below—the double parachordal, with the uniting notochord and its ossifying sheath (b.o, iv, nc).

This section is in front of the supraoccipital cartilage; it cuts through the falcate otic process (ot.p) of the quadrate and its lower or articular part (q); the articular part of the mandible (ar) is seen in situ. Fitting into the fenestra ovalis (fs.o), the columella (m.st) is seen, behind it a narrow tract of cartilage is cut through, and then there is another opening, the fenestra rotunda (fr). This section is through the mouth of the cochlea, and thus seems to show the two fenestrae as opening into one cavity. The fore part of the sacculus (vb) is cut across above and within, and above it, in the crest of the capsule, the neck of the first ampulla (a.s.c). The columella has its medio-stapedial part (m.st) ossified, and its extrastapedial end (e.st) is seen rising outside the otic process of the quadrate. We must look further back for any rudiment of the "tegmen tympani" (Pl. LXV. fig. 8); it exists here merely as the projection of the canals.

The fenestrae in the walls of the skull differ from those in the Bird, and are of less extent than those in the Lizard; in the former the alisphenoid itself is fenestrate; here there is a large space between the orbito- and alisphenoids, well margined above by a band which is not found in the Bird; whilst a smaller band below divides that from another smaller fenestra between the hind part of the orbito-sphenoid and the presphenoid.

As I have just shown, the alisphenoid, instead of lying far from the auditory capsule, as in the Lizard, clings close to it, here, and is only separated from it by a chink. The postspenoidial region is cut through in another section (Pl. LXVII. fig. 7) just at the back of the pituitary cup (py), which is seen to have some "acini" of the "gland" in it. Here the ossification (b.s) has reached the cup (Pl. LXV. figs. 6, 7, b.s); but the part where the parachordals pass into the prochordals, laterally, is unossified; here the alisphenoids (al.s) are seen to be direct continuations of the basal (parachordal) plate. Above, the fenestra is cut across at its hind part, and the upper band (u.o.al) is strong and incurved.

The front angle of the otic process of the quadrate (ot.p) is seen in section, outside and below that band.

In the next section, through the front of the pituitary cup (Pl. LXVII. fig. 6, py), the apices of the trabeculae (tr) are cut across, close in front of the growing basisphenoid bone (b.s). The optic nerves (xi) are severed close below the lower band of cartilage, the lower orbito-alisphenoidal band (l.o.al); and above, at some distance, the upper band (u.o.al) is severed, where it is thickening towards its fore part.

Meckel's cartilage (mk) is seen in section also. In front of the pituitary body
Near the optic nerves (fig. 5, 11) the three elements are well fused together, but further forward (Pl. LXVII. fig. 3) they are seen more distinctly. The trabeculae (tr) are very much flattened against the sides of the large, median, crested bar (i.tr), but at its upper part they thicken, and pass upwards, and a little outwards as the two orbito-sphenoidal plates (o.s); these are convex inside, below, and outside, above, and form a trough for the rhinencephala (C\(^b\)). Further forward (Pl. LXVII. fig. 2) the orbito-sphenoids (o.s) are separated from their root by a tract of membrane, and here the cornua trabeculae (see fig. 1, c.tr) begin. Still further forward (Pl. LXV. figs. 6–8, and Pl. LXVII. fig. 1, c.tr) we see the thick wedge-like ends of the cornua (c.tr); beyond these the whole bar is formed by the intertrabecula (i.tr); this section is through the lower part of the wall, under the olfactory lobes, and through the fore part of the orbito-sphenoids (o.s). The ethmoidal, or true olfactory region of the nasal capsule, forms a pair of irregularly pyriform pouches (Pl. LXV. fig. 8, and Pl. LXVI. figs. 9, 10, al, e), which are covered only by membrane for some distance. I find no “ethmo-palatine” rudiment upon the “pars plana” (p.p), or antorbital face of these pouches. Inside, both in the front of the ethmoidal region and in the back of the proper alinasal territory (Pl. LXVI. figs. 9, 8), there is an outgrowth of the cartilage which encloses, for some extent, two lesser spaces; this is the “inferior turbinal” (i.tb) in a very rudimentary condition; and the “upper turbinal” is represented by a fold above this (fig. 9, u.tb). At this part and in the next section (Pl. LXVI. fig. 7) the floor of the nasal capsule is free from the base of the septum (s.n); but in the next (fig. 6), a short distance behind the outer nostrils, the nasal floor and septum (n.f; s.n) are confluent, like the nasal roof (al.n); the wall here is incomplete. When the nostrils are cut through (fig. 5) we see an upper cartilage or alinasal (al.n) confluent with the swelling floor in front of the septum; here the prenasal rostrum (p.n) or sagittiform end of the intertrabecula is cut across; it is nearly circular in section.

b. **Visceral Arches.**

The quadrate or upper part of the first visceral arch (Pl. LXV. fig. 8, and Pl. LXVI. figs. 1, 3, q) is very large, and is partly ossified.

The otic process (Pl. LXV. fig. 8, ot.p) has a rounded anterior knob, and a falcate hinder lobe which overhangs the first cleft. The anterior limb or “orbital process” has (in this species) scarcely any ascending process, but the pterygoid cartilage (p.g.c) is long and pointed. The body is scooped behind, and a large semicircular notch is formed.
by the hind border; the articular part becomes an oblong sinuous condyle passing across, and a little forward, externally (Pl. LXV. figs. 5 & 8, q).

The quadrate bone (q) possesses the body of the cartilage, but not its outgrowths or processes; it is not pneumatic at present. The free articulo-Meckelian rod or mandible (Pl. LXV. fig. 8, ar, mk) is nearly as long as the skull, has a saddle-shaped condyloid facet (ar.c), a rounded angular process, a bony centre, the "articulare," and a long, terete, Meckelian rod, which is confluent with its fellow in front (Pl. LXVI. fig. 5, mk, b.mn).

In the coronoid region there is a small, notched, squarish plate of cartilage, the "coronoid cartilage" (or.c); the rudiment of the continuous coronoid crest of the mandible in *Lepidosteus* and *Amia*. Meckel's cartilage is thickest in the middle, and is attenuated at each end.

Another remarkable rudiment (or remnant) is seen in the upper part of the first arch; this is an extrapterygoid facet (Pl. LXV. fig. 8, and Pl. LXVI. figs. 1 & 3, pg.c); this is a tongue-shaped tract lying along the outer edge of the pterygoid bone, where it glides against the mandible; it is a partial reappearance of the large ichthyic pterygoid outgrowth.

I shall describe the hyoid arch in both the Alligator and Crocodile in this stage, which gives a stapedio-hyloid bar, almost precisely the counterpart of that of *Hatteria* (Pl. LXVIII. figs. 15, 16, Pl. LXIX. figs. 1–3; see also Huxley, Proc. Zool. Soc. 1869, p. 397, fig. 4).

In the Alligator (Pl. LXVIII. figs. 15, 16) the stapedial disk of the columella is very large and oval; it has its own basistapedial centre (st) on the inside of the disk. The mediostapedial bone (m.st) is dilated on the outside of the disk, and forms a shortish and slightly curved shaft, which reaches nearly to the distal dilatation of the columella; the segmental line seen at this part, in the earlier embryos, is gone. The bar itself is continued upwards and forwards, but grows into a large fan-shaped crest, with a ribbed free outer edge; this is the extrastapedial process (e.st). From its thick (axial) back, near its base, the suprastapedial process (s.st) is given off; it is like a half-open fan, and grows upwards, inwards, and backwards (see Pl. LXV. fig. 8). Coalesced with this, but with the line of junction still evident, we see the suprastapedial cartilage (s.st), an ear-shaped flap, twice as large as its stalk, and having its narrow lower end free. A notch on the outer side of the broad, lower end of the extrastapedial receives the short, curved epihyal (e.hy), and this is joined to a notch on the hinder side of the broad upper end of the ceratohyal (c.hy), now membranous in its lower half, and therefore quite free from the mandible below. These parts are all continuous (see also in the irregular hyoid of another specimen, Pl. LXVIII. fig. 16), and only show the old seams of segmentation.

The most perfectly Hatterian condition is seen in the hyoid arch of an embryo Crocodile taken on July 27th (Pl. LXIX. fig. 1). In this elegant stapedio-hyoid structure the stapedial base (st) has its own inner, osseous centre, and a stout bony
mediostapedial rod (m.st), whose dilated base is nearly of the same length as the outstanding bony bar. The two foliaceous outgrowths of this remarkable “pharyngohyal” grow, the one inside, upwards, backwards, and inwards; and the other outside, forwards, upwards, and outwards, very obliquely.

The broadening curved blade of the suprastapedial stalk (s.st') has its outer face ribbed, and its broad, backwardly turned top confluent with the auriform suprastapedial segment (s.st), whose upper part is bilobate, its lower part rounded, and its proximal edge thick and solid. Together these parts describe an accurate semicircle by their lower edge.

The extrastapedial (e.st) is seen somewhat edgewise (see also fig. 2); both its inner and outer edges are ribbed, and the latter dilates into an elegant crescentic hook, above. Below, this process becomes twisted, narrower first, and then dilated into an oval interstapedial (i.st) disk, where it is confluent (with a trace of the junction left) with the arched band below, the epihyal (e.hy). This in turn is confluent with the ceratohyal (c.hy), but shows the joint. That joint is behind the broadened head of the lower bar, which is gradually attenuated, until it becomes a ligament, attached to the original point of confluence with the mandible.

This is not all; for the ceratohyal itself is half segmented in the middle; the lower part it will soon degenerate into a fibrous tract.

A week later on (August 4th) brings us towards the later changes of these parts (Pl. LXIX. figs. 2, 3), here the parts are also seen from the outside, but drawn out so as to display them better.

The oval stapedial plate, with its inner, central, growing bone (st), is very large, and has a rounded edge for the fenestra ovalis; the shaft, as in the last, is seen to arise much above the middle.

This almost straight, slowly attenuating rod, ends below the outgrowing distal, leafy growths; the suprastapedial (s.st) is figured within, and the extrastapedial (e.st) without.

All the old seams, or lines of segmentation, have opened again, with the exception of that across the columnella (see Pl. LXVIII. figs. 10–14); this is like the dehiscence of “carpellary leaves” that begin in the bud as distinct members of the innermost whorl of a flower, then unite, and reopen, afterwards, to shed the seeds.

The main distal plate, extrastapedial (e.st), is like a bill-hook, but is dilated in an arcuate manner above and below; there is an articulation to the curved segment (epihyal, e.hy) which articulates below with the ceratohyal on one side of its dilated upper part; the lower part is lessening fast. The suprastapedial segment (s.st) is now clearly distinct again from the suprastapedial stem (s.st'); it has developed a pedate process inwards from the point of junction above.

The distal part of the second and third visceral arches of the embryo Alligator (Pl. LXV. fig. 9) shows a dilated basihyo-branchial plate (h.br), which is broad in front,
notched behind, and has two rounded notches antero-externally; there is but little evidence of a hypohyal rudiment, except the dilated sides of the plate in front of the "first ceratobranchials" or thyrohyals (c.bri); these latter are inbent rods, largely ossified.

c. Investing Bones.

These were worked out in the largest embryos of the Alligator (Pls. LXVI., LXVII.); they are already very characteristic of the type, and are much in advance of what has been described in the third stage. The main fontanelle (Pl. LXVI. figs. 1 & 4, fo) is very large as yet; the parietals (p), only flank its sides as small ear-shaped plates; they have a projecting angle inwards, and look like squamosals. The frontals (f) form a sort of "beading" round the large orbits; the upper part is a narrow, crescentic band, gently widening from behind forwards. The largest part is the concave orbital flange, turned inwards along the whole length of the bone. The frontals overlap the parietals behind, and are overlapped by the prefrontals in front.

The latter bones (p.f.) are convex and ear-shaped, with a scooped hind face against the eyeball in front; the two are their own width apart on the top of the head.

In front of these are the nasals (n); they are almost oblong, but are narrow in front; they have a concave fore margin obliquely fitted to the alæ nasi (al.n), and are pointed there at their inner edge.

The premaxillaries (px) form together a semicircle, broken in the middle, where there is a gap between them, showing the prenasal cartilage (p.n); these and the maxillaries have a double wall, a deep common alveolar groove, and fast-growing teeth in it.

On each side of the alveolar groove the maxillaries (mx) are well developed both externally and within; in the former region there is a large facial plate running from the premaxillary in front to a line below the optic nerve (ii) behind; this suborbital part is narrow, scooped above, and pointed at the end. The palatine edge of the premaxillary is small, that of the maxillary is a large ingrowing plate, widest in the middle, but half its own width from its fellow. Between the maxillary and the prefrontal there is a small triangular bone applied to the lacrimal involution; this is the lacrymal bone (l). Close behind it there is a styloid bone, curved upwards in front, downwards behind, and having at its hinder third an ascending triangular process; this is the jugal (j). A similar process comes down from a bone above, finishing the postorbital rim; this is from the postorbital bone (p.ob), the upper part of which is a crescentic shell with an outer and an inner toothed process. The relation of the postorbital to the parietal is antero-external; it clamps the frontal, parietal, jugal, and squamosal. The latter bone (sq) is a large convex trowel, with its "handle," in front, overlapped by the postorbital.

These two bones are separated from the skull-wall by a deep chink—the temporal space; but, behind, the squamosal strongly clamps the auditory capsule, and by its...
sinnous lower edge it forms a large overlapping eave to the tympanic cavity; this is oblique, dipping backwards.

The jugal does not finish the facial series of splints in the Crocodilia; another bone, the quadrato-jugal \((q,j)\), overlaps the quadrate, and is in turn overlapped by the styliform jugal; the shape of this bone is falcate, its sharp blade running obliquely upwards and forwards, strongly binding the antero-inferior region of the quadrate \((q)\).

The palatine region (Pl. LXVI. fig. 3) is now becoming well floored with bone; but there is a large trowel-shaped tract of the chondrocranium unfloored in the middle; its narrow end is behind, and it is lost between the pterygoids \((pg)\). The palatines \((pa)\) are here nearer each other than the maxillaries; but the vomers \((v)\) and the basal bar \((p.e,p.s)\) can be seen between them at their closest part. The amount of bony deposit in these investing tracts, and its relation to the endocranium is to be seen in the sectional views (Pls. LXVI., LXVII.); but these views are most important for elucidating the palatine region. Seen from below (Pl. LXVI. fig. 3) the palatine bones are like falcate blades, with their broad fore end applied obliquely to the gently scooped margin of the palatine plate of the maxillary, right and left.

The outline of the palatine bones is convex in front and externally, convex also along their inner edge, and also notched there in front, and concave on their postero-external margin; their hinder part is a sharp hook turned outwards.

Their exposed upper surface (Pl. LXVI. figs. 1 & 4) is of less extent than the palatal part; their outer edge is thickening into a rather solid tract of bone. All this will be better understood by reference, also, to the sections (Pl. LXVI. fig. 10, and Pl. LXVII. figs. 1, 2, \(pa\)); in these also will be seen the thickness, width, and relations of the vomers \((v)\).

These latter bones (Pl. LXVI. fig. 3) are long, flat styles, curved, and placed back to back. In front (Pl. LXVI. fig. 9, \(v\)) they are V-shaped in section, but afterwards flat, and having their plane dipping towards each other (fig. 10, \(v\)). They overlap the maxillary palatine plate at their folded fore end; behind, they reach the pterygoids \((pg)\). These latter bones (Pl. LXVI. figs. 1 & 3, and Pl. LXVII. figs. 5–7, sections) are two coadapted wings of bone, binding the palatine series well together, and forming a strong underfloor to the basisphenoidal region of the skull. The pterygoid suture is imperfect before and behind; in front, the slightly diverging processes are subtubular, and enclose the narial passage (Pl. LXVII. fig. 6, \(pg, i.n\)); this is where the palatines \((pa)\) end. Then (Pl. LXVI. fig. 3, and Pl. LXVII. fig. 7, \(pg\) these bones spread out into broad wings, a rounded notch lying between their widest expansion and the basi-cranial hinder part. The hind margin of the two bones is notched in the middle, then sinnous, and then becomes dilated outwards and backwards to embrace the fore part of the auditory capsules and their enclosing bony plates, the “basitemporals” \((b.t)\). The outspread fore wings of the pterygoids (Pl. LXVI. fig. 1, \(pg\) descend as well as diverge, and are finished externally with a blunt retral hook. This part is ridged in the middle,
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supero-externally, and scooped fore and aft; against this ridge lies the crescentic cartilaginous facet already spoken of; the direction of both is with the convex edge looking forwards and downwards. A bone, with the outline of an hourglass, fits by its top to the inside of the maxillo-jugal suture, and by its base lies under the fore part of the pterygoid wing, obliquely; this is the “os transversum” or “transpalatine” (t.pa), with the maxillary and palatine it forms a large oval “palatine fenestra.”

All these bones were to be seen in the third stage; but between the pterygoid and the unossified auditory capsules, right and left of the basisphenoid, there is a pair of new investing bones; these are the “basitemporals” (Pl. LXVI. fig. 3, b.t); they are uncinate shells of bone with a thin, toothed hinder margin, and they form a floor to the cochlear pouch (chl). These were first found and described by me in the Chick (see Trans. Zool. Soc. vol. iv. p. 280, and Phil. Trans. 1869, pls. 72-77, b.t); I have not been able to find these “parostoses” distinct in any other kind of Reptile; in the Mammalia they are manifestly represented by the “lingule sphenoidales,” and these have their largest development in Cavia cobaya.

The parostoses of the mandible (Pl. LXVI. figs. 1, 2) are now well developed; the dentary (d) is by far the largest, the splenial (sp) is a very long splint, the coronoid (cr) is a small angular patch applied to the inner face of the “coronoid cartilage” (cr.c), and the supraangular and angular (s.ag, ag) are styliform, and send their long sharp ends forward, over and under the mandibular fenestra (mn.f), which is large and oval; these mandibular splints are also figured in the sections (Pls. LXVI., LXVII.).

6th Stage. Embryo of Crocodilus palustris, taken August 8th, 5½ inches long.

In this stage we find the periastic bones begun, and indeed rapidly developing; an inner view of a vertical section (Pl. LXIX. fig. 6) shows these three bones, and also the alisphenoid and supraoccipital; the bones that had begun in the last stage have grown very much.

The basioccipital bone (b.o) now forms a large, rhomboidal plate, separated from the exoccipitals (e.o) by a widish synchondrosis, a tract of cartilage which runs also across, in front, between the basioccipital and basisphenoid (b.s). At that part the basis cranii is pneumatic, and the median part of the tympanic Eustachian labyrinth is seen there.

A remnant of the notochord still exists in the basioccipital; it dips the large transverse condyle (oc.c). The exoccipitals (figs. 5, 6, e.o) run to the top of the foramen magnum, grow well forward towards the auditory capsule, are separated by a widish tract below from the basal, and also by a wide tract above from the upper bone of the arch (b.o, s.o).

The hypoglossal nerve (xii) behind, and a vein in front of it, pierce the base of the exoccipital; it is notched for the vagus nerve (x). The supraoccipital (s.o) is a rhomboidal plate formed in the hind roof-cartilage; it is rather thick already, ready to become pneumatic; it articulates at its antero-inferior edge with the epiotic (ep).
The basisphenoid is equal to the basioccipital in size; it is entirely surrounded by cartilage, which intervenes between it and the basioccipital behind, the prootic (_pr.o_) above and behind, and the alisphenoid (_al.s_) above and in front. There is no bone in front of it, below, for the rest of the basicranial axis remains cartilaginous.

The fore part of the basisphenoid (_b.s_) is hollowed out for the pituitary body and internal carotid arteries, the hind part is pneumatic, the cavity running into the basioccipital. The bony matter is fast affecting the posterior clinoid wall; and outside that wall, a tract of cartilage intervening, there is an irregularly oblong bony tract on the lower half of the alisphenoidal wall (_al.s_); this centre is pointed above, and square below, it just reaches the large foramen ovale (_v_) behind. For the rest, the basicranial axis and nasal septum (_p.s, p.e, s.a, p.n_) form a relatively larger tract than in the last stage.

The prootic bone (_pr.o_) is a thin ectosteal shell in the front wall of the auditory capsule; it runs upwards and backwards, with deep toothings, towards the meatus internus (_vii, viii_) and the anterior ampulla (_a.s.c_). There is then on the arched fore edge of the capsule an almost equal length of cartilage; above that, the arch of the anterior, and the beginning of the posterior, canal are covered with the second bony tract, the epiotic (_ep_); the upper edge of this bone forms a suture with the super-occipital.

Against the middle of the concave face of the exoccipital, on the inside, we see a third lozenge-shaped bony tract; this is the opisthotic (_op_); it runs round behind, close outside the ampulla of the posterior canal, and is above and behind the great chink for the glosso-pharyngeal and vagus nerves (_ix, x_). These periotic centres appear to be rather more inside than outside; they begin near the edge of the somewhat flattened capsule, and occupy about one fourth of its large sinuous superficies.

All but the projecting angles of the great quadrate (Pl. LXX. fig. 5, q) is ossified, and this bony centre is becoming pneumatic. Also the postero-external face is much more scooped, and the notch behind is somicircular.

The soft fore angle of the otic process (_ot.p_) turns upwards, the hinder corner downwards. A considerable core of cartilage remains over the lower condyle (_g.c_), and the forks of the “orbital process” are unossified; the upper spur is the “ascending process” (_a.p_), and the front spur is the rudimentary “pterygoid cartilage” (_p.p.c_).

Both the lateral cranial fenestrae are pyriform; the lower is now two thirds the size of the upper. The orbito-sphenoidal plate is relatively less; a very small spike-shaped rudiment of the anterior “tegmen cranii” exists, growing backwards from the top of the perpendicular ethmoid (_p.e_).

There is a small foramen below the upper fenestra; and a space for the lesser cranial nerves below and behind the optic passage (11), which is circular, and nearly as large as the foramen ovale (_v_).

In this stage the various canals or passages can be well seen (Pl. LXX. fig. 8); in
the figure the hinder part of the soft palate is cut away so as to expose the "posterior nares" (*i.e.*), which open into a circular recess. Behind them there is a smaller notched fold of membrane, and over the notch a round median passage; this is the middle Eustachian passage (*m.eu*), it opens into the basis cranii.

At a short distance outside this there is, on each side, a curved valvular opening; the broader end of each is behind, and these ends approximate; the convex edge of each is postero-lateral; these paired openings are the lateral Eustachian openings (*l.eu*), and run directly into the main tympanic cavity.

7th Stage. *Nearly ripe, and ripe embryos of* Crocodilus palustris, *taken from September 4th to September 8th, total length 10 to 10½ inches; and ripe embryos of Crocodilus* —— *?*, sp.

a. *Endocranium.*

The general form of the parts of the endocranium alters but little during the last month—August 8th to September 8th; its changes are mainly increase of size and consolidation of the various regions, especially the bony centres. The two paired and the two unpaired bony tracts of the occipital arch (Pl. LXIX, figs. 7, 8, *e.o, s.o, b.o*) now form a strong ring of bone, with very limited synchondroses dividing its elements. The basioccipital (*b.o*) does not reach the basisphenoid (*b.s*), nor fill all the cartilage belonging to it behind; thus the condyle (*o.c*) is a solid mass of cartilage, and not a mere articular plastering left on the bone. The form of the bone is roughly pentagonal (Pl. LXX, figs. 1 & 3, *b.o*), and it is separated from the other bones by narrow tracts of cartilage. It is somewhat grooved in the middle, below, and mamillate right and left, and its gradually narrowing hinder part is imbedded in the reniform condyle, whose "hilus" is filled with the remnant of the notochord (*n.c*). A common round opening leads into both this bone and the basisphenoid, for one pneumatic cavity occupies both; the opening is the "middle Eustachian passage" (*m.eu*). In the front of each lateral angle there is another, lesser passage, which is the *posterior opening* of the "lateral Eustachian tube" or passage (*l.eu*). This opens into a lateral chink behind the basioccipital plate (*b.t*) (Pl. LXX, figs. 3, 4, & 8, *l.eu*), and this chink leads also into the excavated basisphenoid, the *anterior opening* of the "lateral Eustachian tube." The large, winged exoccipitals (*e.o*) and their synchondrosial cartilages complete the ring over the foramen magnum (Pl. LXIX, fig. 11, and Pl. LXX, figs. 1 & 3, *f.m*). They are large, irregular, multangular shells of bone—shells both in their general convexo-concave form, and also because they are hollow or pneumatic. They are riddled with holes on their lower surface, but each hole has its meaning and function.

The hindermost of these, nearest the condyle, is for the hypoglossal nerve (*xii*), then there is a small passage for a vein, and outside in front of that a hollow with two passages, these are for the vagus and glosso-pharyngeal nerve (*x, ix*). At the antero-internal angle there is a notable round hole; this leads to a more or less perfect bony
canal for the internal carotid artery (i.e.), which reappears in the basisphenoid, and ends in the bottom of the pituitary cup (Pl. LXX. fig. 4, i.e.; here the basisphenoidal part of the canal is drawn as having a bristle passed through it).

The two large tracts of the exoccipital that unite, respectively, with the basioccipital, superoccipital, and opisthotic (op) are not faced with more than a trace of cementing cartilage; for large cavities have been already formed. But the tympano-Eustachian labyrinth communicates with all these posterior cranial and auditory bones; the foremost of these spaces, on the opisthotic margin, is seen in the partly disarticulated skull (Pl. LXX. fig. 3, e.o). The inner wall of the exoccipital (Pl. LXIX. figs. 7, 8, e.o) is a convex tract, narrow in the middle and dilated above and below; its posterior margin is sinuous, and its front margin is bevelled and oblique behind the large occipito-auditory chink, which below lets out the ninth and tenth nerves (ix, x). The opisthotic (op) bulges towards its fore margin, and is ankylosed to the exoccipital, now, in front of the chink, and projects inwards as a shell of bone, which is angulate in front. Below (Pl. LXIX. fig. 8, op) it is narrower, and forms a complete loop of bone round the fenestra rotunda (f.r) and divides it from the f. ovalis (fs.o).

The supraoccipital is entirely on the roof of the skull (Pls. LXIX. and LXX. s.o); it also is compound, now, for it has coalesced with the right and left epicotics (ep). It is rhomboidal in form, and its hinder projection is separated by a wedge of cartilage from the foramen magnum; cartilage also can be seen within it behind (Pl. LXIX. figs. 7, 8, s.o), and also above over its junction with the epicotics (Pl. LXX. fig. 6, s.o, ep). It is concave in the middle and scooped right and left in its thick exposed hind part; but in front, where it is covered by the parietals (Pl. LXX. fig. 2, p, s.o), it is thin, has a fenestra on each side, and is crenate along its thin front margin. In front, as is shown in the section (Pl. LXIX. figs. 7, 8, s.o), it is pneumatic, and its cavity opens freely into that of the right and left epicotic, and at the two fenestrae (Pl. LXX. fig. 6, s.o) the general cavity is shut in by the parietals, only. The epicotics (ep) finish this part of the roof; they are hollow shells, with their concavity looking inwards; this swelling contains the junction of the anterior and posterior canals. In the inside views (Pl. LXIX. figs. 7, 8) the general synchondrosial tract between the periotic elements is shown; it is triradiate, and is large and swollen where the three rays meet.

The union of these two canals is imbedded in the thick inner bone close to the cementing cartilage; but there is a thin table of bone above, and then a large pneumatic cavity between it and the part which contains its share of the labyrinth. In the upper view of the epiciotic-superoccipital bone (Pl. LXX. fig. 6) a bristle is shown as traversing this large upper pneumatic cavity, which is open under the parietal, and shows itself again, above, antero-externally, as indicated by the bristle, which is figured as emerging from the prootic margin.

The prootic (Pl. LXIX. figs. 7, 8, pr.o), or foremost of the auditory bony centres, is nearly the size of the other two combined, and is not ankylosed to any neighbour bone.
This element contains the ampullæ and part of the arch of both the anterior and horizontal canals (a.s.c, h.s.c); is perforated for the seventh and eight nerves (vii, viii); and is notched by the fifth nerve (v) and by the stapedial plate (st).

Its fore margin is almost vertical, but its hind margin swells into the largest of the three shells of bone that bound the triradiate synchondrosis. Above, its oblique edge is finished by cartilage, where the alisphenoidal cartilage joins on to the capsule; below, it is separated from the basisphenoid by another similar tract. It binds on to a notch of the alisphenoid above, and then they are both notched to form the large foramen ovale (v). Postero-inferiorly there is an oblique notch a little higher up, finished by cartilage above; this is the fore edge of the fenestra ovalis (fs.o).

This swollen shell forms a sort of penthouse over the "meatus internus;" the two passages for the eighth nerve (fig. 7, viii) lie obliquely under this part, and below and in front of them we see the single hole for the facial nerve (vii). The bone under that hole is rounded; it is scooped above and below the shell in front; this is all inside. Outside (Pl. LXX. fig. 11) there is a thin loop of bone above, where the air-cell of the epiotic ends; the rest of the outer surface is sinuous, answering to the membranous labyrinth within. Below, a crescentic wedge of bone grows obliquely forwards and outwards, and forms with the main plate a large open channel; this channel opens freely into the air-cavity inside the quadrat bone—a labyrinth in itself. The facial nerve (vii) emerges in the top of this tympanic channel; the epiotic air-cell evidently ends in the crescentic sulcus between the thin loop of bone and the body of the prootic, supero-externally.

The alisphenoid (Pl. LXIX. fig. 7, al.s) is an obliquely oblong bone, leaning forward, somewhat, in front of the prootic, and locked by it above, the tooth of the latter fitting into a notch of the former. It is bordered by cartilage above and at all its four angles; its hinder margin is thick and pneumatic, the opening being into the great cavity in the basisphenoid. The fore margin is thin and scooped inside, and its oblique, almost straight free edge bounds the large upper "lateral fenestra," which is now a long oval, with the broader end above. The postero-inferior edge is concave, to finish the foramen ovale (v); in front the dilated base of the bone rises forwards nearly up to the optic foramen (n); then the cartilage runs over the optic nerve and joins the postero-inferior angle of the orbito-sphenoid (o.s). The hollow fore part of the alisphenoid is filled with the optic lobes; the bone is thin at that part, and bulges, correspondingly, outside.

Both the lateral fenestrae are relatively lesser than in the last stage (Pl. LXIX. figs. 6, 7); but, with the exception of the basisphenoid, the rest of the endocranium is entirely cartilaginous, and differs but little from what is seen in the last two stages.

The keystone of the inverted postsphenoidal arch is a very large bone, and has already become compound; for the basitemporals have united with its lower table (Pl. LXX. figs. 8–5, b.t, b.s). These are round shells of bone behind the pterygoid wings; the bony scrolls for the internal carotids (i.c) lie over them. The true basi-
sphenoid \((b.s)\) is composed of a wide square hind part, and of a narrow fore part, which has the outline of a truncated cone; it is, however, flat above and rounded below. The ossification in front stops suddenly against the presphenoidal cartilage \((p.s)\); behind, it has a gently concave form, and is separated from the convex fore margin of the basioccipital \((b.o)\). Beneath the narrow synchondrosis is the middle Eustachian opening \((m.eu)\), and on each side of that the bony matter projects as two small ears inside the larger ears formed by the basitemporals. The basisphenoid also gives off a pair of lateral ears before it narrows in close to the middle; at that part there are two smallish foramina looking forwards. The middle line, below, of the hind part is grooved, the sides are convex. Above (Pl. LXX. fig. 4) the hollow and shelving upper table is square, with the corners trimmed off; the sides next to the cartilage are straight; both the hinder and the free front edge are gently cut away in an arcuate manner. The fore edge is tilted upwards; it is the postcrioid wall \((p.cl)\); behind its shelving face the floor is gently hollowed for the medulla oblongata, but it has a slight median ridge behind. The pituitary cup is oblique, and looks forwards and upwards; it has two large openings below and behind for the emergence of the internal carotids \((i.c)\). The body of the bone behind the pituitary cup is one large air-cell, which opens antero-laterally into the air-cavity of each alisphenoid into the common middle opening \((m.eu)\). That part of the labyrinth of pneumatic passages which is common to the outside of the prootic and the inside of the quadrate also opens into the side of the basisphenoid at its middle. Thus the cavity of the bone has five communications with the labyrinth, right and left and behind. The specialization of the first pair of clefts is so great as to throw them both into one complex system of passages, pervading the whole hind skull, auditory capsules included, and including also, as I shall soon show, the hinder or articular part of the mandibular rods. The internal carotids enter the skull in front of the pouches where the lateral Eustachian tubes communicate with the pneumatic openings of the basioccipital (Pl. LXX. fig. 3, \(l.eu, b.o)\).

A transverse section through the hind skull, exposing the tympanic cavity \((e.ty)\), with its traversing columella (Pl. LXXI. fig. 7, \(c.o)\), shows the relation of the basisphenoid to the fore part of the auditory labyrinth \((a.s.c, \varnothing.b)\), and the manner in which the pneumatic passages enter the quadrate \((q)\), externally, and the basis cranii within.

In the next section (Pl. LXXI. fig. 6) the alisphenoid \((a.l.s)\) is shown as cut down the middle immediately above the fore part of the pituitary body \((p.y)\) and the infundibulum \((i.nf)\).

But the widest part of the cranial cavity is across the thin bulging part of the alisphenoids (Pl. LXXI. fig. 5, \(a.l.s)\); at this part they are ossified to their top edge, but below have a soft tract which ends a little above the presphenoid \((p.s)\). Passing still further forwards (Pl. LXIX. fig. 7, and Pl. LXXI. fig. 4) we see how the three cartilages have built the large orbito-nasal dividing wall, the main mass of which has been formed by the intertrabecula \((i.t.r)\), which is covered with a plaster of cartilage formed by the
trabeculae (tr), that thicken again at the coping of the wall, and then spring upwards and outwards to form the sides of the chamber for the fore brain (C^1e). These diverging plates are the orbito-sphenoids (o.s); they narrow rapidly in front, and end in free points right and left of the olfactory lobes. The double chamber for these lobes (I) is cut across in the next section (fig. 3), and the vertical cartilage at this part is low, for there is a rounded gap in the wall here (Pl. LXIX. fig. 7), which is the perpendicular ethmoid (p.e). Right and left of this low part of wall the postero-inferior part of the olfactory capsule is cut across, and the hinder portion of the inferior turbinal (i.tb) is shown.

The next section (Pl. LXXI. fig. 2) shows a higher septum (s.n), with the roof, walls, and floor of the nasal capsule; above, these cartilages are continuous, but, below, the upturned floor (n.f) is free; the curious tubular inferior turbinal (i.tb) is shown inside the bulging lower wall (n.w).

Still further forwards (Pl. LXXI. fig. 1) the inferior turbinal is missed, and the sinusous walls are confluent with the septum both above and below.

Close behind the alae nasi (Pl. LXX. fig. 15) the alisepalts (al.s) form merely two round tubes, their dividing wall (s.n) being very low. But the narial valves, confluent with the olfactory capsule (Pl. LXX. figs. 2, 12, al.n), are thin coils of cartilage that belong to the "superficial" category, but early unite with the capsules; they lie over the prenasal spike (p.n).

The partial vertical section (Pl. LXIX. fig. 7) is more than half the skull; in another figure (Pl. LXX. fig. 9) less than half is shown, and thus the nasal cavity of the right side is laid open. The transverse sections of the half-ripe Alligator (Pl. LXVI. figs. 5-10) help us here, as they show the ethmoidal region better.

The long bulging part in front (Pl. LXX. fig. 9) is a mere fold of the wall, the next is the "upper turbinal" (u.tb); it, however, is formed merely by a special infolding of the alaiethmoidal wall (Pl. LXVI. fig. 9, u.tb), which in that section seems to be a distinct cartilage, midway from side to side and from top to bottom, and having its convex face looking inwards. This fold lies in front of the upper part of the oblique "pars plana" (Pl. LXVI. fig. 10, p.p) (the lateral ethmoidal antorbital wall), whilst the inferior turbinal (i.tb), which is a single tube behind (Pl. LXXI. figs. 2, 3), and an imperfect double tube further forwards, lies in a postero-inferior position (Pl. LXX. fig. 9). This part is very strong directly in front of the pars plana (Pl. LXXI. fig. 3, i.tb, and Pl. LXVI. fig. 10, p.p).

b. Visceral Arches.

The lower jaw is now as long as the rest of the skull (Pl. LXIX. fig. 9), the facet on the quadrate (q.c) being far back, and the angle of the lower jaw well developed. The quadrate (q) is very large; it occupies most of the side of the hind skull, and is as broad as that part of the basis cranii against which it abuts.
It is bound in and covered by strong outer plates of bone (Pls. LXIX. & LXX., sq, sq, q.j), and only shows itself between these tracts below (PL LXX. fig. 1); the inner (or lower) face of the quadrate is seen to be very broad and somewhat concave. When cleared of its surroundings, and its outer wall removed (PL LXX. fig. 7), this bone shows large pneumatic cavities that traverse every part where the thickness is sufficient; on the inner face the table is very imperfect, and without any paring away shows the large air-cavities; they open freely into the first (tympanic) cleft. The middle third of its hind margin is notched, so as to form a large circular opening, finished behind by the hyoid cartilages; through this passage the columella escapes to lie on the hollow outer face of the quadrate. This bone is roughly four-sided, but the upper edge, or otic process, is extended fore and aft, and these rounded angles are not yet ossified. The hind margin is generally concave, but has the large notch in it; the lower is sinuous, ending behind in the large cylindroidal condyle (q.c), and in front runs to the end of the "orbital process," which is not yet ossified at the forked end. The ascending and pterygoid spurs (a.p., pg.c) are now very short. Above these, on the fore edge, there is a toothed process on an outline which is gently concave. A thick rib of bone, partly cut away in the specimen figured (PL LXX. fig. 7), runs obliquely downwards and backwards from the front angle above to the fore edge of the articular condyle (g.c). The upper edge is also developed into a rounded balk of bony substance; thus the postero-external face of the bone forms a large shallow crescentic space, over which the tight tympanic membrane is drawn, and under which, at the middle of its upper part, the extrastapedial end of the columella (e.st) projects; this is analogous to the "manubrium mallei," but its homology with it is doubtful. A large air-cell runs inside the front oblique ridge, and a lesser cavity is seen below the hind notch; the pneumatic opening of this lesser cavity is halfway down the solid part under the notch. From that aperture there proceeds a membranous tube, which forms a communication with a similar aperture on the top of the articular region of the mandible close behind the joint; this tube is the "siphonium" (Nitzsch). In the figure a bristle is shown running through the upper space; below there is a large bilobate cavity in the "os articulare" (ar); this is the lowermost and the hindermost part of the extensive tympano-Eustachian labyrinth, formed by specialization of the "first visceral cleft."

In front of that hollow bony centre the mandible is a soft and terete rod, coalesced with its fellow at the chin (PL LXX. figs. 12, 13, PL LXXI. figs. 1, 2, 5, 7, mk). In the coronoid region the rudimentary coronoid tract of cartilage is still seen facing the mandible, where it would chafe against the huge wing of the pterygoid bone, that bone having also a facing of pterygoid cartilage (PL LXIX. figs. 9-11, PL LXX. fig. 1, and PL LXXI. fig. 7, cr.c, pg.c).

The upper elements of the hyoidal arch (PL LXIX. fig. 4, PL LXX. fig. 7, and PL LXXI. fig. 7) are now seen as distinct and, for the most part, reduced and arrested
nuclei of cartilage. But the columnella itself is a continuous half-bony rod, and has lost its early segmental tract; it has also become fused, proximally, as one bony tract with the stapedial centre (Pl. LXIX. fig. 4, st, m.st). The bony shaft ends where the foliaceous forks begin; that lobe which is more directly a continuation of the primary (pharyngo-hyal) rod is the extrastapedial (e.st); it is falcate, with a free retractor hook and a terminal crescentic dilatation. The suprastapedial stalk (s.st') passes inwards, upwards, and backwards, and is a broad flap with a pedate free end, the “toe” of which is above. Behind, and a little below it, and quite detached backwards from it, is the pyriform suprastapedial segment (s.st), one of the upper links of the proper hyoid chain.

To its broad lower end the epihyal, once more free, is attached by ligamentous fibres; it is a thickish nodule, with its lower end split; it is attached by its inner face to the sheath of the facial nerve (vii), the hinder fork of which emerges beneath it and the next nucleus; through the Crocodilian representative of the “stylomastoid foramen” the great branch (vii) can be seen crossing the medio-stapedial, and running downwards.

In front of the main nerve, but still behind the cleft, we see the remains of the main hyoid bar or ceratohyal (c.hy); it is like an arrested rib, with a capitular and a tubercular process. The two lower nuclei both rest upon the lower part of the quadrate, behind, where the great semicircular tympanic notch is finished below (Pl. LXIX. fig. 4, q, and Pl. LXX. fig. 7). Close behind the ceratohyal we see the unossified free edge of the projecting “paroccipital” (see also Pl. LXX. fig. 3, e.o); this is the part which in the Bird is developed so as to form a sort of cranial tympanic “bulla,” but whose office is largely held in the Crocodile by the quadrate bone; here the main cavity lies forwards, in the Bird it lies backwards.

The distal part of the hyoid arch is only a region of the common distal rudiment of the hyoid and the “first branchial” arch. There is a median cartilaginous, and a pair of lateral ossified, tracts; the former is a wide scoop, round in front, notched at the sides, and circularly emarginate behind. The side rods are the first “ceratobranchials” or “thyrohyals” (Pl. LXX. fig. 10, c.br'); these are sigmoid rods, with a hooked, soft, free end, turning inwards. The tendency to form a lobulate hypohyal was arrested, and the whole median plate is merely developed as a wide, concave “basihiyo-branchial” (b.br).

c. The Investing Bones.

Since the 5th stage (Pl. LXVI.) the outer bones have grown so as to finish a skull which is a very perfect miniature of that of the adult Crocodilian (Pls. LXIX.–LXXI.). The only instance of ankylosis is that of the basitemporals (Pl. LXX. figs. 1, 3, 5, b.t) with the basisphenoid (b.s).

The upper fontanelle (Pl. LXX. fig. 2) is now completely obliterated, and the parietals and squamosals (p, sq) almost cover the hind skull. In the palate also (Pl. LXX. fig. 1) the palatines (p.a) have hidden the vomers, and the pterygoids (p.g) have united along the middle, and even coalesced behind and over the posterior nares (i. n); between

2 z 2
these passages the united bones form a small styloid partition. Nearly half the median part of the pterygoids is united by suture to form a continuation of the "hard palate," which in front is formed by the premaxillaries and the maxillaries (\(p_x, m_x\)), and in the middle by the long, narrow, subtubular palatines (\(p_a\)). The pterygoids can still be peeled off the basisphenoid in ripe (or nearly ripe) young (Pl. LXX. figs. 4, 5, \(p_y, b.s\)). When the lower bony floor has been removed (Pl. LXX. fig. 3), the relation of the vomers (\(v\)), palatines (\(p_a\)), and pterygoids (\(p_y\)) to the basis crani is shown. At first the vomers appear to be merely styloid bones, with their pointed end behind; but the pointed part has a thin curved flange, which is coadapted to the upper plate of the palate of the same side. The pterygoids run forward between the vomers, and end there as sharp styles; they are scoops, with their hollow part downwards; further back, they unite into one, with a median crest looking downwards. All this is in the fore half; behind, these bones grow into deep wide wings, but up to the posterior nares they are tubular.

The lacrimal bone (Pl. LXX. fig. 2, \(l\)) has completed its tube. The bones of the hind face have finished the temporal and zygomatic arches, also the splints of the mandible (Pl. LXIX. figs. 9, 10) are fairly complete.

The sectional views (Pl. LXX. figs. 12, 13) show the thickness of the splint-bones, and their relation to the endocranial elements.

8th Stage. Adult Crocodiles and Alligators.

For descriptions of the skull of the adult I must refer the reader to the works mentioned in the "Bibliographical list" (p. 264), and especially to Professor Miall's valuable "Study." That work, with the actual skull of a full-grown Crocodilian, will enable the worker to finish this "demonstration."

General Remarks.

A more difficult task will be the comparison of the skull of this type in its various stages with the skulls of other Sauropsida in their various stages, and then to see how these oviparous, amniotic types, each in their own way, specialize their skulls and from the most similar elements develop such dissimilar skulls as those of a Snake, a Tortoise, a Lizard, a Crocodile, and a Bird.

I am able now to refer the reader to memoirs on all these (including the present paper); they are to be found in the 'Transactions' of the Microscopical, Linnean, and Royal Societies, of this Society and in the first volume of the 'Reports of the Challenger' (that on the skull of the Sea-Turtle).

It seems therefore that, to give completeness to the present paper, I ought to point out the more important modifications seen in the skull of the Sauropsida—how that skull is a mere specialization of the underlying Ichthyic type, and in what manner and degree
it gives promise and prophecy of the highest of all skulls, viz. that of the Mammal. It is hardly necessary for me to state that I do not consider this last kind as arising from a type directly overlying the Sauropsida. The Mammalia form another branch of the Amniota, which has a separate root, and has, on the whole, a much higher culmination. In some very important things the skull of the Anurous Amphibian forms a better leading-step to that of the Mammal than any to be seen in Reptiles and Birds.

The highest of the many branches of the Sauropsidian stock is the Passerine form; but there is no crossing over from that to the Mammalia possible; we must slide down the whole of the vertebrate trunk, to its very root, before we are in a position to find the first shoot that grew Mammal-ward; this, perchance, was quite as low as the point from which the Sauropsida grew.

**Summary.**

As to the first stage it is scarcely necessary to point out the extreme similarity of the early embryo of the Crocodilian, not only to that of the other Sauropsida, but also to that of every other vertebrate type.

The cartilage at this stage is becoming solid, the sense-capsules are seen to be all separately formed, and the basis cranii can be made out, although it is in a very primordial condition. As in the Axolotl, the prochordal tracts are merely small horns budding out from the large parachordal plates. But the rapid growth of the hemispheres, the outgrowing optic vesicles and olfactory lobes—all developments of the vesicular fore brain—is attended with an equal amount of prepituitary skull-growth, and in the second stage the prochordal outgrowths are equal in length to the proper axial tracts, or parachordal plates. These latter run with the notochord into the hollow of the folded mid brain, but not beyond it; for that azygous axial rod bends downwards a little, as in the Chelonians and Elasmobranchs, but the mesencephalic fissure affects it less than it does the overlying brain-mass; it is arrested in its forward (and upward) growth. This partial arrest or suppression of the front part of the notochord is correlated with a great and, as it were, sudden development forwards and upwards of the investing basal cartilage.

The part which grows upwards appears to me to be the true end of the paired elements of the skeletal axis; and it is this part, viz. the large sloping "postclinoid" wall, which gives rise to the neural laminae of the hinder sphenoidal region, the alisphenoids. Behind, the occipital ring is directly formed as an upgrowth, right and left, from the parachordal plates, and the want of continuity of the pre- and post-auditory walls is due to the intrusion of the large auditory capsules, which push the fifth and seventh nerves forwards, and the ninth and tenth nerves backwards. The proper termination of the primary neural and skeletal axes appears to me to be just where the "infundibulum" grows down to meet the oral involution (pituitary rudiment), and where the bulbous end of the hook of the notochord is seen. The hemispheres now rest upon the large adze-shaped front wings of the sphenoid (orbito-sphenoids),
and these wings are direct upgrowths of the paired trabeculae, which grow, like new shoots, from the under surface of the upturned parachordals.

In front of the pituitary involution, there being no axial notochord, a new axis appears; this preaxial rod, the "intertrabecula," is very large indeed in the second stage in this type. It is seldom absent (as in the Ophidia), but in all forms that have a projecting snout this bar, rod, or plate forms the axis of such foregrowth of the skull, and may be equally hypertrophied in the Mammals (Cetacea) as in the Elasmobranchs (Pristidae).

The Crocodilia, as this stage shows, have inherited a compound nasal labyrinth—(a) the valvular cartilage outside (in front), (b) the ethmoidal region, behind, (c) the proper nasal roofs, and (d) the middle wall formed by the intertrabecula; these are all chondrified continuously, and we must go down to the Amphibians, Elasmobranchs, and Marsipobranchs for a true interpretation of what is seen in these high Reptiles.

In this stage the clefts are fast closing in, and the inner opening of the persistent pouch, the first or tympanic cleft, is a mere crescentic slit, and corresponds to what is permanent in some Batrachia.

Instead of the ichthyic, large, symmetrical, perforated pharynx there is here a mere funnel-shaped enlargement of the fore end of the oesophagus; and only three of the visceral arches are developed at all, whilst only the first attains to its full size.

With the total loss of branchial function there is an extraordinary amount of new specialization; and only by tracing out the early stages can a true interpretation of the parts be made.

In this stage the first and second visceral arches, if compared with those of the Elasmobranchs, Chimaeroids, and Urodeles, will be found to be normal, or nearly so.

There are only two main segments on each side in the mandibular arch, viz. the pterygo-quadrat and the articulo-Meckelian. The pier of this foremost arch has a huge "otic process," and a rudimentary "pedicle" with two forks—one a small "ascending process," and the other a small "pterygoid cartilage."

The next arch has several normal branchial segments, like its counterpart, the hyoid of Chimæra; but it has also supernumerary segments like those seen in Acipenser and in other Ganoids. As in many Selachians, its pharyngo-hyal or upper joint pushes itself into the side of the auditory capsule; below this there is an epihyal and a ceratohyal, the latter stopping short behind the hinge of the mandible, and becoming solid continuously with the articular head of that part, its proper serial homologue. Distally there is but a small region of basihyal cartilage continuous with that of the third arch or first branchial, proper. That arch has merely a small pair of ceratobranchials.

Passing on to the third and fourth stages, we find that the whole of the chondrocranium (with its visceral arches) has become Sauropsidan, and the investing bones, which are now demonstrable, are in number and relation quite Crocodilian.
The chondrocranium is better developed than in any existing order of Reptiles and in any kind of Birds; that of the African Ostrich (Struthio) comes nearest to it. The best kind for comparison with it, below, is that of the Skate; if compared with that which is above, it is seen to come very near to that of any ordinary Mammal at the same stage, e.g. the Pig; but the auditory labyrinth is in the condition in which it is found in an embryo of the Pig three quarters of an inch in length. The occipital condyle, however, in the Crocodile is single, and not double as in the Skate, below, and the Mammal, above; but the development of the occipital arch, the impaction of the large auditory capsules, the continuity of the upper part of the wings of the sphenoid with the nasal and auditory capsules, and the development of the whole basis cranii (crested in the prepituitary region, and carrying the long nasal capsules)—all these things are like what we see in the Mammalia, except that the top of the alisphenoid is not free. The hard palate of this type is equal to what we see in such a mammal as Myrmecophaga, where it has its fullest growth, the pterygoids continuing the floor.

As we dissect the arrested and highly modified hyoid arch, we seem to be examining a creature very different from a Mammal; the basal part of the stapes is not distinct as in the Frog, and the parts which are specialized to auditory functions are normally Sauropsidan, but have an additional segment, the suprastapedial. Yet, below, the basihyo-branchial plate and the hinder cornua are very much like what we see even in Man.

But the mandibular arch is as far as can be from that of a Mammal; here it is at its utmost development, the lower jaw of the oviparous type in its culmination.

In the Mammal, on the other hand, the arrest of this as well as of the other visceral arches—in all the “Amniota” the hindermost arches are suppressed—reveals a great gulf between them and the Sauropsida. This is correlated with the fine and perfect coiling of the cochlea; to that highest development of the auditory labyrinth there is superadded, in Mammals, an additional arrested and specialized visceral arch in the outer (tympanic) part of the organ.

In the early stages the mandibular suspensorium of the Crocodile is extremely like that of the more generalized Selachians—Notidanus, Cestracion—just as the hyoid arch is like that of the Skate, or even of the Chimera.

But the fore part of the pterygo-quadrato bar, or working upper jaw, is arrested in the Crocodile, whilst the “otic process” is inordinately large.

A separate rudiment of the Shark’s huge, projecting upper jaw (“pterygoid cartilage”) appears, as in Siredon, below, and the Passerine birds, above; and so also does a remnant of the great coronoid crest of Selachians and Ganoids reappear in the lower jaw of the Crocodile.

Here, in spite of the strong fixation of the quadrato suspensorium, the lower jaw is separated by it from the skull in the squamosal (or temporal) region; whereas in mammals the overdeveloped “dentary” bone reaches up to the squamosal, and articulates with it, aborting the simple single quadrato-Meckelian rod within.
During the middle period of incubation the hyostapedial chain becomes continuous, and remains for a time united with the articular part of the mandible; and the air-cell in that part, which was first seen in the last stage, burrows still deeper in the mandible at this time. A large annular (spiracular) cartilage is to be seen now, as in the Chelonia and Batrachia.

In the beginning of the latter period of incubation the endoskeletal bony centres are found; the tympanic labyrinth is rapidly developed, and the hyoid arch first becomes severed from the mandible, and then breaks up again into its primary segments.

The specialization of the first pair of clefts in relation to the organ of hearing in the Crocodile is so great and so remarkable, that it is worth while to compare it with what is seen in other types.

In some of the Urodeles (where the stapes is first seen) a second pharyngo-hyal segment is seized by the outgrowing ectosteal plate of the stapes, and is thus united with it to form the columella; in that group there is no cavum tympani.

In the majority of the Anura the first cleft, which in them never opens externally, becomes a considerable tympanic cavity, and opens by a large lateral, internal hole between the pedicle and the stylohyal. The stapes is always distinct, even when, as in Bombinator, there is no columella and the merest trace of a tympano-Eustachian pouch; where, as in most cases, the columella is present, it appears long after the stapes, and may be composed of one, two, or three segments; it begins as a stylliform second pharyngo-hyal. The epihyal (=stylohyal) end of the suddenly elongated hyoid bar, may, as is the rule, coalesce with the auditory capsule behind the Eustachian opening, or be attached by ligament, or coalesce with the second or permanent pedicle; in all these cases it is below and a little behind the emerging facial nerve. In the Aglossal Anura the Eustachian openings meet at the mid line; in Dactylethra and in some of the Phaneroglossa (e. g. Callula and Iylaplesia) the columella is as large as the average "hyomandibular" of Fishes; in Pipa the columella is formed and finished much earlier than in the other types.

In the Ophidia the columella is formed by ossification of a single pharyngohyal; but there is no cavum tympani, and, therefore, no pneumatic bones.

In the lower Lacertilia (e. g. Iatteria) and the Chameleonidae the cavum tympani is scarcely at all developed, and where it is, as in most of the types, there are no pneumatic bones; yet the columella is very avian, and has, besides its bony shaft and base, upper, external, and descending cartilaginous processes.

In the Chelonia, especially in the lesser freshwater kinds, the squamosal and the quadrate bones are hollowed out to form a large and elegant ear-drum; the opisthotic (mastoid) is also excavated behind the main cavity.

Their columella, with its discoid "extrastapedial," is very much like that of several Anura, especially that of the "Aglossa," and for a time is in two segments; the oval
stapedial plate has only a temporary and imperfectly separate existence; here, however, the cartilaginous "amnulus tympanum" reappears—a large and highly developed "spiracular cartilage."

But the Crocodiles and Birds have the most remarkable development of the tympanic labyrinth; and in them the two basi-temporal wings of the Ichthyopsidan parasphenoid reappear as primarily distinct parostoses; these bones are intimately connected with the auditory apparatus.

In the Crocodiles as well as in the Aves Ratite these basi-temporals are lateral, outside the basisphenoid; but in the Aves Carinatae they are much larger, and meet and coalesce below the skull-base.

In the Bird the columnella is a pharyngo-hyal, with a dilated upper part; it coalesces with an epiphary (stylo-hyal) rudiment of the main bar, through the medium of an "infrastapedial" (=inter-hyal) tract, which is later in appearance than the other parts. The distal part of the hyoid arch is a hypohyal, which meets its fellow at a sharp angle in the tongue to form a "glossohyal."

Here we miss what is found in the Crocodile, namely, a distinct suprastapedial; the distal rudiment of the main bar does run into the ceratohyal region for a small extent.

In the Birds the Eustachian tubes open at the mid line in one common vestibule, which is the homologue of the middle Eustachian passage of the Crocodile. Also in Birds the periosteal growths of the basisphenoid (which start from the little cartilaginous lingula, parts present in both Crocodiles and Birds) there form, above the basi-temporal floor, a pair of "anterior tympanic recesses." These trumpet-shaped cavities answer, in some degree, to the passages in the Crocodile where the lateral and median Eustachian tubes combine; they converge towards each other, but do not meet, in the thick diploe of that part of the skull.

In the Crocodile the quadrat forms much of the tympanic cavity; in the Bird it is pneumatic, and opens by a hole into that cavity, which is enlarged by a wing of the exoccipital. That cavity also, as in Crocodiles, communicates with cavities in the occipito-otic bones above. In the Crocodile the whole hind skull is excavated by these pneumatic diverticula; in Birds the whole hind (as well as fore) skull is pneumatic, but the cavities are traversed by fine reticulations of the diploe.

In the Crocodile, as pointed out by Professor Huxley, the tympanic cavity in the quadrat communicates with a hollow in the "articulare" by the "siphonium." In the Birds, as shown by Professor Nitzsch, the "siphonium" arises behind the quadrat in the general tympanic space.

In the Crocodiles I have seen no bony centres round the "siphonium;" but in the Birds these fragments of the "os tympanicum" (proper) sometimes number as many as six or seven, and the main bone forms a ring to the pneumatic tube; two such centres are seen inside the "cartilaginous annulus" in Dactylethra, an aglossal Anuran.
I need not show the reader how all these modifications tend towards, or illustrate, what we are familiar with in the auditory apparatus of Man, and the Mammalia, generally. But there are some things worth especial notice.

In the Insectivora (e.g. Mole and Hedgehog) the basisphenoid gives off wings to enlarge the tympanic cavities; in the Marsupials the alisphenoids do the same; whilst in others (notably many of the Carnivora) a distinct, hollow lunule of cartilage appears on the outside of the parachordals: it is the innermost segment of the external ear, and helps the more superficial “os tympanicum” to form the drum-cavity. Pneumaticity of the hind skull is very variable in Mammals; it is very much developed in Peturus sciuereus. In some Mammals large air-cavities are developed, retrally, in the base of the skull, from the hind part of their extensive nasal labyrinth; these burrow the skull-base in the same way as the Eustachian tubes do in the Crocodile.

In the Mammals the first and second visceral arches are formed after the hyostylic pattern of the Skate, but are much specialized. Both the malleus and the incus lie under the tegmen tympani. The part answering to the cerato-branchial (Meckel’s cartilage) is still large in Manis, at birth, and in that stage it rapidly re-enlarges from the sharp end of the “processus gracilis,” and lies inside the hind part of the dentary. The stapes is not a periotic element; the incus is either a second “pharyngo-hyal” added to the stapes, or the quadrate in an arrested state; the “epihyal” end of the main bar is ossified as the “tympano-hyal” (Flower); the rest of that bar is the “ceratohyal,” which finishes below as a “hypohyal” to articulate with the common “basihyo-branchial.” The little “interhyal” (= infrastapedial of the Sauropsida) is detached and carried away by the perfectly specialized stapedius muscle, to whose tendon it becomes attached, and thus gets to be united to, and often ankylosed with, the neck of the stapes.

I put these things down as they appear to me from my present standpoint; anyhow the study of the development of the Crocodile’s skull is very profitable, and from it I hope to borrow much light in a renewed investigation of the Mammalian skull in its various ordinal modifications. If the Crocodile does not lie directly below the Mammals, it nevertheless shows us how the Mammals may have arisen from some generalized oviparous form.

1 There is a division between the two parts of the “cavum tympani” in the Carnivora: the bony and cartilaginous annuli are not distinct in most Mammals, but the bone-cells soon transform the cartilaginous lunule into a bony ring: outside this, the inner part of the concha is more or less segmented.

2 That little segment, with the stapes itself, would appear to be all that the Mammal shows of the stapedial chain of the oviparous types; Professor Huxley’s terms for the parts of that chain (namely, stapedial, medio-stapedial, &c.) are of permanent value, being morphologically accurate.
DEVELOPMENT OF THE SKULL IN THE CROCODILIA.

DESCRIPTION OF THE PLATES.

PLATE LXII.

Fig. 1. Alligator mississipensis, Daudin (1st Stage): total length 11 lines (head 3, body 5, tail 3). Side view of embryo, × 6 diameters.

Fig. 2. The same, lower view of head, × 6 diam.

Fig. 3. Alligator mississipensis (2nd Stage): total length 1½ inch (head 4 lines, body 6, tail 8). Side view of embryo, × 6 diam.

Fig. 4. The same, lower view of head, × 6 diam.

Fig. 5. Crocodilus palustris, Lesson (3rd Stage): total length 2 inches (head 6 lines, body 8, tail 10). Side view of embryo, × 3½ diam.

Fig. 6. The same, upper view of head, × 3½ diam.

Fig. 7. The same, lower view of head, × 3½ diam.

Fig. 8. Crocodilus palustris (3rd Stage): total length 2½ inches (head 5 lines, body 10, tail 12). Side view of embryo, × 2½ diam.

Fig. 9. The same, upper view of head, × 2½ diam.

Fig. 10. Crocodilus palustris (4th Stage): total length 3½ inches (head 11 lines, body 13, tail 18). Upper view of head of embryo, × 2 diam.

Fig. 11. The same, side view of head, × 2 diam.

Fig. 12. Alligator mississipensis (5th Stage): total length 4¼ inches (head 1 inch), × 2 diam.

Fig. 13. The same, front view of head, × 2 diam.

Fig. 14. The same, upper view of head, × 2 diam.

PLATE LXIII.

Fig. 1. Alligator mississipensis (1st Stage). Head of embryo, with lower arches removed; lower view, × 12½ diam.

Fig. 2. The same, with lower surface of base of skull exposed, × 12½ diam.

Fig. 3. Alligator mississipensis (2nd Stage). Head of embryo, with lower arches removed, × 10 diam.

Fig. 4. The same, with lower surface of base of skull exposed, × 10 diam.

Fig. 5. The same, base of skull, oblique view, × 15 diam.

Fig. 6. The same, dissected head of embryo, upper view, × 10 diam.

Fig. 7. The same, head of embryo, in vertical section, × 10 diam.

Fig. 8. The same object, with brain removed, × 10 diam.

S A 2
PLATE LXIV.

Fig. 1. *Alligator mississippiensis* (2nd Stage). Subhorizontal section of head (No. i), lowest, $\times 10$ diam.
Fig. 2. The same (No. ii), $\times 10$ diam.
Fig. 3. The same (No. iii), $\times 10$ diam.
Fig. 4. The same (No. iv), highest, $\times 10$ diam.
Fig. 5. *Crocodilus palustris* (3rd Stage): embryo, 2 inches long. Base of skull, upper view, $\times 6\frac{3}{8}$ diam.
Fig. 6. Part of same object, $\times 20$ diam.
Fig. 7. *Crocodilus palustris* (3rd Stage): 2\(\frac{1}{2}\) inches long. Palatal view of head, $\times 4\frac{3}{8}$ diam.
Fig. 8. The same object, dissected, $\times 4\frac{3}{8}$ diam.
Fig. 9. The same, upper view of head, dissected, $\times 4\frac{3}{8}$ diam.
Fig. 10. The same, inner view of mandible, $\times 4\frac{3}{8}$ diam.
Fig. 11. The same object, outer view, $\times 4\frac{3}{8}$ diam.

PLATE LXV.

Fig. 1. *Crocodilus palustris* (4th Stage): embryo, 3\(\frac{1}{2}\) inches long. Chondrocranium of embryo, upper view, $\times 5\frac{1}{8}$ diam.
Fig. 2. The same object, lower view, $\times 5\frac{1}{8}$ diam.
Fig. 3. Part of same object, outspread, lower view, $\times 8$ diam.
Fig. 4. Same embryo, visceral arches, obliquely external view, $\times 5\frac{1}{4}$ diam.
Fig. 5. *Alligator mississippiensis* (5th Stage): larger embryos of this species, 4\(\frac{1}{4}\) inches long. Palatal view of head, with lower arches removed, $\times 3$ diam.
Fig. 6. The same, head in vertical section, $\times 4\frac{1}{2}$ diam.
Fig. 7. The same object, with the brain removed, $\times 4\frac{1}{2}$ diam.
Fig. 8. The same head, outer view of chondrocranium, $\times 4\frac{1}{2}$ diam.
Fig. 9. The same head, upper view of hyobranchial plate, $\times 4\frac{3}{8}$ diam.

PLATE LXVI.

Fig. 1. *Alligator mississippiensis* (5th Stage): largest embryos. Dissected skull, side view, $\times 4\frac{1}{2}$ diam.
Fig. 2. The same, inner view of mandible, $\times 4\frac{1}{2}$ diam.
Fig. 3. The same, lower view of skull, $\times 4\frac{1}{2}$ diam.
Fig. 4. The same, upper view of skull, $\times 4\frac{1}{2}$ diam.
Fig. 5. The same, transversely vertical section (1st) of head through external nostrils, $\times 8$ diam.
DEVELOPMENT OF THE SKULL IN THE CROCODILIA.

Fig. 6. The same (2nd section), behind external nostrils, × 8 diam.
Fig. 7. The same (3rd section), through middle of nasal capsule, × 8 diam.
Fig. 8. The same (4th section), through turbinal folds, × 8 diam.
Fig. 9. The same (5th section), through rhinencephalic recess, × 8 diam.
Fig. 10. The same (6th section), through antorbital wall, × 8 diam.

PLATE LXVII.
Fig. 1. Alligator mississippiensis (as in last Plate, 7th section). Through fore part of eyeball, × 8 diam.
Fig. 2. The same (8th section), through orbito-sphenoids, × 8 diam.
Fig. 3. The same (9th section), through middle part of eyeballs, × 8 diam.
Fig. 4. The same (10th section), through hind part of eyeballs, × 8 diam.
Fig. 5. The same (11th section, part), through prepituitary region, × 8 diam.
Fig. 6. The same (12th section, part), through pituitary region, × 8 diam.
Fig. 7. The same (13th section), through alisphenoid, × 8 diam.
Fig. 8. The same (14th section), through auditory capsules, × 8 diam.

PLATE LXVIII.
Fig. 1. Alligator mississippiensis (2nd Stage). Additional (partial) view of subhorizontal section of the head (as in Pl. LXIV. figs. 1–4), No. v, through first cleft and first and second arches, × 18 diam.
Fig. 2. The same (No. vi), a similar section, × 18 diam.
Fig. 3. The same (No. vii), through notochord and pituitary body, × 18 diam.
Fig. 4. The same (No. viii), through quadrate and hyoid, × 18 diam.
Fig. 5. The same (No. ix), through hinge of mandible, × 18 diam.
Fig. 6. The same (No. x), a similar section, higher up, × 18 diam.
Fig. 7. The same (No. xi), through Meckel's cartilage and hyoid, × 18 diam.
Fig. 8. The same (No. xii), through the same parts, higher up, × 18 diam.
Fig. 9. The same embryo. Outer view of quadrate, part of mandible, and hyoid arch, × 16 diam.
Fig. 10. Crocodilus palustris (3rd Stage): 1\(\frac{3}{8}\) inch long. The same arches, × 12 diam.
Fig. 11. Part of same object, × 24 diam.
Fig. 12. The same species (4th Stage); embryo, 3\(\frac{1}{2}\) inches long. The same arches, outer view, × 7\(\frac{1}{2}\) diam.
Fig. 13. The same object, inner view, × 7\(\frac{1}{4}\).
Fig. 14. Part of same object, inner view, × 14\(\frac{1}{2}\) diam.
Fig. 15. Alligator mississippiensis (5th Stage): embryo, 4\(\frac{1}{2}\) inches long. Hyoid arch, inner view, × 12 diam.
Fig. 16. Part of hyoid arch of another specimen of same, × 12 diam.
PLATE LXIX.

Fig. 1. Crocodylus palustris (5th Stage): embryo, 4$\frac{1}{2}$ inches long. Hyoid arch, outer view, $\times$ 12 diam.

Fig. 2. Same species (5th Stage): embryo, 5 inches long. Hyoid arch, outer view, $\times$ 12 diam.

Fig. 3. The same object (part), basal view of columella, $\times$ 12 diam.

Fig. 4. Same species (7th Stage): ripe embryo, 10 inches long. Outer view of hyoid arch, $\times$ 12 diam.

Fig. 5. Same species (6th Stage): embryo, 5$\frac{3}{4}$ inches long. Hind part of skull, outer view, $\times$ 3$\frac{3}{4}$ diam.

Fig. 6. Same skull, inner view of vertical section, $\times$ 3$\frac{3}{4}$ diam.

Fig. 7. Same species (7th Stage): embryo, 9$\frac{1}{2}$ inches long. Inner view of vertical section of skull, $\times$ 3 diam.

Fig. 8. Part of same, inner view, $\times$ 6 diam.

Fig. 9. Same species (7th Stage): ripe embryo, 10 inches long. Side view of skull, $\times$ 2$\frac{3}{4}$ diam.

Fig. 10. Same skull, inner view of mandible, $\times$ 2$\frac{3}{4}$ diam.

Fig. 11. Same skull, end view, $\times$ 2$\frac{3}{4}$ diam.

PLATE LXX.

Fig. 1. Crocodylus palustris (7th Stage): ripe young, 10 inches long. Lower view of skull, $\times$ 2$\frac{2}{3}$ diam.

Fig. 2. Same skull, upper view, $\times$ 2$\frac{2}{3}$ diam.

Fig. 3. Crocodylus —— ?, sp. (7th Stage): ripe young. Part of base of skull, lower view, $\times$ 3$\frac{1}{4}$ diam.

Fig. 4. Part of same object, upper view, $\times$ 3$\frac{1}{4}$ diam.

Fig. 5. Part of same object, lower view, $\times$ 3$\frac{1}{4}$ diam.

Fig. 6. Supraoccipital of same skull, upper view, $\times$ 3$\frac{1}{4}$ diam.

Fig. 7. Crocodylus palustris (7th Stage): ripe embryo, 10 inches long. Auditory region, outer view, $\times$ 5$\frac{1}{2}$ diam.

Fig. 8. Same species (6th Stage), part of palate of embryo, 6 inches long, $\times$ 3$\frac{1}{3}$ diam.

Fig. 9. Same species (7th Stage): ripe young, 10 inches long. Inside of nasal labyrinth, side view, $\times$ 2$\frac{3}{4}$ diam.

Fig. 10. Same species (7th Stage): ripe young, 10 inches long. Hyobranchial plate, upper view, $\times$ 2$\frac{3}{4}$ diam.

Fig. 11. Right prootic of Crocodylus —— ?, sp., outer view, $\times$ 5 diam.

Fig. 12. Crocodylus palustris (7th Stage): ripe young, 10 inches long. First section of head, transversely vertical, $\times$ 5 diam.

Fig. 13. Same head, 2nd section, $\times$ 5 diam.
DEVELOPMENT OF THE SKULL IN THE CROCODILIA.

PLATE LXXI.

Fig. 1. Same head of *Crocodilus palustris* as in figs. 12 & 13 of Plate LXX, 3rd section, × 5 diam.

Fig. 2. The same, 4th section, × 5 diam.

Fig. 3. The same, 5th section, × 5 diam.

Fig. 4. The same, 6th section, × 5 diam.

Fig. 5. The same, 7th section, × 5 diam.

Fig. 6. The same, 8th section, × 5 diam.

Fig. 7. The same, 9th section, × 5 diam.

EXPLANATION OF ABBREVIATIONS.

The Roman numerals refer to nerves or their foramina.

- ag. Angulare.
- al.s. Alisphenoid.
- al.f. Alisphenoidal fenestra.
- ar. Articulare.
- ar.c. Articular cartilage.
- a.s.c. Anterior semicircular canal.
- au. Auditory capsule.
- a.ty. Annulus tympanicus.
- b.mn. Basimandibular.
- b.o. Basioccipital.
- b.s. Basisphenoid.
- b.t. Basitemporal.
- C<sup>1</sup>. Fore brain.
- C<sup>2a</sup>. Hemispheres.
- C<sup>3a</sup>. Olfactory lobes.
- C<sup>4</sup>. Mid brain.
- C<sup>5</sup>. Hind brain.
- e.br. Ceratobranchial.
- chl. Cochlea.
- c. hy. Ceratohyal.
- c. l. Cleft.
- cr. Coronoid.
- c.r.c. Coronoid cartilage.
- e. Eye.
- e.hy. Epihyal.
- e.n. External nostril.
- e.o. Exoccipital.
- e.p. Epitypic.
- e.st. Extrastapedial.
- f. Frontal.
- f.o. Fontanelle.
- f.r. Fenestra rotunda.
- f.s.o. Fenestra ovalis.
- h.br. Hyobranchial.
- h.s.c. Horizontal semicircular canal.
- i.c. Internal carotid.
- i.hy. Interhyal.
- i.n. Inner nares.
- i.nf. Infundibulum.
- i.st. Infraotapedial.
- i.tb. Inferior turbinal.
- i.tr. Inter trabecula.
- j. Jugal.
- l. Lacrymal.
- l.i. Lacrymal involution.
- l.eu. Lateral Eustachian tube.
- l.o.al. Lateral orbito-alisphenoidal fenestra.
- m. Mouth.
- m.eu. Middle Eustachian tube.
- m.k. Meckel’s cartilage.
- m.n.f. Mandibular fenestra.
ON THE STRUCTURE OF THE SKULL IN THE CROCODILIA.

mx. Maxillary.
my. Myelon.
n. Nasal bone.
nr. Nasal roof.
nc. Notochord.
n.f. Nasal floor.
n.w. Nasal wall.
o.a.f. Orbito-alisphenoid fenestra.
oc.c. Occipital condyle.
ol. Olfactory capsule.
op. Opisthotic.
os. Orbito-sphenoid.
ot.p. Otic process.
p. Parietal.
pa. Palatine.
p.cl. Posterior clinoid.
pf. Prefrontal.
pg. Pterygoid.
p.g.c. Pterygoid cartilage.
pl. Pineal gland.
p.ob. Postorbital.
p.s. Presphenoid.
p.s.c. Posterior semicircular canal.
p.x. Premaxillary.
p.y. Pituitary body or space.
q. Quadrate.
g.c. Quadrate condyle.
q.j. Quadrato-jugal.
s.a.y. Supraangular.
s.n. Septum nasi.
sp. Splenial.
sph. Siphonium.
s.st. Suprastapedial.
s.st'. Stem of suprastapedial.
st. Stapes.
tg. Tongue.
tr. Trabecula.
tr.p. Transpalatine.
u.o.al. Upper orbito-sphenoidal band.
w.t. Upper turbinal.
v. Vomer.
EMBRYOS OF CROCODILIA.
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### VOLUME IX. (1875–1877, containing 99 Plates)

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Secretary.

October 1883
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OF

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Received and read June 19th, 1883.

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PART I. INTRODUCTION. By E. Ray Lankester.

WHEN, two years ago, I undertook to institute a close comparison of the structure of Limulus, on the one hand with that of the Crustacea, and on the other hand with that of the Scorpion and other Arachnida, in order to definitely and fully substantiate the view which for many years had appeared to me plausible, viz. that Limulus is no Crustacean, but an Arachnid, I found considerable difficulty, owing to the fact that details concerning the structure both of Limulus and of Scorpio, in reference to many critical points, were not to be met with in the literature of zoology. In consequence, I have found it necessary to undertake, in conjunction with my pupils, investigations upon various matters connected with the histology and coarser anatomy of both Limulus and Scorpio, which have yielded remarkable results—remarkable because they were obtained in the attempt to verify a hypothesis, and have uniformly tended to verify it. Thus, I discovered in Scorpio an organ which represents the brick-red coxal glands of Limulus (Proc. Roy. Soc. 1882), and in the remarkable microscopical structure of these "vascular glands" I have detected a character which connects Limulus and the Arachnids in the closest way whilst having no exact equivalent in any Crustacean.
(Quart. Journ. Microsc. Sci., January 1884). Further, I investigated the structure of both the simple and the compound (or aggregated) eyes of Limulus and of Scorpio, and again obtained from the minute microscopic structure evidence of the closest agreement between these two genera and of total divergence from the Crustacea (Quart. Journ. Micr. Sci., January 1883).

Again, since the structure of the genital ducts in Crustacea is simple or, in any case, non-reticulate (except in the male Apus), whilst both oviducts and sperm-ducts in Scorpio and other Arachnida have the characteristic form of a mesh-work, I requested my pupil Mr. W. B. S. Benham to investigate the structure of the spermatic duct and glands of Limulus, hitherto unexplored. Mr. Benham found (and has described in the 'Transactions of the Linnean Society,' 1883) a highly subdivided reticulum, or mesh-work, constituting the spermatic duct, as in the Scorpions. The oviduct had previously been shown by Owen to have essentially the form of a network.

Lastly, I have found (and am about to explain in detail in the Quart. Journ. Micr. Sci.1) the most intimate agreement between Limulus and Scorpio in respect of the following points of minute structure:—(1) the blood-corpuscles; (2) the softer connective tissues; (3) the entochondrite (internal sternum of Straus Durkheim), which is, in both cases, a mass of condensed connective tissue with cells of very characteristic appearance, but so like in the two cases as to be practically indistinguishable; (3) the gastric caeca and their lining epithelium.

Amongst the most important points of agreement between Limulus and the Arachnids is that insisted upon by Straus Durkheim, namely, the possession of an internal freely suspended sternum or plastron of connective tissue (cartilaginoid tissue), to which numerous muscles are attached. Such an entochondrite exists in no Crustacean2; it probably is more or less closely similar in nature to the so-called "chorda" discovered by Leydig in insects of the genus Sphinx.

In order to carry out fully the comparison of the entochondrite of Limulus with that of Scorpio, it became necessary to make an investigation of the muscles attached to this organ in each case, and this has led on to a general investigation of the whole muscular system and its related supports in the two animals. The investigation of Limulus has been carried out by Mr. Benham, that of Scorpio by Miss Beck. No account of the muscular system of either animal has before been given, although imperfect descriptions of parts of the muscular system of Limulus are to be found both in the memoirs of Owen and of Alphonse Milne-Edwards.

As might be expected, we find a considerable specialization of the muscular system in the two animals compared, resulting in a wide divergence as to certain muscles; but there remain, nevertheless, certain agreements which are of the most striking and important character.

1 Since published, in January 1884.
2 I have since found a rudimentary structure of the kind in Apus (Quart. Journ. Micr. Sci., January 1884).
It will be sufficient to point out here, by way of introduction, that necessarily in *Scorpio* the muscles to the appendages of the mesosoma are almost entirely suppressed (those of the last four pairs of appendages, which have become lung-books, entirely), whilst, on the other hand, the same muscles are large and functionally important in *Limulus*. Again, in *Scorpio* the free articulation of the segments of the mesosoma and of the metasoma is retained, and accordingly the musculature connected with that articulation is developed. In *Limulus*, on the other hand, the segments of the mesosoma are ankylosed, and there are consequently no intersegmental muscles. One great joint, however, that between prosoma and mesosoma, is retained by *Limulus*; and accordingly, in connexion with that one joint, we find an enormous and specialized muscular development, differing from anything in *Scorpio*.

The most remarkable agreements to which the reader's attention is directed beforehand are in respect of (1) a large number of the muscles attached to the prosomatic entochondrite; (2) certain of the muscles attached to the pectines of *Scorpio* and the first gill-bearing appendage of *Limulus* and to the related small entochondrites in both cases; (3) the muscles arising from the pericardium and inserted into the investment of the great venous sac, which in the one case lies at the base of a gill-book and in the other case forms the investment of the in-sunken lung-book. This is a most important agreement, since in each case the muscle must have a very definite and peculiar action in determining the flow of blood from the respiratory sinus to the heart. These muscles were described as "brides transparentes" by A. Milne-Edwards, in his account of the vascular system of *Limulus*. By Newport they were seen in the Scorpion, and figured in his drawing, fig. 27, pl. xiv. of the 'Philosophical Transactions' for 1843; but they are not described or referred to by him in any way, and their significance has never yet been pointed out.

Lastly, the agreement in the origin and insertion of the great dorso-ventral vertical muscles of the mesosoma is a prominent one. In the fourth Chapter of the present memoir a further discussion of the agreements and differences of the muscular system in *Scorpio* and *Limulus* will be found.
PART II. Description of the Muscular and Endoskeletal Systems of Limulus.
By W. B. S. Benham, B.Sc.

HARD PARTS.

Some of the Hard Parts in Limulus to which Muscles are attached.

I. The Tergites.

a. External View.

1. The Prosomatic Carapace has a horseshoe-shape, rounded and convex in front and at the sides, which latter are produced beyond the central portion, ending in a point behind. (For a general description and figures of the segments fused to form the anterior and posterior carapaces of Limulus, see Lankester, "Limulus an Arachnid," Quart. Journ. Micr. Sci. 1882.)

The carapace is bounded behind by an almost straight line, reaching about halfway on each side of the middle line. This straight portion bends sharply downwards, so that the posterior border is nearly vertical, but of little depth. In the middle of this portion is an arch, and on each side of this is a slight depression running forwards along the carapace to about half its length: this depression produces a ridge on the inner surface, at the posterior end of which an invagination of the chitin has taken place, forming a pair of entapophyses (Pls. LXXIII., LXXV., and LXXVI., Ent¹), indicated externally by a shallow pit, on each side of this hinder arch, and situated in the vertical border.

Outside these two parallel depressions, about two thirds from the middle line to the edge of the carapace, is a slight longitudinal ridge; on this ridge are situated the lateral eyes. It is outside this ridge that the carapace commences its downward course.

2. Meso-metasomatic Carapace.—The hinder border of the prosomatic carapace is joined to the front edge of the abdominal (meso-metasomatic) carapace by a leathery membrane extending right along the straight border; on this border is an arch corresponding to that in the prosomatic carapace. This front border is bent slightly downwards, and at the end of the straight piece bends backwards and outwards, parallel with the recurved portion of the sides of the prosomatic carapace. About halfway along this oblique border is a ridge, ending in a point directed outwards. At the edge the meso-metasomatic carapace is produced into six sharp recurved points, between each consecutive pair of which is a rounded excavation in which is articulated a movable spine: there are thus six pairs of movable spines to this
carapace. Behind the last of these the edge is continued into a point similar to that of the recurved hinder portion of the prosomatic carapace. Behind the arch in the anterior border is a median arched portion of the carapace, transversely marked by six very slight depressions; between each of these, at the side of the arched part, is a pair of pits, the point of invagination of six pairs of "entapophyses" (Owen). Outside this line the carapace slopes downwards to the edge. Behind the last pit of invagination is a smoother part, which extends a short way backwards, and is continued outwards to form the posterior portion of the edge, which ends in a point. The hinder edge of the abdominal carapace is scooped out; in the bay thus formed a postanal spine is articulated by means of a strong membrane.

3. The Postanal Spine itself consists of a long tapering piece, triangular in section, with the apex of the triangle upwards. It is the hinder portion of the typical "telsonic" segment, and is the exact equivalent of the Scorpion's "sting." At its articulation with the body it has a dorsal process, which curves slightly forwards, and has the strong articulating membrane attached to it. The basal piece spreads out, and is likewise continued slightly forwards, and has also the strong membrane attached (Pl. LXXIII. sp).

b. Internal Aspect. (Plate LXXVI. fig. 1.)

1. The Prosomatic Carapace is thus concave when seen from below and within, running downwards in front and at the sides to join the sternite. Behind, from the vertical border, rise the entapophyses; these are strong processes, triangular in transverse section at their base, but flattened and broadened at their free ends; they are directed forwards, downwards, and slightly inwards (ent³). To these structures various muscles are attached.

From each of these entapophyses there runs forward a ridge (seen as a depression from without) with slight minor ridges branching at the sides; outside this are attached the main coxoteral muscles, each attachment being roughly separated by a slight ridge from its neighbours (25, 26, 28, &c.); within the ridge are attached other muscles from the coxae, and from the plastron and from the abdominal appendages (18, 51, 52, &c.). Lying along the posterior edge of the carapace is a curious network of chitin (Pl. LXXVI. N); this is continued forwards along the line of the lateral eyes.

2. The inner surface of the Abdominal (Meso-metasomatic) Carapace is far less extensive. It is in front continuous with the hinder portion of the prosomatic carapace, and thence backwards this surface narrows till behind it has only the width of the postanal spine.

At the sides the floor of the mesosoma rises upwards, meeting it above the mesosomatic appendages just beyond the line of the entapophyses; thence the two, fused together, continue outwards as a thin plate for a short way. This then rapidly thickens
a great deal, and becomes triangular in cross section, with its base horizontal; this is pierced by a lateral canal, in which runs an artery supplying the movable spines (Pl. LXXVI. figs. 10, 11). This canal is open behind into the metasoma, and in front curves along the oblique anterior edge of the abdominal carapace and opens into the prosomatic cavity.

On each side of the median arch mentioned above, are situated six entapophyses (Pl. LXXVI. Ent\(_1^2\) to Ent\(_6^2\)), smaller than the pair in the prosomatic carapace, but with the same direction; each is smaller than its predecessor, the last being very short. Five of these belong to the mesosoma, the first of the six fused segments of which has no entapophysis: the last belongs to the metasoma. They all vary a good deal in shape, though in general they are flattened laterally. Several muscles are attached to each of these, as will be seen later on.

Along the anterior edge is a similar chitinous network to that found on the prosomatic carapace. This is continuous along the line of the entapophyses, leaving spaces for attachment for muscles, and is found elsewhere.

II. The Sternites (seen from within). (Plate LXXII.)

1. Prosomatic Region.—Outside the attachments of the limbs, whose basal joints form the sides of the prosomatic region, the ventral hard chitinous portion of this region curves outwards and downwards to join the dorsal portion (lateral convexity): thus the floor of the prosoma, at the sides, is convex from within, and there is only a very shallow space between tergite and sternite.

Anteriorly, in the median portion, there is a triangular flat portion, the subfrontal area (Sf\(_a\)), which forms the floor of a much deeper space between tergite and sternite, in which is lodged the muscular stomach. The sides of this triangular space curve upwards and outwards, forming a continuation with the general convex sternal portion outside the coxal attachments. The apex, which is median and posterior, has an almost vertical wall, which rises for a short distance and is then continued as a chitinous membrane backwards.

The median portion of the floor of the prosoma, the real sternal region of this division of the body, above which are lodged the various organs, is principally membranous, with certain chitinous sclerites here and there.

The mouth is situated in almost the centre of this part, between the bases of the third pair of prosomatic limbs. The oesophagus (\(o\)) is of chitinous membrane, and has harder ridges along it, which radiate along the floor of the prosoma towards the coxae of the limbs.

In front of the mouth, and between the coxae of the first pair of prosomatic appendages, is an ovate piece of hard chitin, the sclerite of the "camerostoma" of Latreille, which forms a sort of upper lip (Cam).
AND ENDO SKELETAL SYSTEMS OF LIMULUS. 317

In front of this, in the median line, is another sclerite, the subfrontal sclerite (Sf').

Behind the mouth is a large somewhat pear-shaped sclerite, with its broad end directed backwards: this is the pro-meso-sternite (marked p.m.st in Pl. LXXVI.).

Behind this come the two apertures leading into the chilaria (ntst), identified by Prof. Lankester as the metasternite. Mr. Packard has shown by their development that they do not belong to the series of appendages, and it is obvious enough that they represent the pentagonal or triangular sternal sclerite of the Scorpions.

Slightly behind these, and high up the sides of the membrane, behind the last entocoxite, where the membrane rises upwards to join the outward-sloping sternite of chitin, is a sclerite on each side, the lateral sclerite (Pl. LXXVI. lat.scl).

The sides of the prosomatic region are formed simply by the basal joints of the appendages. These basal joints are elongated dorso-ventrally, forming an entocoxite; and, while the top of this portion, in each case, is attached to the "lateral convexity" (convex chitinous sternal portion of the prosoma), the lower part and the sides are simply held in place by chitinous membrane, which extends all along the ventral median region and up between the basal portion of the limbs to reach the lateral convexity (chitinous portion of the prosomatic floor). This holds for the hinder five pairs of prosomatic appendages; but the first pair is not articulated to any hard part, but simply lies in the membrane. Instead of having an anterior and posterior border to the entocoxite (vide below) there is only one bar to each: and anterior to this, in a line with it, are two sclerites on each side (near the word Cam in Pl. LXXII.).

Each of the last five pairs of thoracic limbs is attached to the lateral convexity (sternal chitinous portion) of the thorax by means of a knob, at the top of the entocoxite; this articulates with a little hollow in a thickened portion of chitin, whence diverge two rods of harder chitin, continuous with and part of the lateral convexity (chitinous sternite), may be called the coxal pivot or hyper-coxite (see fig. 7, Pl. LXXVI.).

The Floor of the Abdomen (meso- and metasoma).—This is continuous with the median floor of the prosoma, and, like it, is membranous. It narrows posteriorly, and is interrupted by six transverse hollows (vII to xII), leading into the six mesosomatic appendages, viz. the genital operculum and five gill-plates. From the hinder edge of each of these hollows there rises on each side, near the middle line, a hollow tendon (ts to ts'), continuous posteriorly with the stigmata on the base of the abdominal appendages, and at their anterior ends having each a muscle inserted. These tendons and their stigmata will be found described and figured in Prof. Lankester's Memoir "Limulus an Arachnid."

Between each pair of these "tendinous stigmata" is situated in the middle line, on the posterior border of the transverse hollows in the floor, a small rectangular cartilaginous "entochondrite," to which muscles are attached (s to s').
Thus there are six of these abdominal entochondrites, and six pairs of tendinous stigmata.

The sides of the mesosoma rise up, and are continuous with a chitinous portion, which continues outwards, and becomes fused with the tergite; the two thus fused are continued laterally for a short distance, then separate again and thicken out, containing a canal, carrying an artery &c. to the movable abdominal spines. The floor of this is horizontal.

The membranous floor of the mesosoma is continuous behind with the chitinous floor of the metasoma; this is scooped out on its anterior border, in the middle line; in the hollow thus formed is situated the last entochondrite, and to the sides of this hollow are attached the last pair of tendinous stigmata (see Pl. LXXII.). The metasomatic floor itself bends sharply downwards, widens posteriorly, and curves upwards at the sides to join the tergite; thus it is concave from within. This metasomatic cavity is continuous with the lateral canal above mentioned.

The hinder border, which is almost flat, is scooped out; and in this bay is situated the anus, surrounded by a membrane similar to that round the mouth (R). Behind this is the postanal spine (sp).

Thus, if the abdominal region be looked at from below, supposing the appendages to be removed, the sides curve upwards towards the observer (downwards, of course, in its natural position), and outside this is the flattened floor of the lateral canal.

On the concave sides are five transverse lines (see woodcut, fig. 3, in Lankester’s “Limulus an Arachnid”), corresponding with those slight depressions seen on the abdominal tergite, starting from between each pair of entapophyses. From the last line rises upwards (downwards in natural position) the metasomatic sternite. This line starts between the sixth and seventh entapophyses, so that the latter lies in the metasoma, and, as will be seen by the muscles attached to it, must be considered as belonging to this portion. In the same way the muscles attached to the first pair of entapophyses, which are invaginated from the posterior vertical border of the prosomatic carapace, seem to show that these belong really to the mesosoma.

The microscopical structure of the carapace shows it to consist of three layers of chitin of various thicknesses, the outermost being very thin and remaining yellow, while the second remains almost colourless, and the innermost deeply stained under the action of borax-carmine. The middle layer shows fine wavy lines parallel to the surface, as well as finer transverse striations. The inner layer is more coarsely striated, mainly transversely, but sometimes obliquely, to the surface.

These layers are traversed by fine tubes, which on reaching the outer layer contract suddenly into an exceedingly fine capillary; these contain connective tissues, and to some are attached hairs, around whose bases the external layer is depressed into a small pit.
Below the outermost layer of chitin are the flattened epidermic cells which produced the cuticle; these are surrounded by pigment, or contain pigment.

In the case of the network on the inner surface of the carapace, the layers of chitin, except the outermost, are continued, surrounding spaces filled with connective tissues. The tubes piercing the layers are more or less filled with connective tissue-cells.

III. Appendages.

1. Prosomatic Appendages—Of the six pairs of prosomatic appendages, the five hinder pairs are more or less alike (the walking-legs), the last being used for digging as well as walking. The first pair is much smaller and has fewer joints.

The proximal joint (coxa) of a walking-leg is a short piece, widening out from its distal end dorso-ventrally till it becomes very wide at its attachment to the body.

Attached to the coxa of the third, fourth, and fifth pairs is a small movable piece, described by Lankester as the epicoxite, and directed towards the middle line.

The coxa itself, where it projects below the floor of the thorax, is strongly toothed; this portion is the sterno-coxal process, and is used for manducatory purposes.

The sterno-coxal process of the sixth proximal appendage is not toothed but is slightly roughened.

When the base of a walking-leg is looked at from within the body (see Pl. LXXII. and Pl. LXXVI. fig. 7) there are seen, rising almost vertically from the sterno-coxal process, two narrow chitinous bars, at first diverging from one another, so as to form an anterior and posterior border to this portion; to these borders various muscles are attached. After running nearly parallel for a short distance, and inclined outwards, they converge and meet in a slightly thicker piece; from the posterior end of this a short thick bar rises upwards and backwards, whilst from its anterior end another piece goes upwards and forwards to a knob, which articulates with the "coxal pivot" on the "sternal convexity." From this a rod goes backwards to meet the anterior short bar; the part where they meet is a rounded knob, into which the principal coxo-tergal muscle is inserted. Other smaller bars go from the anterior border to this articulate "knob."

Each of these sets of chitinous bars may be termed an "entocoxite."

The first thoracic appendage differs from this in that there is but a single chitinous rod passing upwards, forwards, and outwards from the coxa along the membranous sternal region in front of the camerostome, at the side of which the coxa is situated.

This single rod probably represents the posterior border of the other entocoxites, judging from the insertion of its muscles. The entocoxite is not fixed to any hard structure at its upper and anterior end, and in a line with it are two small sclerites.

2. Mesosomatic Appendages. a. Gill-plates.—Of these there are five pairs, each pair being united across the median plane.

The appendage consists of a bag, flattened antero-posteriorly, open to the mesosomatic
cavity above; the sides of this bag may be termed the anterior and posterior lamellæ. Across the middle line, for a short distance on each side, these two lamellæ are free from one another and membranous, and are produced in the middle line ventrally as a membranous tongue-like appendix called the sternal lobe (Pl. LXXIII. fig. 4, ml), containing a space continuous with that between the lamellæ.

A single branchiferous appendage, considered apart from its fellow to which it is joined across the middle line, consists of a broad, flat, chitinous basal piece, which carries the gill-book on its posterior face. From this basal joint there springs a broad chitinous exite on the outer side, and on the inner side the limb continues in three joints, the last of which hangs pretty freely downwards at the side of the membranous tongue already spoken of as the sternal lobe (see Pl. LXXIII. fig. 4). The gill-book is placed on the basal joint outside the posterior lamella, and consists of about 150 double leaves, the double leaf being a flattened bag of two plates opening into the space between the anterior and posterior lamellæ of the appendage. Of these the smallest is placed anteriorly, and the largest posteriorly, each one overlying the succeeding lower one.

The anterior lamella of the branchiferous limb is strengthened by two chitinous bars, one going obliquely outwards, the other passing downwards along a flat chitinous plate, which is situated just outside the sternal lobe. To these chitinous pieces some of the muscles of the appendage are attached. On the posterior lamellæ are also one or two small sclerites (see Pl. LXXIII. fig. 4).

Close to the base of the sternal lobe, on each side, and close to the middle line, is situated a stigma (stg); this leads into a hollow tendon, which passes upwards and forwards for about ⅔ inch, and in its anterior end is inserted a muscle. The six muscles from these tendinous stigmata on each side form the two large branchio-thoracic muscles, which raise the floor of the abdomen by their contraction.

The chitinous supports of the anterior lamelle have a similar structure to that of the other chitinous parts, but bear some very curious large hairs inserted in cups situated in the outer layer of chitin. These compressed hairs are of two sorts, large and small; the large ones have a number of flat processes standing out from the sides, into each of which apparently a canal runs. The smaller kind of hair is narrower, and bears more needle-shaped processes on it.

b. The Genital Operculum.—This is formed of a right and a left portion, which have fused more completely across the middle line than have the lamelliferous appendages. It consists of an anterior and posterior lamella, which are separate and chitinous right across, there being no membranous "sternal lobe" nor tongue-like appendix (Pl. LXXIV. figs. 4, 5).

The posterior lamella bears no gill-book; but about one third of the way from the base of the appendage, and near the middle line, are a pair of small chitinous papillæ;
these are pierced by the genital apertures; each leads into a duct, which passes upwards and slightly outwards, lying parallel to the "posterior lamellar" muscle, coming nearly up to the thoracic carapace, alongside the sixth coxotergal muscle; here it breaks up into branches.

There are a pair of tendinous stigmata, and in all other respects the genital operculum is similar to the succeeding appendages.

IV. Entochondrites.

1. Prosomatic or Plastron.—This internal skeletal structure (Pl. LXXVI. figs. 3, 4, 5, 6) is a flat, roughly rectangular, cartilaginous body, with its longer axis directed antero-posteriorly. It lies in the centre of the prosoma, above the mouth and nerve-collar, between the entocoxites, to which a large number of muscles pass from it. Dorsal to it lies first the alimentary canal, and then the anterior aortic trunk. Muscles pass from it to other parts.

It is convenient for subsequent use in the terminology of the muscles to apply the name "plastron" to the prosomatic entochondrite.

The general flat surface may be called the "body" of the entochondrite or plastron; its anterior border is concave anteriorly, and each side is produced forwards as a short stout process, to which various muscles are attached: these may be called the "anterior cornua" (A.c.en).

The front edge is produced laterally into a long slender bar of cartilage, which, rising outwards and upwards, passes between the third and fourth entocoxites; to the distal end of this process is inserted a short muscle, attaching it to the carapace outside the coxotergals.

Behind this, and springing close to it, is a second long process; this passes outwards between the fourth and fifth entocoxites, and like the front one is attached to the carapace by a muscle beyond the coxotergals. These may be called the "lateral cornua" (l.c.en).

The hinder part of the side of the "body" passes outwards, and with the produced posterior edge of the entochondrite forms a "latero-posterior process" on each side (l.p.e.en).

Posteriorly, in the middle line, is a "posterior process," which rises very slightly above the "body" (p.c.en).

From the dorsal face of this entochondrite, just behind the base of this hinder lateral cornu, is a short stout "dorsal process" (d.c.en) on each side, which rises backwards, upwards, and slightly outwards.

To all these processes are attached muscles, some from the thoracic appendages, others going to the carapace &c.

The microscopic structure of this organ has been described by Prof. Lankester since 3 c 2
this Memoir was in type; the reader is referred to his paper in Quart. Journ. Micr.

2. Mesosomatic Entochondrites.—There are six of these, lying on the floor of the
mesosoma on the hinder border of the bases of the appendages (see Pl. LXXII. for
their position). The nerve-cord is dorsal to these entochondrites, and not below them
as it is in the case of the plastron. They are more or less rectangular in shape, with
their long axis transversely directed (Pl. LXXXVI. fig. 8). The anterior and posterior
corners are slightly produced, giving attachment to muscles. On the median ventral
surface is a ridge.

These have the same microscopic structure as the plastron.

V. The Entapophyses.

There are seven pairs of these, one on the thoracic carapace on its hinder vertical
border, the rest in a line with these on the abdominal carapace. Each consists of an
invagination of the chitin to form a strong process, directed forwards, downwards, and
slightly inwards; they are flattened from side to side. Several muscles are attached to
each entapophysis; thus, e.g., on the inner face, anteriorly, are attached the bundles of
the oblique muscle (1, 2, 3); posteriorly, in the case of the last three, the ventral pygo-
tergal (9); to the ventral edge, the posterior lamellar muscle (23) from the abdominal
appendage of the same segment; on the outer surface, ventrally, the posterior lamellar
muscle (22) from the succeeding abdominal appendage; posteriorly, the dorsal pygal
muscle (6). To different entapophyses are attached different muscles.

To the outer edge of each entapophysis is attached a half-ring of hyaline cartilage
(capsulogenous tissue of Lankester) by the intervention of some fibro-cartilage (fibro-
massive tissue of Lankester); by means of this ring some of the muscles from the
abdominal appendages are attached.

The fibro-massive tissue is continuous from each entapophysis to the next one, and
forms a definite band-like structure on each side of the mesosoma, to which I give the
name of "entapophysial ligament" (Pl. LXXXIII. ee): it ends in the postabdominal
sternite.

Microscopic Structure.—The entapophyses are similar to the carapace; the outermost
layer of chitin in the latter now, of course, lines the cavity which exists within the
entapophysis: the layers are a good deal contorted, and are pierced by tubes in the
same way as is the carapace. Some of these carry hairs, which project within the
cavity.

Below the chitin are seen the epidermic cells which produce the chitin. These are
a good deal obscured by pigment.
VI. Tendinous Stigmata.

These are invaginations of the cuticle near the base of the abdominal appendages, one on each side of the middle line on the posterior face of each appendage: the hollow invagination is as much as one inch in depth (Pl. LXXXIV. figs. 4, 5, st).

The stigma is at first composed of two or three layers of epidermal chitin; then, as we pass inwards, we find it invested by fibrous connective tissue forming a tendon, to which the branchio-thoracic muscle is attached.

MUSCLES.

I. The Longitudinal Muscles.

The Prosoma and the Mesosoma.—These cannot be separated, as the principal muscles rise in the prosoma, but mainly lie in the mesosoma.

No. 1. The Dorsal Entapophysio-plastral.—This rises on the dorsal face of the posterior process of the plastron or prosomatic entochondrite, beneath 54, and passes over the base or attachment of the dorsal plastro-tergal muscle (55), directly backwards into the mesosoma, below the intestine, just on each side of the median plane (Pl. LXXXIII. figs. 1, 2, and Pl. LXXVI. fig. 4). On reaching the mesosoma it gives off a bundle (83) to the third entapophysis, to which structure it is attached on the anterior edge. The main muscle then passes on, giving off a bundle successively, to each of the following entapophyses (84, 85, 86), nos. 4, 5, 6, the main bundle (87) running on to the last entapophysis—the metasomatic. In its course it includes the vertical mesosomatic muscles (12) between the main bundle and each branch to the entapophyses.

No. 2. The Ventral Entapophysio-plastral.—This rises from the dorsal face of the plastron, nearly covering this structure, passing beneath no. 54; like the preceding, just below which it passes, it runs into the mesosoma, breaking up into bundles, which go to the entapophyses 3, 4, 5, and 6. It likewise ends in the metasomatic (seventh) entapophysis. Just outside its branches rise the veno-pericardiac muscles (68).

The branch to the third entapophysis is lettered 103 in the Plates.

The branches to the fourth, fifth, and sixth entapophyses are lettered 104, 105, 106 respectively.

The terminal slip (107) is inserted into seventh entapophysis.

No. 3. The Ventral Longitudinal.—This is a much smaller muscle than either of the preceding, lying on the abdominal floor. It is shown in Pl. LXXV. fig. 3. It rises from the dorsal face of the plastron underneath the origin of no. 2. On reaching the mesosoma it gives off a bundle (no. 69) to the second mesosomatic entochondrite. It
gives off similar bundles (70, 71) to the next two entochondrites, as well as bundles (74, 75, 76, 77) to the fourth, fifth, sixth, and seventh entapophyses.

It is continued backwards on the floor of the abdomen, after giving off its last slip, and is inserted into the metasomatic sternite.

No. 4. The Inter-entapophysial Muscles.—Of these there are four (best seen in Pl. LXXV. fig. 2):—

4 a. A small one running from the hinder edge of the first entapophysis to the anterior inner face of the second.
4 b. A larger one from the first to the third.
4 c. From the first to the fourth.
4 d. From the first to the fifth.

These lie successively lower, no. 4 a being uppermost.

No. 78. The Arthrotergal Muscle (Pl. LXXV. fig. 2).—This large muscle passes from the tergum of the prosoma to the tergum of the mesosoma, across the joint; it assists in flexing the prosoma on the mesosoma.

No. 5. Intersternal or Longitudinal Muscle.—Rising from the dorsal face of the plastron close to the posterior process of this structure, it passes from segment to segment of the mesosoma, being attached in each case to the mesosomatic entochondrites, and ending in the metasomatic sternite, being fixed near its anterior edge (Pl. LXXV. fig. 3).

The Longitudinal Muscles of the Metasoma.

No. 6. Internal Pygo-tergal Muscle.—Arising close to the median plane, from the membrane (mb) attached to the dorsal process of the post-anal spine, it passes almost directly forwards, being attached partly to the carapace (6); then passing forwards it is attached successively to the inner faces of the metasomatic, the sixth, and the fifth entapophyses, by its branches 91, 92, and 93 respectively.

No. 7. Middle Pygo-sternal.—Arising also from the membrane above mentioned more laterally than no. 6, it passes laterally forwards, to be inserted into the carapace, splitting into branches 94, 95, which are inserted into that part of the metasomatic sternite (p, ab, st) which rises sharply upwards to join the carapace.

No. 8. The External Pygo-tergal has the same arrangement as no. 7, but is placed more laterally, and slightly ventrally; its slips to the metasomatic sternite are lettered 96, 97.

No. 9. The Ventral Entapophysio-pygal.—This muscle arises below no. 6 in the membrane of the main part of the spine, runs forwards, and is inserted into the seventh, sixth, and fifth entapophyses on their outer faces by branches 90, 88, and 89 respectively.

No. 10. The Inner Sterno-pygal arises in membrane at the basal portion of the spine,
and runs slightly outwards and forwards to the uprising portion of the post-abdominal sternite, to which it is attached. It is more laterally placed than no. 9, and below no. 7.

No. 11. The Outer Sterno-pygal arises from the basal membrane of the spine more laterally than no. 10. Passing below no. 8 it is attached to the floor of the metasoma.

No. 61. A few muscular fibres, rising in the floor of the fourth mesosomatic segment, run to the fifth and thence to the sixth segment, and end in the metasomatic sternite, a good deal mixed with nos. 3 and 5.

II. Dorso-ventral Muscles. (Plate LXXV.)

No. 12. The Vertical Mesosomatic Muscles.—Of these there are six on each side. Each is inserted into one of the six mesosomatic (or abdominal) entochondrites on its outer edge, and rising slightly obliquely across the bundles of no. 1, between the branches of which it passes, is attached to the tergum anteriorly to the base of each of the entapophyses, its general course being vertical. [It is especially noteworthy that the first pair of this series passes from the entochondrite of the genital operculum to the prosomatic tergum, being attached just in front of the great entapophysis on each side.—E. R. L.]

No. 13. The Oblique Entopophysis-ternals.—A muscle from the second mesosomatic entochondrite passes backwards, upwards, and outwards above no. 3, and below the branches of no. 2, to its attachment to the deep (free) end of the fourth entapophysis.

No. 14. A muscle, with a similar course, from the third mesosomatic entochondrite to the fifth entapophysis.

No. 15. A similar muscle from the fourth mesosomatic entochondrite to the sixth entapophysis.

No. 16. A similar muscle from the fourth mesosomatic entochondrite to the metasomatic (seventh) entapophysis.

No. 17. A similar muscle from the fifth abdominal entochondrite to the metasomatic (seventh) entapophysis.

No. 18. The Branchio-thoracic Muscles.—A series of muscles pass from the hollow tendons which open at the stigmata of the mesosomatic appendages. There are six pairs of these. Each tendon has attached to it a thickening bundle of muscle which in its passage upwards and forwards passes outside no. 12 muscle to the inside of the entapophyses, beneath the dorsal lateral plastro-tergal muscle (52) to its attachment to the carapace in the prosoma, alongside that of the coxo-tergal muscles, but nearer the median plane.

No. 19. From the bundle attached to the last stigma (see Pl. LXXV. fig. 1), before it has joined those arising from the anterior stigmata, there rises a muscle which passes more directly upwards than the mass of the branchio-thoracic, and is attached to the inner posterior face of the second entapophysis.
No. 20. The External Branchial Muscles.—Inserted in the anterior lamella of the genital operculum is a large muscle which passes at first upwards (Pl. LXXV. fig. 1); then, when it leaves the appendage, it passes outwards, backwards, and upwards, outside the other muscles of the metasoma to its attachment on the anterior border of the mesosomatic carapace, outside the line formed by the bases of the entapophyses (Pl. LXXIV. fig. 1, and Pl. LXXVI. fig. 1).

There is a similar pair of muscles in each of the other five mesosomatic appendages. [These are attached at their tergal origins near the corresponding entapophysis (Pl. LXXV. fig. 7). There is no entapophysis to the tergum of the genital segment, as is rendered obvious by the position of this muscular attachment, unless we may consider the great prosomatic entapophyses as originally belonging to that segment, but transferred and ankylosed to the prosoma, just in the same way as the body of the atlas vertebra of mammals is transferred to the axis.—E. R. L.]

No. 21. Anterior Entapophysio-branchial Muscles.—Nearer the middle line than no. 20 is a smaller muscle inserted in the anterior lamella of the genital operculum, and passing nearly directly upwards, and slightly outwards, outside all the other muscles of the mesosoma but no. 20, to its attachment to the great prosomatic entapophysis (see Pl. LXXIV. fig. 1).

A similar muscle occurs in each of the five succeeding mesosomatic appendages, each attached to the entapophysis of its own segment.

No. 22. Posterior Entapophysio-branchial Muscles.—From the posterior lamella of the genital operculum there goes a muscle upwards and forwards, beneath the muscle 1, to its attachment on the prosomatic carapace, alongside the sixth coxo-tergal muscle, nearer the median plane.

In each of the five succeeding mesosomatic appendages is a similar muscle, but each is attached to the entapophysis of the preceding segment; thus this muscle from the second mesosomatic appendage is attached to the great prosomatic or first entapophysis, that from the third to the second entapophysis, and so on.

No. 23. Pre-entapophysio-branchial Muscles.—In the second and following mesosomatic appendages is a second muscle, attached in each case to the entapophysis of the preceding segment, but inserted into the anterior instead of the posterior lamella of the appendage.

No. 65. Chilarial Muscles.—A small muscle passes from the posterior process of the prosomatic entochondrite into the chilaria.

III. Muscles of the Appendages.

a. Prosomatic Appendages. No. 24. The Tergo-coxal Muscles of the first Pair.—From the coxa of the first prosomatic appendage a small muscle rises nearly vertically, passing just across the inner border of the anterior corn of the prosomatic entochondrite, and between the muscles of this process to the carapace, to which it is attached
on the level of the third coxo-tergal (the second large muscle seen on opening the animal), but nearer the median line.

No. 25. *The Tergo-coxals of the second, third, fourth, fifth, and sixth Pairs.*—A large muscle, short, but thickening rapidly, is attached to the rounded knob at the top of the ring formed by the two borders of the entocoxite of each of the five following prosomatic limbs (25 a, 25 b, 25 c, 25 d, 25 e). They arise from the carapace in order one behind the other (Pl. LXXVI. fig. 1 and fig. 7, also Pl. LXXIII.).


No. 27. *Antero-inferior Tergo-coxal Muscles.*

No. 28. *Postero-superior Tergo-coxal Muscles.*

No. 29. *Postero-inferior Tergo-coxal Muscles.*

These four sets of muscles are found in connexion with each of the five pairs of prosomatic appendages succeeding the first. They are inserted into different parts of the entocoxite of each limb, as shown in Pl. LXXVI. fig. 7, and arise from areas on the carapace surrounding the origin of the muscles 25 a, 25 b, 25 c, 25 d, and 25 e.

No. 30. *Anterior Plastro-coxal Muscle.*—A muscle attached to the inner ventral face of the anterior cornu of the prosomatic entochondrite, and passing forwards is inserted into the anterior face of the rod-like entocoxite of the first prosomatic appendage.

No. 31. *Posterior Plastro-coxal Muscle.*—A muscle arising behind no. 30, from the entochondrite, also goes to the entocoxite of the first appendage, but is inserted below no. 30.

No. 32. *Superior Plastro-coxal Muscle.*—A muscle arising from the outer face of the anterior cornu of the prosomatic entochondrite, passes slightly forwards, enters the space bounded by the two borders of the entocoxite of the second limb; it here breaks up into two—*m* going to the inner face of the anterior, *n* to the inner face of the posterior border. Here they each spread out, passing upwards; they do not go far into the coxa. For this and nos. 33, 34, see Pl. LXXVI. fig. 7.

No. 33. *Mid Plastro-coxal Muscle.*—This muscle rises below no. 32 from the entochondrite, and passes slightly forwards; it is inserted into the posterior border of the entocoxite of the second limb.

No. 34. *Inferior Plastro-coxal Muscle.*—Rises behind and below no. 33 from the under-surface of the body of the entochondrite, and passing forwards, below no. 33, is inserted into the anterior border of the entocoxite of the second prosomatic limb.

No. 35.  

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<td><em>a</em>, its anterior;</td>
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No. 38. This muscle is similar to 32 and 35, rises behind them, and goes to the fourth appendage: *q*, its anterior; *r*, its posterior branch.

No. 39. This muscle passes in a more backward direction from its origin in the edge of the entochondrite to the fourth entocoxite (corresponds to 33).
No. 40. This muscle passes beneath 39, and goes to the fourth entocoxite (corresponds to 34).

No. 41. This muscle is similar to 32, 35, and 38, and goes to the fifth prosomatic appendage: it, its anterior; i, posterior branch.

No. 42. This muscle lies parallel to but behind 39, and passes backwards to the fifth appendage (corresponds to 33, 36, and 39).

No. 43. This muscle rises under and behind 40, passes beneath 42, and goes to fifth limb. It corresponds to 34, 37, and 40.

No. 44. This muscle is similar to 32, 35, 38, and 41, and goes to sixth appendage: y, its anterior, z, its posterior branch. It rises from the postero-lateral process of the entochondrite.

No. 45. Rises behind 42, runs parallel to it, and goes to the sixth appendage, passing under 44.

No. 46. This is a much larger muscle than the corresponding ones 34, 37, 40, 43, rising from the middle line of the ventral surface of the body of the prosomatic entochondrite, beneath and behind the previous muscles of the limbs, and, passing rather backwards, goes to the sixth appendage.

No. 47. Is smaller than 46, rises behind it, and goes outwards to the entocoxite of the sixth appendage.

No. 48. Rises from the postero-lateral process of the plastron behind 44, and goes to the posterior border of the entocoxite.

b. Mesosomatic Appendages.—The muscles connected with these have nearly all been described under the heading "Dorso-ventral Muscles." These are:

No. 20. The external branchials: six pairs.

No. 21. The anterior entapophysio-branchials: six pairs.

No. 22. The posterior entapophysio-branchials.

No. 23. The pre-entapophysio-branchials: five pairs.

No. 48. The Internal Branchial Muscles.—Rising from the ventral ridge of the first mesosomatic entochondrite a small muscle dips into the genital operculum, and is distributed partly to its anterior and partly to its posterior lamella (see Pl. LXXIV. figs. 4 & 5).

A similar muscle occurs in the five succeeding appendages (Pl. LXXIV. fig. 3).

No. 18. The Branchio-thoracic Muscles have been described above; they rise from the tendinous portion of the stigmata, which lie at the base of the posterior lamella of each of the six pairs of mesosomatic appendages, near the middle line.

Nos. 112, 113. These muscles appear to be branches from no. 20 to the lobes of appendages (see fig. 3, Pl. LXXIV.).

No. 114. Muscle of the Inner Lobe.—This muscle passes from the sclerite (a), in each half of each appendage, to the extremity of the internal lobe.

No. 115. Branch of 48, to sclerite (p) on anterior face.
IV. Muscles connected with the Plastron or Prosome Entochondrite not described in the preceding Sections.

No. 49. The Tergo-proplastral Muscles (Anterior Plastro-tergals).—This muscle (r and l) is inserted into the inner side of the anterior cornu of the plastron, and passes outwards, upwards, and forwards to its attachment to the carapace, slightly in front of and mediad of the muscle 25.

No. 50. A smaller muscle, inserted behind 49, passes slightly forwards and upwards, in front of 24, to its attachment to the prosome carapace.

No. 51. Similarly inserted, passing behind 24 to its attachment to the carapace, behind and mediad of the third coxotergal (25 b).

No. 52. The Dorso-lateral Plastro-tergal.—This (r and l) is inserted into the inner side of the anterior cornu of the plastron, and passes backwards, upwards, and outwards across no. 18, and is attached to the carapace in the same line with this latter muscle.

No. 53. The Dorso-lateral Entapophysio-plastral.—This muscle (r and l) is inserted on the hinder edge, near the base, of the dorsal process of the plastron, and passes upwards and backwards, and only very slightly outwards, crossing the attachments of no. 2, to the first entapophysis, to the anterior inner edge of which it is attached.

No. 54. The Anterior Entapophysio-mesoplastral Muscles.—Each of these (r and l) rises along the middle line of the dorsal surface of the "body" of the plastron, and passing across the attachment of no. 2, outwards, and slightly backwards and upwards, is attached to the first entapophysis alongside 53.

No. 55. The Posterior Entapophysio-mesoplastral Muscles.—Each (r and l) rises from the base of the posterior process of the plastron, and passing outwards, across no. 2, goes to the first entapophysis, to which it is attached close to 54.

No. 56. The Posterior Entapophysio-metoplastral Muscles.—Each (r and l) rises below 55, from the side of the posterior process, and passing outwards and backwards crosses no. 2, and is attached to the second entapophysis.

No. 57. The Lateral Tergo-proplastral Muscles.—A short muscle (r and l) is inserted into the distal end of the anterior lateral cornu of the plastron, and is attached to the carapace between nos. 25 (b and c), but outside the line formed by these muscles.

No. 58. A similar muscle (r and l) is inserted into the posterior lateral cornu, and is attached behind 57, between 25, c and d.

No. 59. A small muscle is inserted a short way down the posterior lateral cornu, and is attached to the carapace close to 25 (d).

No. 72. The Vertical Entapophysio-metoplastral Muscles.—Each (r and l) rises below 56, from the edge of the posterior process of the plastron, and passes to the third entapophysis.

No. 67. Plastro-buccal Muscle.—From the under-surface of the entochondrite, a few muscular fibres go to the œsophagus close to the mouth.
The other muscles attached to the plastron which have been mentioned in previous sections are:

No. 1, from its posterior process;
No. 2, from the dorsal face of the body;
No. 3, from the dorsal face of the body;
and those from the under-surface, 30 to 47, which go to the prosomatic appendages.

V. Muscles connected with the six Mesosomatic Entochondrites.

First: Muscle No. 5 from the prosomatic entochondrite is inserted here.
No. 12 (first pair of vertical mesosomatic muscles) is inserted here and passes vertically to the carapace.

Second: No. 5 passes on from its connexion with the first mesosomatic entochondrite.
No. 12 (second pair of vertical mesosomatic muscles).
No. 13, the first pair of oblique entapophysio-ternal muscles, passes from this entochondrite to the fourth entapophysis.
No. 62. The first pair of mesosomatic intersternal muscles passing from this to the fourth entochondrite.
No. 63. A similar muscle passing from this to the fifth entochondrite.
No. 69. A slip from the ventral longitudinal muscle (no. 3) is also inserted here.

Third: No. 5 continues from the second entochondrite. Also a third pair of vertical mesosomatic muscles, no. 12, and a slip (70) from no. 3 are inserted here.
No. 14, the second pair of oblique entapophysio-ternal muscles, goes hence to the fifth entapophysis.

Fourth: No. 64, the second pair of mesosomatic intersternal muscles, arises here and passes to the fifth entochondrite.
No. 5 is continued.
No. 12 is present as the fourth pair of vertical mesosomatic muscles.
No. 71 is a slip attached here from the great ventral longitudinal muscle, similar to the slips 69 and 70.
No. 15, the third pair of oblique entapophysio-ternal muscles, is inserted here, arising from the sixth pair of entapophyses.
No. 16, a fourth pair of oblique entapophysio-ternal muscles, arising from the seventh pair of entapophyses, is also inserted into the fourth mesosomatic entochondrite, as shown in fig. 3, Pl. LXXV. In fig. 1, Pl. LXXIV., it is represented as inserted into the fifth entochondrite. The drawings have been somewhat complicated and difficult to letter accurately. Apparently the muscle no. 16 is omitted in fig. 1, Pl. LXXIV., and that to which the reference 16 is attached should properly be lettered 17.
No. 62 arising from the second mesosomatic entochondrite, and noted above, is inserted here.
Fifth: No. 5 is continued.
No. 12 is present as the fifth pair of vertical mesosomatic muscles.
No. 17, a fifth pair of oblique entapophysio-sternal muscles, arising (like No. 16) from the seventh pair of entapophyses, is inserted into this fifth mesosomatic entochondrite.
No. 63 arising from the second mesosomatic entochondrite is inserted here.
No. 64 arising from the third mesosomatic entochondrite is inserted here.

Sixth: No. 5 is continued from the preceding entochondrite to this one, and passes on from this to its final insertion in the solid metasomatic sternite (epidermal chitin forming the floor of the hind part of the meso-metasomatic carapace).
No. 12 is present as the sixth and last pair of vertical mesosomatic muscles.

VI. Pharyngeal.

No. 66. The Sterno-pharyngeal Muscles.—From the ventral surface of the anterior curvature of the alimentary canal a number of muscular bands pass, though not in regular distinct bands, to the subfrontal area of the chitinous prosomatic carapace.
No. 67. The Plastro-buccal Muscle.—A few muscular fibres go from the oesophagus to the ventral surface of the entochondrite.

VII. Pericardiac.

No. 68. The Veno-pericardiac Muscles.—On the floor of the mesosoma (as in the Scorpion), on each side, near the middle line, is a blood-sinus, the “venous collecting-sinus” as M. Milne-Edwards calls it; here the blood collects from the body, on its way to be aerated in the leaves of the gill-books. From the floor of the sinus a vessel goes into each of the abdominal appendages; from the space between the anterior and posterior lamellae of these it reaches the gill-books.

From the roof of this collecting-sinus in each abdominal segment a muscle arises, which is inserted into the floor of the pericardium; it is a narrow, flat, almost transparent mass of muscular fibre, called by M. Milne-Edwards “brides transparentes,” and not recognized by him as composed of muscular tissue. These are the *veno-pericardiac* muscles. Besides the six pairs in the abdomen, two pairs occur on each side of the thoracic entochondrite (Pl. LXXV, fig. 2).

DESCRIPTION OF PLATES LXXII. to LXXVI. (Illustrating *Limulus*).

References.

a. Chitinous sclerite on the anterior plate of a mesosomatic appendage.

Ab. Anterior thickened border of the meso-metasomatic carapace.

Ab. Anterior border of an entooxite.

A.c.e. Anterior cornu of the entosternite or plastron: the proplastral process.

Al. Alimentary canal.
Ap. Aperture leading to the space between the two plates forming a mesosomatic appendage.

ar. Anterior process of the mesosomatic sternite.

c. Chitinous bar in mesosomatic appendage.

Ca. Canal in the side wall of the mesosoma.

Cam. Camerostome (chitinized upper lip).

Con. Convexity of the lateral region of the prosoma.

cp. Coxal pivot.

d.e.eu. Dorsal process of the plastron, or dorsal metaplastral process.

Ec or ec. Entapophysial ligament.

Ext. Cut portion of the same ligament.

Evoc. Entocoxite.

Ento–Ento?. The seven entapophyses.

gd. Genital duct.

gp. Genital pore.

il. Inner lobe of a mesosomatic appendage.

Int. Intestine.

K. “Knob” of entocoxite, to which the tergo-coxal muscle is attached.

L. Liver and genital organ.

l. Lamellar, forming the “gill-book” of a mesosomatic appendage.

lat. scd. Lateral sclerite.

l.c.eu. Lateral cornu of plastron, or proplastral cornu.

l.p.e.eu. Lateral-posterior process of plastron, or lateral metaplastral process.

M. Mouth.

mb. Membrane of attachment of the pygal muscles.

m, n, o, p, q, r, s, t, y, z. Portions of the proplastral muscles 32–14.

ml. Median lobe of a mesosomatic appendage (part of the sternal wall produced).

nst. Mesosomatic tergite.

mtat. Metasternite or “chilaria.”

N. Network of chitin on the inner surface of the carapace.

Na. Angle of the posterior carapace belonging to mesosomatic area.

O. Aperture of the branchial blood-vessel into the venous collecting sinuses.

ow. Oesophagus.

Ol. Outer lobe of a mesosomatic appendage.

P. Plastron or thoracic entosternite.

p. Chitinous sclerite on mesosomatic appendage.

p.ab.st. Postabdominal, or metasomatic sternite.

Pb. Posterior border of the thoracic carapace.

p.b. Posterior border of an entocoxite.

Pr. Pericardium.

p.e.eu. Posterior process of the plastron or lateral metaplastral process.

p.m.st. Pro-sternite.

pr. Posterior process of a mesosomatic entochondrite.

pr’w. Prosemblastic sternite.

pT. Metasomatic tergite.

R. Rectum.

r. Ventral ridge of a mesosomatic entochondrite.

Ri. Ridge on the inner surface of the thoracic carapace.

S. Muscular stomach.

S1–S6. Mesosomatic entochondrites.

Sf or sf. Subfrontal sclerite.

sfa. Subfrontal area.

sp. Postanal spine or “pygö” (τυγου).

sty. Aperture (stigma) leading into the hollow tendon of a branchio-thoracic muscle.

T. Tergite.

ts–ts’y. The hollow tendons of the branchio-thoracic muscle.

Ve or ve. Venous collecting sinus.

W. Wall of mesosoma.

X. Portion of mesosomatic sternite.

x. Point of attachment of mesosomatic appendage.

References to Muscles.

1. Dorsal entapophysio-plastral.

2. Ventral entapophysio-plastral.

3. Ventral longitudinal.

4. Inter-entapophysial.

4 a. Muscle from first to second entapophysis.

4 b. From first to third entapophysis.

4 c. From first to fourth entapophysis.

4 d. From first to fifth entapophysis.
5. Intersternal.
6. Internal tergo-pygal.
7. Middle tergo-pygal.
8. External tergo-pygal.
10. Internal sterno-pygal.

16.
17.
19. A slip from 18 to the second entapophysis.
20. External branchial.
22. Posterior entapophysio-branchial.
23. Pre-entapophysio-branchial.
24. Tergo-coxal of the first prosomatic appendage.
25. Tergo-coxals of the succeeding appendages.

25 a. Tergo-coxal of second appendage.
25 b. Tergo-coxal of third appendage.
25 c. Tergo-coxal of fourth appendage.
25 d. Tergo-coxal of fifth appendage.
25 e. Tergo-coxal of sixth appendage.
27. Antero-inferior tergo-coxal.
29. Postero-inferior tergo-coxal.
30. Anterior plastro-coxal of first appendage.
31. Posterior plastro-coxal of first appendage.
32. Second superior plastro-coxal.
   m, its anterior slip (to anterior border of entocoxite).
   n, its posterior slip (to posterior border of entocoxite).
33. Second mid plastro-coxal.
34. Second inferior plastro-coxal.
35. Third superior plastro-coxal.
   o, its anterior slip.
   p, its posterior slip.
36. Third mid plastro-coxal.
37. Third inferior plastro-coxal.
38. Fourth superior plastro-coxal.
   q, its anterior slip.
   r, its posterior slip.
39. Fourth mid plastro-coxal.
40. Fourth inferior plastro-coxal.
41. Fifth superior plastro-coxal.
   s, its anterior slip.
   t, its posterior slip.
42. Fifth mid plastro-coxal.
43. Fifth inferior plastro-coxal.
44. Sixth antero-superior plastro-coxal.
45. Sixth mid plastro-coxal.
46. Sixth antero-inferior plastro-coxal.
47. Sixth posterio-inferior plastro-coxal.
48. Internal branchial.
49. Three tergo-proplastrals.
50. Dorso-lateral plastro-tergal.
51. Dorso-lateral plastro-entapophysial.
52. Anterior mesoplastron-entapophysial.
53. Posterior mesoplastron-entapophysial.
54. Dorsal metamplastro-entapophysial.
55. First lateral proplastron-tergal.
56. Superior second lateral proplastron-tergal.
57. Inferior second lateral proplastron-tergal.
58. Sixth posterio-superior plastro-coxal.
59. Mesosomatic inter-sternals.
60. Chilarial.
63. Plastro-coxal.
64. Plastro-tergal.
65. Veno-pericardiae (pericardio-ventrals).
66. A slip from the ventral longitudinal (3) to the second abdominal sternite.
67. A slip from 3 to third abdominal sternite.
68. A slip from 3 to fourth abdominal sternite.
69. Vertical entapophysio-metaplastral.
70. Middle entapophysio-plastral (part of 2).
71. Slip from 3 to fourth entapophysis.
72. Slip from 3 to fifth entapophysis.
73. Slip from 3 to sixth entapophysis.
74. Slip from 3 to seventh entapophysis.
75. Intertergal.
76. Slip from 1 to third entapophysis.
77. Slip from 1 to fourth entapophysis.
78. Slip from 1 to fifth entapophysis.
79. Slip from 1 to sixth entapophysis.
80. Termination of 1 in seventh entapophysis.
88. **Mid-ventral entapophysio-pygal.**
89. **Externo-ventral entapophysio-pygal.**
90. **Interno-ventral entapophysio-pygal.**
91. **Externo-dorsal entapophysio-pygal.**
92. **Mid dorsal entapophysio-pygal.**
93. **Interno-dorsal entapophysio-pygal.**
94. Internal sternal slip from 7 (a tergo-pygal).
95. External sternal slip from 7 (a tergo-pygal).
96. Internal sternal slip from 8 (a tergo-pygal).
97. External sternal slip from 8 (a tergo-pygal).
103. A slip from 73 to the third entapophysis.
104. A slip, partly from 2 and partly from 73 to fourth entapophysis.
105. A slip from 2 to fifth entapophysis.
106. A slip from 2 to sixth entapophysis.
107. Terminal portion of 2 (the ventral entapophysio-plastral).

112. Muscle from a selerite (p) on mesosomatic appendage to the outer lobe of the same.
113. A slip from 20 to selerite (a) on the mesosomatic appendage.
114. A muscle from selerite (p) on mesosomatic appendage to the inner lobe of the same.
115. A slip from 48 to selerite (p) on the mesosomatic appendage.

i.-vi. **Prosomatic appendages.**

vii.-xii. **Mesosomatic appendages.**

vii a. Immovable spine belonging to the first mesosomatic segment.

viii a.-xiii a. Movable spines corresponding to the last five segments of the mesosoma and the first of the metasoma.

**PLATE LXXII.**

The floor of the animal (natural size) after removal of muscles and viscera. It shows the raised subfrontal area (sfa), the great arching of the chitinous floor at the sides (cen), whilst along the line of attachment of the appendage there is a nearly vertical dip; the walls of this hollow being formed by the entocoxites and the intervening membrane. In the middle of the prosoma or thorax is seen the cut oesophagus (w), in front of this the camerostome (cam), and behind it the "promesosternite"; behind these again are seen a pair of cavities leading into the chilaria (metasternite). The transverse hollows (vii-xii) in the mesosomatic floor are the entrances to the spaces between the plates of the mesosomatic appendages; the hollow tendons (ts) of the branchio-thoracic muscles are seen. On the post-abdominal sternal region (p.ab.st) are seen the areas of attachment of some of the pygal muscles. Behind this is the cut rectum, and then the post-anal spine or "pyge." On the left wall of the mesosoma has been cut away to show the canal (ca), which runs forwards to the front part of the mesosoma, and holds blood-vessels and nerves.

**PLATE LXXIII.**

The carapace and heart have been removed, and the alimentary canal. Fig. 1 is a more superficial dissection than fig. 2.

Fig. 1. On the right side the dissection is more superficial than on the left: the tergo-coxals (24, 25) are seen attached to the "knob" of the entocoxites. That of the first appendage (24) is seen nearer the middle line than the rest.
Various plastro-entapophysial muscles are shown attached to the first entapophysis. One sees the inter-entapophysial muscles (4) passing from one entapophysis to the other, the tergo-pygals (6, 7, 8) and entapophysio-pygals (91, 92, 93), the external branchials (20), the small veno-pericardiacs (68) passing outwards and upwards across the intersternals. The larger vertical abdominals (12) also pass across the intersternals. Besides these the cut bases of the entapophyses are shown, and connecting these the inter-entapophysial cartilages (ee); and at the sides of the anterior part of the figure are the lateral cornua of the plastron with their muscles 57, 58.

On the left side of the figure the liver and genital organ have been removed, so as to expose the body of the entosternite or "plastron" (P) and its dorsal process. The dorsal entapophysio-plastral (1) is now seen passing across the vertical muscles, and giving off various slips to the entapophyses. The pygal muscles and the cartilaginous band have been removed.

Fig. 2. On the left side the dissection is more superficial than on the right: the course of the dorsal entapophysio-plastral muscle is more completely shown, the inter-entapophysials having been removed. The anterior cornua of the plastron (A.c. en), with their muscles (49, 50, 51), are also seen; and posteriorly the sterno-pygals (10, 11) and entapophysio-pygals (88, 89, 90). The abdominal sternites (s1–s6) lying on the floor of the mesosoma are also exposed.

On the right side of the figure the above-named muscles have been removed, so as to show the course of the ventral entapophysio-plastral muscles (2 & 73) with their slips to the entapophyses. The entapophysio-meta-plastrals have been cut, so as to show the posterior median process of the plastron (pceu).

PLATE LXXXIV.

Fig. 1. All the overlying muscles have been removed, and thus the floor of the animal is exposed. On the right the distribution of the ventral longitudinal (3) and the intersternal muscles (5) is seen. The slips passing from the various sternites to the entapophyses, and the vertical muscles (12) inserted in the abdominal sternites are also seen.

On the left the aforementioned muscles have been removed in order to show the venous-collecting sinus (Vc) lying at the side of the floor of the animal, passing anteriorly above the plastron, where it has been cut. The veno-pericardiac muscles (68) are shown springing from this canal, and are turned towards the middle line. Passing up at the side of the canal are shown the hollow tendons of the branchio-thoracic muscles (18), each ending anteriorly in a muscular portion, which has been cut. Attached to the side of each abdominal entochondrite is seen a small muscle (48), the internal branchial.
Outside the canal are seen the various branchial muscles rising from the mesosomatic appendages to their attachment in that portion of the entapophysial ligament (ee) which partly embraces each entapophysis.

Fig. 2. A portion of the venous-collecting sinus, removed and enlarged; in front the wall has been cut to show the apertures (O) of the descending vessels to the mesosomatic appendages. The hollow portions of some of the branchio-thoracic muscles (18) are seen uniting to form the large muscular portion. Some of the branchial muscles are also seen.

Fig. 3. Two mesosomatic appendages seen from below.

VIII. The deep face of the anterior plate of the eighth appendage. The appendage is turned forwards. The posterior plate—except the portions which bear the gill-lamellae (l), and the "stigmata" (stg) leading into the hollow tendons of the branchio-thoracic muscles—has been dissected away.

IX. is the inner face of the posterior plate of the ninth appendage, after removal of the anterior face. At the base of each appendage is an abdominal sternite (s) with muscles passing in various directions from it. The second pair of entapophyses (ent. 2) are seen with a portion of the entapophysial ligament (ee), to which some of the branchial muscles (21, 22, 23) are attached. Various sclerites (a.p.c) with their muscles (23, 48, 112, 113, 114, 115) are also seen, which lie on the surface of the appendages. The tendons (ts) of the branchio-thoracic muscle are shown.

Fig. 4. Inner surface of posterior plate of the seventh appendage, "genital operculum."

The genital duct (gd) cut short is seen.

Fig. 5. Inner surface of anterior plate of the genital operculum. The stigmata (stg) of the basal portion (ts) of the branchio-thoracic muscle. The genital duct and aperture (gp), and the first pair of entapophyses are shown.

PLATE LXXV.

Longitudinal sections.

Fig. 1. Shows two entocoxites (Encc) with their muscles (25): the camerostome and basal part of first appendage and its muscle (24): the entosternite or plastron (P) and its muscles (19, 50, 51, 52, 53): the course of the branchio-thoracic muscle (18) with its hollow tendons (ts) and their apertures (stg): the pygal muscles, attached partly to the tegum of the metasoma and partly to the hinder entapophyses (6, 7, 90, 91, 92). A few only of the branchial muscles (20, 22, 23) and two of the vertical mesosomatic muscles (12) are represented. This figure also shows the claw-like termination of the second appendage (nt) characteristic of the male Limulus polyphemus. The other prosomatic appendages have been cut short.
AND ENDOSKELETAL SYSTEMS OF LIMULUS.

Fig. 2. Shows the relation of the pericardium (Pe) and the venous collecting sinus (vc) to the other parts and to one another. To be especially noticed are the pericardio-ventral or veno-pericardiac muscles (68): the vertical mesosomatic muscles (12): the ventral pygal muscles (9, 10, 11): the muscular stomach (s) with its muscle (66) to the subfrontal area (sfu). Also the intergal muscle (78) flexing the abdominal upon the thoracic region.

Fig. 3. Shows the plastro-tergal muscles (49 to 54): the genital duct in appendage vii: the inter-entapophysial muscles (4): the course of the ventral longitudinal (3) and intersternal muscles (5), with their various slips to the entapophyses. Also the vertical abdominals (12).

Fig. 4. External view of two entapophyses of the left side (twice nat. size) showing the cartilaginous interentapophysial ligament (ec) swelling out to partly embrace the entapophysis, and serving for the attachment of various muscles which pass to the mesosomatic appendages. The area of attachment of two of the external branchial muscles (20) is shown.

Fig. 5. Internal view (mediad face) of two entapophyses of the right side (twice nat. size). The cartilaginous interentapophysial ligament is seen, and various muscles attached to the entapophysis itself. Also the area of attachment of two of the vertical mesosomatic muscles (12) is seen on the tergite.

Fig. 6. A three-quarter view from in front and within of an entapophysis and cartilage.

Fig. 7. A three-quarter view from behind and without, showing the cut end (ect) of that part of the inter-entapophysial ligament that passes from one swelling to another. The swelling of the ligament is deeply cupped and fixed to the chitinized entapophysis. It contains a core of capsuligenous tissue, whilst the rest of the ligament consists of fibro-massive tissue.

PLATE LXXVI.

Fig. 1. Inner face of the prosomatic and mesosomatic carapaces, showing the areas of attachment of the various tergal muscles. [Unfortunately this figure is very inaccurate and incomplete in respect of the areas of muscular attachment, and must not be relied upon in that matter.—E. R. L.] On the right half the areas are left uncoloured, and are more plainly limited than on the left half. The entapophyses are shown, and the ridge (ri) on each side, corresponding to a depression on the exterior. The lateral parts of the terga have a chitinized network raised upon their inner surface. In the mesosomatic portion is shown a part (x) of the sternal region which rises to meet the tergite.

Fig. 2. Shows the relative positions of the entocoxite (whose knobs (k), to which the tergo-coxals are attached, are seen), the prosomatic entochondrite (plastron) (P), and the mesosomatic entochondrites (s). The hollow tendons (ts) of the
last pair of branchio-thoracic muscles are seen, rising from the front edge of
the metasomatic sternite (p.ab.st).

Fig. 3. Ventral view of the plastron or thoracic entochondrite, after all muscles have
been removed.

Fig. 4. View of the dorsal face of the plastron, with the various plastro-tergal and
plastro-entapophysial muscles &c.

Fig. 5. Dorsal view of the plastron, the left edge cut away to show the plastro-coxal
muscles (32–44) entering the entocoxites. (The dorsal process (d.c.en) is
represented as rather too rounded at the top.)

Fig. 6. Ventral view of the plastron, with the various plastro-coxal muscles attached on
the observer's right.

Fig. 7. An entocoxite, being the inner articular surface of a prosomatic appendage.
It is made up of an anterior (ab) and a posterior (pb) border, and superiorly
of a knob (k) to which the tergo-coxal (25) is attached, and of a coxal pivot
(cp), by which the appendage is articulated with the sternal plate of the
carapace.

Fig. 8. A mesosomatic entochondrite seen from below.
Fig. 9. A mesosomatic entochondrite from in front (represented with its ventral face
upwards).

Fig. 10. A transverse section across the mesosoma (from C to D, Pl. LXXII.), showing
the thick wall, with a canal within it. The sternal region rises to meet
the tergal, and leaves but a narrow membranous area for the attachment of
the appendage (x), which has been removed.

Fig. 11. A transverse section across the metasoma (from A to B, Pl. LXXII.), showing
complete chitinous floor (p.ab.st).
ANATOMY OF LIMULUS
ANATOMY OF LIMULUS

Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.
PART III. Description of the Muscular and Endoskeletal Systems of Scorpio.

By Miss E. J. Beck.

For this work, in which I have been assisted by the kind supervision of Professor Lankester, I have used the Ceylon Scorpion (*Buthus cyaneus*) for dissecting, whilst I have also referred to a series of sections of the small Scorpion (*Scorpio italica*), by means of which I have been able to find some small muscles which I should have otherwise passed unnoticed, and some which are too small to be seen by the naked eye.

I have named the muscles as much as possible from the names of the two points to which they are attached. Thus in many cases the names are long and awkward. In order to somewhat modify this difficulty I have given to each muscle a separate number, and have numbered them similarly in the figures.

It must be remembered that each of the muscles which I shall mention is repeated in a corresponding position on the opposite side of the animal, with the exception of a few which are situated in the median line, and which I shall particularly point out.

Before giving a description of the muscles of the Scorpion it will be necessary to examine the general form of the animal, and more particularly its skeleton, external and internal, with any other parts that form attachments for muscles.

External Skeleton.—The body of the Scorpion may be divided into three parts, the prosoma, mesosoma, and metasoma, each of which represents six segments, and corresponds precisely to the similarly named part in the King Crab. The segments are indicated partly by sclerites and partly by appendages. Following the metasoma is the postanal spine or sting.

Dorsal Sclerites.—The whole of the dorsal surface of the prosoma is covered by one large chitinous plate, the cephalothoracic plate or carapace (car). This is followed by seven wide sclerites, six of which represent the six segments of the mesosoma (vii—xii), whilst the seventh (xiii) belongs to the first segment of the metasoma, and is fused towards its posterior end to a corresponding sclerite on the external surface. Posteriorly this sclerite becomes narrower, and is followed by five narrow cylindrical sclerites (xiv—xviii), which are formed by the fusion of the tergite of the dorsal surface with the sternite of the ventral.

Appendages and Sternal Sclerites.—On the ventral surface of the prosoma there are six leg-like appendages, which indicates that six segments have coalesced to form the carapace.

The first appendage, chelicera (i), is small, consisting of three sclerites: the protomerite or coxa, the deutomerite, and the tritomerite. The deutomerite is drawn out, and forms with the tritomerite a pincer. This pair of appendages is situated in front of the mouth and projects anteriorly.
The second appendage, chela (ii), is large and composed of six sclerites. As in the first appendage the penultimate sclerite forms with the last a powerful chela; between the coxal sclerites of this pair is the remarkable upper lip, the camerostome (cam), on the dorsal surface of which is a small chitinous sclerite.

The third and following appendages of the prosoma each consist of seven sclerites and two small terminal claws; these appendages are the walking-legs.

On the coxal joints of the second, third, and fourth appendages there are small processes which meet in the median line and assist the mouth as mandibular organs; these are the "sterno-coxal processes." The coxal joint of the fifth appendage is fused to that of the sixth, and is immovable without it.

To the sterno-coxal process of the third appendage is attached a movable "epicoxite" similar to the pieces so named on limbs 2, 3, 4, and 5 of Limulus1.

The coxal sclerites of the second, third, and fourth appendages of one side meeting those of the other side in the median line have almost obliterated the sternite of the prosoma; all that remains is a small pentagonal sclerite situated in the median line between the coxal joints of the fifth and sixth appendages of either side. This is called the "thoracic metasternite" (met), and is the exact equivalent of the chilaria of Limulus. (See Lankester, loc. cit.)

The appendages of the mesosoma are much modified. In an early state of development a rudimentary pair of appendages appears on each of the six segments. These afterwards disappear from view, with the exception of the first and second pairs. The first pair are simply small plates which together form the genital operculum (go) as in Limulus. The second pair, the pectines (pec), are carried on a small sternal sclerite, and are comb-like organs with a number of lamellæ set on their inferior margin.

On the sternal surface of the four last segments there are wide sclerites which apparently carry no appendages; on closer examination two stigmata will be seen on each sclerite; these lead into small sacs, which are, according to Professor Lankester, nothing more or less than the appendages themselves invaginated, that is, completely pushed outside in. The appendages are composed of an axis, on which are set a number of lamellæ, like the pages of a book; they perform the function of respiration, and exactly represent the four posterior branchial appendages of Limulus in an introverted condition.

The six sternal sclerites of the metasoma have been mentioned above as fused to the tergites, and as being, in the last five segments, of a cylindrical form. These segments carry no appendages.

For a more detailed description of the skeleton of the Scorpion the reader is referred to a paper by Prof. E. Ray Lankester, "Limulus an Arachnid" (Quart. Journ. of Micr. Science, 1881).

[1 The epicoxites of Limulus and Scorpio appear to be similar in character to the rudimentary second ramus of the limbs of Scelopendra and other forms noted by Wood-Mason.—E. R. L.]
Arthrodial Membrane.—The lateral part of the body and all the interspaces between
the sclerites are covered with a flexible membrane, the “arthrodial membrane” (am).

Internal Skeleton.—The internal skeleton may be divided into two parts, the ento-
sclerites and the entochondrites. The entosclerites are epidermal in origin, and are
really only ingrowths of the external skeleton; they may be divided into two kinds,
the coxal entosclerites, which are internal processes of the coxal sclerites of the
appendages, and the median entosclerites, which are continuous with the external
skeleton in the median line. The entochondrites are fibro-cartilaginous pieces which
are freely movable, not being fixed to any chitinous parts of the skeleton, and only
attached to them by fibrous tissue and muscles. They form a strong point of attach-
ment for muscles, which radiate from them to the appendages, tergites, and other parts
of the body. These skeletal pieces have been formed by a condensation of connective
tissue.

Fig. 1.

Fig. 1. Diagrammatic view of the anterior portion of a Scorpion (Butulus) divided along the median lon-
gitudinal line, all the soft parts being removed so as to show the relations of the entosclerites (ingrowths
of the epidermic cuticle) and the entochondrites, which is alone shaded. (Compare Pl. LXXIX. fig. 15.)

1, chelicera; II, second appendage (chela); VII, VIII, IX, tergal sclerites of the seventh, eighth, and
ninth segments; A, coxal entosclerites of the chelicera; H, preoral entosclerite; K, postoral entosclerite;
L, carino-sternal entosclerite; Cam, camerostome (upper lip); VII gc, sternal region of the genital seg-
ment; VIII nee, pecten; ap, left anterior process of the great entochondrite attached to the left arm of
preoral entosclerite; cut, body of the great entochondrite; Sup, subneural arch of the same; nc, neural
canal of the entochondrite; gc, gastric canal of the entochondrite; nf, posterior flap or fibrous expansion
of the entochondrite spread out as a diaphragm across the body; arc, arterial canal; Ent 2, second ento-
chondrite (suprapectal).

Coxal Entosclerites (Pl. LXXIX. figs. 15, 16).—The coxal entosclerites are called
either anterior or posterior, according to the portion of the interior margin of the
coxal sclerite on which they are situated.
In the first appendage the posterior portion of the coxal sclerite is drawn out into a narrow and long process (A), which extends backwards and gradually tapers to a point.

In the second appendage the anterior margin of the coxal sclerite presents on its inner face a small process (B) which points down towards the posterior margin of the same sclerite.

In the third appendage the coxal sclerite is drawn out internally into a process on both the anterior and posterior margins. That on the anterior (C) is very small and is near the median line; that on the posterior (D) is large and is situated laterally.

In the fourth appendage there are also two internal processes on the coxal sclerite, the one anterior, the other posterior. The anterior process (E) is larger than that of the third appendage and has a more lateral position. The posterior process (F) is similar to that of the third, and is lateral.

In the fifth appendage there is a small process (G) on the anterior margin of the coxal sclerite, which is quite lateral and behind the posterior process of the fourth appendage. There is no process on the posterior margin of this sclerite.

The coxal sclerite of the sixth appendage carries no process on either margin.

*Median Entosclerites.*—In the median line anterior to the mouth is situated an entosclerite (H), to the anterior portion of which the superior portion of the coxal sclerite of the second appendage is articulated. From either side of this anterior portion there is a lateral process which runs posteriorly in a horizontal plane. It is marked in fig. 16, Pl. LXXIX., by the figures appropriate to muscles which are attached, viz. 95, 96, 97. This entosclerite may be called the “preoral entosclerite.”

A small entosclerite (K) is situated in the median line close behind the mouth; on it the inferior portion of the second appendage, and the third and fourth appendages, are articulated. This may be called the “postoral entosclerite.”

Posterior to this in the median line lies the pentagonal thoracic metasternite, on the internal surface of which is a narrow process (L) standing up in the middle line. This process soon forks and ends anteriorly to the genital operculum. This may be called the “carino-ster nal entosclerite.”

*The Plastra* (Pl) or *Prosomatic Entochondrite* (Entosternite of Lankester, *loc. cit.*).—Towards the posterior part of the prosoma, between the cephalothoracic plate and the sternum surface, is situated the plastron (Pl. LXXX. fig. 13). The alimentary canal passes through it in a canal (GC) which lies between two dorsal ridges running on the dorsal surface from the anterior to the posterior portion. The nerve-cord also runs through a canal (NC) in the plastron, and thus forms a subneural portion (Pl. LXXX. fig. 14, snp) on the ventral side. The anterior aorta also perforates the plastron by the canal AC. The muscles 65 and 83 also perforate the lateral regions of the plastron. This entochondrite is not fixed to any of the chitinous skeletal pieces, except by muscles and fibrous tissue. At its posterior end there is a large posterior flap (pf), which is
attached ventrally to the posterior margin of the coxal sclerite of the sixth appendage, and dorsally to the arthrodial membrane between the carapace and the first tergite of the mesosoma; it forms a septum between the prosoma and the mesosoma (see woodcut, fig. 1, and explanation). From the plastron there are several processes which are similar on each side. The anterior processes (ap) are long and run forwards; each at its anterior end (a) is attached by fibrous tissue to the ventral surface of the posterior end of the corresponding "cornu" of the preoral entosclerite. A lateral median process (Imp) starts from the side of the plastron and runs out laterally on each side. A posterior process (pp) runs from the posterior end of the plastron, being fused for part of its way with the fibrous flap. There is also a small pair of anterior processes on the subneural portion of the plastron, the "anterior subneural processes" (asp).

Suprapectinal Chondrite or Second or Mesosomatic Entochondrite.—There is a second and much smaller entochondrite in the segment of the pectines, which is a simple fibrous band lying ventral of the nerve-cord (as do the mesosomatic entochondrites of Limulus), to which several muscles are attached.

Muscles.

The muscles of the Scorpion may be classified as follows:—

I. Longitudinal Muscles.
   a. Prosoma.
   b. Mesosoma.
   c. Metasoma.

II. Dorso-Ventral Muscles.
   a. Prosoma.
   b. Mesosoma.
   c. Metasoma.

III. Muscles attached to the Plastron.

IV. Muscles attached to the Suprapectinal Entochondrite.

V. Muscles attached to the Preoral Entosclerite.

VI. Muscles attached to the Appendages.

VII. Muscles attached to the Epimeron.

VIII. Muscles attached to the Pharynx.

IX. Muscles attached to the Pericardium.
   a. Mesosoma.
   b. Metasoma.

I. Longitudinal Muscles.

All the segments of the mesosoma and metasoma are moved on one another by longitudinal muscles. In the prosoma, however, as there is but one tergite, so there is but...
one set of longitudinal muscles, which is situated in the posterior portion, and moves
the carapace on the first segment of the mesosoma.

For the dorsal longitudinal muscles see Pl. LXXVII. fig. 2.
For the ventral longitudinal muscles see Pl. LXXVII. fig. 3.

a. *Prosoma.*

*Dorsal.*—The *antero-posterior muscle* (1) is a large muscle running parallel with the
longitudinal median line. It extends laterally from the pericardium to the side of the
animal. Anteriorly it is attached to the carapace, and posteriorly to the arthrodial
membrane posterior to the carapace.

The *arthrodio-tergal obliquus muscle* (2) is smaller, and is attached posteriorly to
the arthrodial membrane between the carapace and the first segment of the mesosoma.
It is superficial to the antero-posterior muscle (1), and runs obliquely forward towards
the median line, being attached anteriorly to the carapace.

*Ventral.*—There are no ventral longitudinal muscles in the prosoma.

b. *Mesosoma.*

*Dorsal.*—The *antero-posterior muscle* (3) of the first segment of the mesosoma runs
parallel with the median line, stretching laterally from the pericardium to the side of
the body. It is attached anteriorly and posteriorly to the arthrodial membrane, ante-
rior and posterior to the segment.

The *antero-posterior muscle* (4) of the second segment of the mesosoma; the *antero-
posterior muscle* (5) of the third segment of the mesosoma; the *antero-posterior muscle*
(6) of the fourth segment of the mesosoma; the *antero-posterior muscle* (7) of the fifth
segment of the mesosoma; and the *antero-posterior muscle* (8) of the sixth segment of
the mesosoma, are exactly similar to the antero-posterior muscle (3) of the first segment
of the mesosoma.

The *arthrodio-tergal obliquus muscle* (9) of the first segment of the mesosoma is
attached posteriorly to the arthrodial membrane between the first and second segments.
It is superficial to the antero-posterior muscle (3), and runs obliquely forward towards
the median line, being attached anteriorly to the tergite.

The *arthrodio-tergal obliquus muscle* (10) of the second segment of the mesosoma; the
*arthrodio-tergal obliquus muscle* (11) of the third segment of the mesosoma; the
*arthrodio-tergal obliquus muscle* (12) of the fourth segment of the mesosoma; the
*arthrodio-tergal obliquus muscle* (13) of the fifth segment of the mesosoma; and the
*arthrodio-tergal obliquus muscle* (14) of the sixth segment of the mesosoma, are all
similar in form and position to the arthrodio-tergal obliquus muscle (9) of the first
segment of the mesosoma.

The *latero-dorsal muscle* (15) of the first segment of the mesosoma is attached at its
posterior end to the lateral portion of the arthrodial membrane at the posterior angle of the segment. It bends round to the tergite, to which it is attached.

The *latro-dorsal muscle* (16) of the second segment of the mesosoma; the *latro-dorsal muscle* (17) of the third segment of the mesosoma; the *latro-dorsal muscle* (18) of the fourth segment of the mesosoma; the *latro-dorsal muscle* (19) of the fifth segment of the mesosoma; and the *latro-dorsal muscle* (20) of the sixth segment of the mesosoma, are all similar in form and position to the *latro-dorsal muscle* (15) of the first segment of the mesosoma.

**Ventral.**—The *median antero-posterior muscle* (21) of the third segment of the mesosoma runs along the median line from the arthrodial membrane anterior to the sternite, to the arthrodial membrane posterior to the sternite. As this muscle is in the median line it is not repeated on each side of the animal (Pl. LXXXVII. fig. 3).

The *median antero-posterior muscle* (22) of the fourth segment of the mesosoma; the *median antero-posterior muscle* (23) of the fifth segment of the mesosoma; and the *median antero-posterior muscle* (24) of the sixth segment of the mesosoma, are similar to the *median antero-posterior muscle* (21) of the third segment of the mesosoma.

The *lateral antero-posterior muscle* (25) of the first segment of the mesosoma is attached anteriorly to the plastron, and posteriorly to the suprapectinal chondrite (Pl. LXXX. fig. 14).

The *lateral antero-posterior muscle* (26) of the second segment of the mesosoma is attached anteriorly to the suprapectinal chondrite, and posteriorly to the sternite of the third segment (Pl. LXXXVII. fig. 3, and Pl. LXXIX. fig. 14).

The *lateral antero-posterior muscle* (27) of the third segment of the mesosoma is a similar muscle to (26), but is attached anteriorly to the sternite of its own segment, and posteriorly to the sternite of the following segment. This muscle is lateral to the *median antero-posterior muscle* (21) of the first segment of the mesosoma.

The *lateral antero-posterior muscle* (28) of the fourth segment of the mesosoma, and the *lateral antero-posterior muscle* (29) of the fifth segment of the mesosoma are similar to the *lateral antero-posterior muscle* (27) of the third segment of the mesosoma, and are attached anteriorly to the sternite of the segment to which they belong and posteriorly to the sternite of the following segment.

The *lateral antero-posterior muscle* (30) of the sixth segment of the mesosoma is similar to the *lateral antero-posterior muscle* (27) of the third segment of the mesosoma, except that it is attached anteriorly to the sternite of the sixth segment, and posteriorly to the arthrodial membrane posterior to the segment.

The *arthrodio-sternal obliquus muscle* (31) of the third segment of the mesosoma is a small muscle superficial to the *lateral antero-posterior muscle* (27), attached posteriorly to the arthrodial membrane posterior to the segment. It runs obliquely forward towards the median line, and is attached anteriorly to the sternite.

The *arthrodio-sternal obliquus muscle* (32) of the fourth segment of the mesosoma,
the arthrodio-tergal obliquus muscle (33) of the fifth segment of the mesosoma, and
the arthrodio-tergal obliquus muscle (34) of the sixth segment of the mesosoma are
similar in form and position to the arthrodio-tergal obliquus muscle (31) of the third
segment of the mesosoma.

The post-stigmatic muscle (35) of the third segment of the mesosoma is a small
muscle attached anteriorly to the posterior edge of the stigmata of the lung-sac, and
posteriorly to the arthrodial membrane posterior to the segment (for the post-stigmatic
muscles see Pl. LXXVIII. figs. 8 & 9).

The post-stigmatic muscle (36) of the fourth segment of the mesosoma, the post-
stigmatic muscle (37) of the fifth segment of the mesosoma, and the post-stigmatic
muscle (38) of the sixth segment of the mesosoma are similar muscles to the post-
stigmatic muscle (35) of the third segment of the mesosoma.

c. Metasoma.

Dorsal.—The arthrodio-tergal rectus muscle (39) of the first segment of the meta-
 soma is a small muscle attached posteriorly to the arthrodial membrane posterior to
the segment; running forwards by the side of the pericardium it is attached anteriorly
to the tergite.

The arthrodio-tergal rectus muscle (40) of the second segment of the metasoma is
attached posteriorly to the arthrodial membrane posterior to the segment; running
forwards by the side of the median line it spreads out anteriorly, and is attached to
the tergite.

The arthrodio-tergal rectus muscle (41) of the third segment of the metasoma and
the arthrodio-tergal rectus muscle (42) of the fourth segment of the metasoma are
exactly similar to the arthrodio-tergal muscle (40) of the second segment of the
metasoma.

The arthrodio-tergal rectus muscle (43) of the fifth segment of the metasoma is a
narrow muscle attached posteriorly to the arthrodial membrane posterior to the segment
which runs forward by the median line, and is attached to the tergite.

The arthrodio-tergal rectus muscle (44) of the sixth segment of the metasoma is
narrow and long; it is attached to the arthrodial membrane posterior to the segment,
and runs forward by the median line, being attached anteriorly to the tergite.

The arthrodio-tergal obliquus muscle (45) of the first segment of the metasoma is
a small muscle attached posteriorly to the arthrodial membrane posterior to the segment.
It runs obliquely forward, towards the median line, and is attached anteriorly to the
tergite. This muscle is similar to the arthrodio tergal obliquus muscles (9–14) in the
segments of the mesosoma.

The arthrodio-tergal obliquus muscle (46) of the second segment of the metasoma,
the arthrodio-tergal obliquus muscle (47) of the third segment of the metasoma, and
the arthrodio-tergal obliquus muscle (48) of the fourth segment of the metasoma are
similar to the arthrodio-tergal obliquus muscle (45) of the first segment of the metasoma. There are no corresponding muscles in the fifth and sixth segments of the metasoma.

The superficial dorso-ventral muscle (49) of the first segment of the metasoma is attached to the arthrodial membrane posterior to the segment on the ventral surface, and bends round superficially to the tergite to which it is attached. This muscle is unlike any other, in that it starts on the ventral surface and bends round superficially to the tergite.

Ventral.—The median antero-posterior muscle (50) of the first segment of the metasoma is attached to the arthrodial membrane, anterior and posterior to the segment. It is similar to the median antero-posterior muscles in the mesosoma.

The arthrodio-ster nal rectus muscle (50 A) of the first segment of the metasoma is attached posteriorly to the arthrodial membrane posterior to the segment; running forward it is attached anteriorly to the sternite.

The lateral antero-posterior muscle (51) of the first segment of the metasoma is attached to the arthrodial membrane anterior and posterior to the segment. This muscle is similar to the lateral antero-posterior muscles (25–30) of the mesosoma; but there is no further continuation of it in the following segments.

The median antero-posterior muscle (52) of the second segment of the metasoma is a large muscle lying in the median line, and therefore not repeated on each side of the animal. It is attached to the arthrodial membrane anterior and posterior to the segment.

The median antero-posterior muscle (53) of the third segment of the metasoma, the median antero-posterior muscle (54) of the fourth segment of the metasoma, and the median antero-posterior muscle (55) of the fifth segment of the metasoma are similar to the median antero-posterior muscle (52) of the second segment of the metasoma. There is no corresponding muscle in the sixth segment.

The lateral arthrodio-ster nal muscle (56) of the second segment of the metasoma is attached to the arthrodial membrane posterior to the segment; it runs forward and is attached to the sternite, and lies lateral to the median antero-posterior muscle (52).

The lateral arthrodio-ster nal muscle (57) of the third segment of the metasoma and the lateral arthrodio-ster nal muscle (58) of the fourth segment of the metasoma are similar to the lateral arthrodio-ster nal muscle (56) of the second segment of the metasoma.

The lateral arthrodio-ster nal muscle (59) of the fifth segment of the metasoma is a large muscle attached to the arthrodial membrane posterior to the segment. Some of the fibres run to the dorsal surface, and are attached to the tergal portion of the sclerite, whilst the others run forward and are attached to the sternal portion.

The lateral arthrodio-ster nal muscle (60) of the sixth segment of the metasoma is a large muscle, some of the fibres of which run dorsally and are attached to the tergal portion of the sclerite, whilst the others run ventrally and are attached to the sternite.
They are united in a common attachment on the arthrodiel membrane posterior to the segment.

There are no muscles attached to the chitinous investment of the postanal spine or sting, though both 44 and 60 are attached to the arthrodiel membrane connecting this body with the sixth metasomatic segment.

II. Dorso-Ventral Muscles.

The dorso-ventral muscles of the Scorpion lie near the longitudinal median line; they are attached dorsally and ventrally to sclerites. Certain other muscles may be classed amongst the dorso-ventral muscles, which start from the tergites near the longitudinal median line and run ventrally, but before reaching the ventral surface have been intercepted by, and are attached to, the entochondrites. For the dorso-ventral muscles see Pl. LXXVII. figs. 1, 4, 5, and Pl. LXXVIII. fig. 6.

a. Prosoma.

The dorso-chelicero-sternal muscle (61) is the most anterior of the dorso-ventral muscles. It is very small, and is attached to the carapace near the median line anterior to the central eyes; it runs forward ventrally, and is attached to the arthrodiel membrane between the chelicerae.

The median dorso-preoral entosclerite muscle (62) is a large muscle, between which and its fellow of the opposite side are situated the eyes. It is attached dorsally to the carapace, and ventrally to the preoral entosclerite (besides the figures above cited, see Pl. LXXIX. fig. 12).

The anterior dorso-plastron muscle (63) is attached dorsally to the carapace in the median line, being joined to its fellow of the opposite side; they separate and are attached ventrally to the plastron. Through the arch thus formed pass the alimentary canal and the dorsal vessel (see Pl. LXXX. fig. 13).

The median dorso-plastron muscle (64) is attached dorsally to the posterior portion of the carapace. It runs forward on the anterior surface of the posterior flap of the plastron to the body of the plastron, to which it is attached (Pl. LXXX. fig. 13).

b. Mesosoma.

The posterior dorso-plastron muscle (65) is attached to the tergite of the first segment of the mesosoma by the side of the pericardium. It runs forward, and at first lies closely on the posterior surface of the posterior flap of the plastron; it soon penetrates the flap, and continues its course on the anterior surface until it reaches the body of the plastron, to which it is attached.

The dorso-suprapectinal-chondrite muscle (66) is attached to the second tergite of the mesosoma by the side of the pericardium. It runs forward to the suprapectinal chondrite, to which it is attached (see Pl. LXXIX. fig. 14).
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The dorso-ventral muscle (67) of the third segment of the mesosoma is attached to the tergite of the third segment by the side of the pericardium. On passing to the sternite of the third segment to which it is attached, it runs through the lateral antero-posterior muscle (27) of the ventral longitudinal muscles, having a portion of the latter muscle between itself and the lung-sac (see Pl. LXXVIII. figs. 8, 9).

The dorso-ventral muscle (68) of the fourth segment of the mesosoma, the dorso-ventral muscle (69) of the fifth segment of the mesosoma, and the dorso-ventral muscle (70) of the sixth segment of the mesosoma are similar in position and character to the dorso-ventral muscle (67) of the third segment of the mesosoma, being attached to the tergites and sternites of the segments to which they belong.

c. Metasoma.

The dorso-ventral muscle (71) of the first segment of the metasoma is similar to the dorso-ventral muscles (67–70) of the mesosoma. There are no dorso-ventral muscles in the following segments of the metasoma.

III. Muscles attached to the Plastron or First Entochondrite. (Plate LXXVII. fig. 1, and Plate LXXX. figs. 13, 14.)

The plastron forms the base of attachment for many muscles, the larger number of which are distributed to the appendages. In order to distinguish the muscles belonging to the different appendages, I have called them "first," "second," &c., in reference to the appendages to which they belong. Other muscles are distributed from the plastron to the dorsal and ventral epidermal sclerites, to the epimeron, and to the suprapectinal chondrite.

The muscles between the plastron and the dorsal surface have been mentioned above among the dorso-ventral muscles under the names of—

The anterior dorso-plastron (63); The median dorso-plastron (64); and The posterior dorso-plastron (65) muscles.

The anterior second coxo-plastron muscle (72) is attached posteriorly to the anterior process of the plastron; running forward, it is attached anteriorly to the second coxal sclerite.

The third deutomerite-plastron muscle (73) is attached to the anterior process of the plastron. It runs into the third appendage, and is attached to the interior edge of the deutomerite sclerite.

The third postcoxal entosclerite-plastron muscle (74) is attached to the anterior process of the plastron. It spreads out on the posterior surface of the third coxal entosclerite, to which it is attached.

The median second coxo-plastron muscle (75) is attached posteriorly to the body of
the plastron on the anterior side of the base of the anterior process. It runs forward, and is attached anteriorly to the second coxal sclerite.

The posterior second coxo-plastron muscle \((76)\) is attached posteriorly to the body of the plastron posterior to the attachment of the muscle \(75\). It runs forward, and is attached to the second coxal sclerite.

The fourth deutomerite-plastron muscle \((77)\) is attached to the lateral portion of the body of the plastron posterior to the anterior process. It runs into the fourth appendage, and is attached to the interior margin of the deutomerite sclerite.

The fourth postcoxal entosclerite plastron muscle \((78)\) is attached to the median lateral process of the plastron. It spreads out on the posterior surface of the fourth coxal entosclerite, to which it is attached.

The anterior epimero-plastron muscle \((79)\) is attached to the lateral portion of the body of the plastron posterior to the median lateral process, and to the arthrodial membrane between the fourth and fifth appendages behind the posterior fourth coxal entosclerite.

The fifth deutomerite-plastron muscle \((80)\) is attached to the posterior process of the plastron, running into the fifth appendage. It is attached to the interior margin of the deutomerite sclerite.

The median epimero-plastron muscle \((81)\) is attached to the posterior process of the plastron and to the lateral portion of the arthrodial membrane between the fifth and sixth appendages.

The sixth deutomerite-plastron muscle \((82)\) is attached to the posterior process of the plastron. It runs into the sixth appendage, and is attached to the interior margin of the deutomerite sclerite.

The posterior epimero-plastron muscle \((83)\) is attached to the posterior part of the body of the plastron. It runs laterally for a short distance on the anterior surface of the posterior flap of the plastron, but soon penetrates the flap, and continues on the posterior surface (see Pl. LXXX, figs. 13 & 14). It is attached to the arthrodial membrane posterior to the sixth coxal sclerite.

The sterno-subneural plastron muscle \((84)\) is a small muscle attached to the anterior subneural process of the plastron, and, ventrally, to the small postoral entosclerite.

The operculo-plastron muscle \((85)\) is attached to the posterior part of the subneural portion of the plastron and to the seventh appendage or genital operculum.

The plastron-suprapsectinal-chondrite muscle \((86)\) is a small muscle attached anteriorly to the posterior part of the subneural portion of the plastron, and posteriorly to the anterior face of the suprapsectinal chondrite.

The lateral antero-posterior muscle \((25)\) has already been mentioned with the ventral longitudinal muscles. It starts from the posterior part of the subneural portion of the plastron, and is attached posteriorly to the suprapsectinal chondrite.

The sixth coxo-plastron muscle \((86 a)\) is attached to the lateral portion of the plastron.
ventral to the lateral median process, and to the arthroDal membrane between the metasternite and the coxal joint of the sixth appendage.

IV. Muscles attached to the Suprapectinal Chondrite.

The lateral antero-posterior muscle (25) of the first segment of the mesosoma has already been mentioned as being attached posteriorly to the suprapectinal chondrite and anteriorly to the plastron.

The lateral antero-posterior muscle (26) of the second segment of the mesosoma is attached anteriorly to the suprapectinal chondrite.

The dorso-suprapectinal-chondrite muscle (66) of the dorso-ventral series of muscles is attached to the superior surface of the suprapectinal chondrite, as has been mentioned above in speaking of the dorso-ventral muscles.

The plastron-suprapectinal-chondrite muscle (86) has been mentioned with the muscles attached to the plastron as being attached anteriorly to the plastron and posteriorly to the suprapectinal chondrite.

The epimero-suprapectinal-chondrite muscle (87) is a small muscle attached to the most lateral portion of the suprapectinal chondrite. It is also attached to the epimeron lateral to the pecten.

The posterior pectino-suprapectinal-chondrite muscle (88) is a small but broad muscle which runs from the inferior portion of the suprapectinal chondrite to the posterior margin of the pectine.

The sterno-suprapectinal-chondrite muscle (89) starts from the suprapectinal chondrite, and runs to the sclerite between the pair of pectines.

The anterior pectino-suprapectinal-chondrite muscle (90) is a small but broad muscle which runs from the inferior surface of the suprapectinal chondrite to the anterior margin of the pecten.

The interior pectino-suprapectinal-chondrite muscle (91) is a small muscle attached to the median part of the suprapectinal chondrite, which runs down to the interior margin of the pecten.

The exterior pectino-suprapectinal-chondrite muscle (92) is attached to the suprapectinal chondrite, and runs down to the exterior margin of the pecten.

V. Muscles attached to the Preoral Entosclerite. (See Plate LXXIX. figs. 11, 12, and 16.)

Muscles are distributed from the preoral entosclerite to the dorsal surface, the coxal entosclerite of the first appendage, and to the pharynx. There are four muscles to the dorsal surface, of which one has a median attachment, the other three have lateral attachments.

The median dorso-preoral entosclerite muscle (62) is attached to the anterior part of vol. XI.—Part X. No. 6.—May, 1885.
the preoral entosclerite, and runs straight up, being attached to the carapace near the median line (one on each side). It has been mentioned before amongst the dorso-ventral muscles.

The anterior latero-dorsal preoral entosclerite muscle (93) is attached to the anterior part of the preoral entosclerite. It runs underneath the coxal entosclerite of the first appendage, and is attached to the lateral part of the carapace.

The median latero-dorsal preoral entosclerite muscle (94) is attached to the posterior process of the preoral entosclerite, and runs laterally to the carapace, to which it is attached.

The posterior latero-dorsal preoral entosclerite muscle (95) is attached to the posterior part of the posterior process of the preoral entosclerite, and runs laterally to the carapace, to which it is attached.

The anterior first-coxal-entosclerite preoral-entosclerite muscle (96) is a broad muscle attached to the interior surface of the posterior process of the preoral entosclerite and to the interior surface of the first coxal entosclerite.

The posterior first-coxal-entosclerite preoral-entosclerite muscle (97) is a small muscle attached to the posterior end of the posterior process of the preoral entosclerite and to the posterior portion of the first coxal entosclerite.

The anterior preoral entosclerite pharyngeal muscle (98) (Pl. LXXIX. fig. 12) is a small muscle attached to the interior surface of the anterior portion of the preoral entosclerite, and runs down to the pharynx, to which it is attached on its superior surface.

The posterior preoral entosclerite pharyngeal muscle (99) (Pl. LXXIX. fig. 11) is a larger muscle, attached to the interior surface of the preoral entosclerite. It runs horizontally towards the similar muscle of the other side, and is attached to the lateral walls of the pharynx.

VI. Muscles to the Appendages.

Prosoma.—The muscles belonging to the appendages of the prosoma are of two kinds, intrinsic and extrinsic.

Intrinsic Muscles.—Of the intrinsic muscles, I shall only speak of those which run inwards from the appendages, and are attached internally to the coxal entosclerite or to the interior margin of the coxal sclerite. In speaking of the interior margin of the coxal and deutomerite sclerites I refer to that margin nearest to the body of the animal.

The exterior first-coxal entosclerite-deutomerite muscle (100) is a broad muscle attached posteriorly to the exterior margin of the coxal entosclerite and anteriorly to the interior margin of the deutomerite sclerite of the first appendage.

The interior first-coxal entosclerite-deutomerite muscle (101) is a narrow muscle
attached to the posterior portion of the first coxal entosclerite and to the interior margin of the deutomerite sclerite of the first appendage.

The third-coxal entosclerite-deutomerite muscle (102) is attached to the third coxal entosclerite and to the interior margin of the deutomerite sclerite of the third appendage.

The fourth-coxal entosclerite-deutomerite muscle (103) is attached to the fourth coxal entosclerite and to the interior margin of the deutomerite sclerite of the fourth appendage.

The fifth coxo-deutomerite muscle (104) is attached to the fifth coxal sclerite and to the interior margin of the deutomerite sclerite of the fifth appendage.

The sixth coxo-deutomerite muscle (105) is attached to the sixth coxal sclerite and to the interior margin of the deutomerite sixth sclerite of the sixth appendage.

Extrinsic Muscles.—Most of the extrinsic muscles of the appendages are attached to the carapace; when this is removed a compact mass of muscles is exposed, which is shown in Pl. LXXVIII. fig. 6. The under-surface of the carapace, with the attachments of the muscles, is represented in Pl. LXXVIII. fig. 7, and the attachments of the muscles to the appendages are shown in Pl. LXXIX. fig. 16. There are three series of extrinsic muscles to the appendages of the prosoma—those running to the deutomerite sclerites, the coxal sclerites, and the coxal entosclerites.

Deutomerite Muscles.—There is one deutomerite muscle to each of the appendages of the prosoma, with the exception of the first, to which there are two. These muscles are attached extrinsically to the carapace (those running to the first and second appendages) and to the plastron (those to the third, fourth, fifth, and sixth appendages).

The deutomerite muscles (73, 77, 80, 82) from the plastron have already been described under the muscles attached to the plastron; it remains to mention those from the carapace to the first and second appendages.

The superior first dorso-deutomerite muscle (106) is a narrow muscle attached to the carapace near the median line posterior to the eyes; running forward, it is attached to the superior portion of the interior margin of the deutomerite sclerite of the first appendage.

The inferior first dorso-deutomerite muscle (107) is a larger muscle, attached to the carapace more laterally. It runs forward and is attached to the inferior portion of the interior margin of the deutomerite sclerite of the first appendage.

The second dorso-deutomerite muscle (108) is a thick muscle attached to the carapace towards its posterior portion. It runs forward to the exterior portion of the interior margin of the deutomerite sclerite of the second appendage, to which it is attached.

Coxal Muscles.—The coxal muscles are attached extrinsically to the carapace, with the exception of three which run to the coxal sclerite of the second appendage from the plastron and have been mentioned above under the muscles attached to the plastron (72, 75, 76).

The exterior first dorso-coxal muscle (109) is attached to the carapace near the
median line. It runs laterally to the exterior portion of the interior margin of the coxal sclerite of the first appendage.

The interior first dorso-coxal muscle (110) is a large muscle, the larger part of which is attached posteriorly, the smaller part more laterally, to the carapace; these are united in a common origin at the interior portion of the interior margin of the coxal sclerite of the first appendage.

The superior first dorso-coxal muscle (111) is attached posteriorly to the carapace. It is a narrow muscle, running underneath the larger part of the last-mentioned muscle, and is attached anteriorly to the superior portion of the coxal sclerite of the first appendage.

The anterior second dorso-coxal muscle (112) is a thick muscle attached posteriorly to the carapace, and running forward to the antero-lateral portion of the interior margin of the second coxal sclerite.

The posterior second dorso-coxal muscle (113) is attached to the carapace towards its lateral portion and to the postero-lateral portion of the interior margin of the second coxal sclerite.

The third dorso-coxal muscle (114) is attached to the lateral portion of the carapace and to the antero-lateral portion of the interior margin of the third coxal sclerite.

The fourth dorso-coxal muscle (115) is attached to the lateral portion of the carapace and to the antero-lateral portion of the interior margin of the fourth coxal sclerite.

The anterior fifth dorso-coxal muscle (116) is attached to the carapace near the median line, at its posterior portion, and to the antero-lateral portion of the interior margin of the fifth coxal sclerite.

The posterior fifth dorso-coxal muscle (117) is attached to the lateral portion of the carapace and to the postero-lateral portion of the interior margin of the fifth coxal sclerite.

The anterior sixth dorso-coxal muscle (118) is attached to the posterior portion of the carapace near the median line and to the antero-lateral portion of the interior margin of the sixth coxal sclerite.

The posterior sixth dorso-coxal muscle (119) is attached to the lateral portion of the carapace and to the postero-lateral portion of the interior margin of the sixth coxal sclerite.

Coxal Entosclerite Muscles.—The extrinsic muscles of the coxal entosclerites are attached to the plastron and to the carapace. Those running from the plastron are attached to the posterior surfaces of the third and fourth posterior coxal entosclerites, and have been mentioned under the muscles attached to the plastron (74, 78).

There are four muscles from the carapace to the coxal entosclerites, two of which are attached to that of the first appendage, and one to each of the posterior coxal entosclerites of the third and fourth appendages.

The lateral first dorso-coxal entosclerite muscle (120) is attached to the lateral portion
of the carapace. It runs inwards, and is attached to the posterior part of the first coxal entosclerite.

The posterior first dorso-coxal entosclerite muscle (121) is attached posteriorly to the carapace. Running forwards, it is attached to the exterior edge of the first coxal entosclerite.

The third dorso-coxal entosclerite muscle (122) is a thin broad muscle attached to the carapace towards its lateral portion and to the posterior margin of the posterior third coxal entosclerite.

The fourth dorso-coxal entosclerite muscle (123) is attached to the carapace and to the posterior margin of the posterior fourth coxal entosclerite.

Mesosoma.—To the first appendage of the mesosoma, or genital operculum, there is only one muscle, which is attached to the plastron, and has been already mentioned with the muscles which are attached to the plastron as the seventh plastron muscle (85). (See Pl. LXXX. figs. 13, 14.)

To the second appendage, or pectine, there are six muscles, four of which are attached to the suprapectinal chondrite, and have been already mentioned with the muscles attached to the suprapectinal chondrite as the posterior (88), anterior (90), interior (91), and exterior (92) pectino-suprapectinal-chondrite muscles (see Pl. LXXXIX. fig. 14).

The epimero-pectinal muscle (124) is attached to the epimeron by the postero-lateral portion of the interior margin of the sixth coxal sclerite. It runs into the pectine (fig. 8).

The sterno-pectinal muscle (125) is attached to the sternal sclerite, on which the pectines are carried near the median line; it runs laterally, and is attached to the interior portion of the opening of the pectine (Pl. LXXIX. fig. 14).

No muscles are attached directly to the lung-books, although there are two series of muscles by which they are influenced. Amongst the ventral longitudinal muscles will be seen the post-stigmatic muscles (35, 36, 37, & 38) of the third, fourth, fifth, and sixth segments of the mesosoma; these are attached to the posterior edge of the stigmata and to the arthroidal membrane posterior to the segment in which they occur.

The muscles of the other series run ventralwards from the pericardium, and spread out on the surface of the blood-holding lung-sac in those segments in which the lung-books occur. Of this series I shall speak later under the heading of "Muscles to the Pericardium."

VII. Muscles to the Epimeron. (Plate LXXVII. fig. 1, and Plate LXXVIII. fig. 6)

Muscles are distributed to the epimeron from the carapace, the plastron, the second entochondrite, and the pectines. All of these have been mentioned above, with the exception of those from the carapace.
The muscles 79, 81, & 83 run between the epimeron and the plastron, the muscle 87 between the epimeron and the second entochondrite, and the muscle 124 between the epimeron and the pectine.

The anterior dorso-epimeron muscle (126) is attached to the lateral portion of the carapace and to the epimeron lateral to the interior margin of the second coxal sclerite.

The median dorso-epimeron muscle (127) is attached to the lateral portion of the carapace and to the epimeron lateral to the interior margin of the third coxal sclerite.

The posterior dorso-epimeron muscle (128) is attached to the lateral portion of the carapace, and to the epimeron lateral to the interior margin of the fourth coxal sclerite.

VIII. Muscles to the Pharynx. (See Plate LXXIX. figs. 11, 12.)

The pharynx of the Scorpion is a large dilatation of the alimentary canal closely following the aperture of the mouth. This aperture is so minute that the animal lives entirely on the juices of its prey, and on the hard parts finely pulverized by the action of the chelicerae: these juices are drawn in at the oral aperture by the expansion and contraction of the pharynx. On contracting the muscles form within the pharynx a partial vacuum; and as the aperture of the oesophagus on leaving the pharynx is smaller than that of the mouth, the vacuum is more readily filled from the latter. The muscles attached to the pharynx are of two kinds, the extrinsic, which dilate, and the intrinsic, which contract it. It is thus rendered a powerful suctorial organ. In transverse section it is shown to be very narrow, the lateral walls almost meeting; its dorsal portion is curved downwards, and forms a lateral groove, which gives it a triradiate form.

The dorsal intrinsic muscle (129) consists of three small bands of muscle which are attached to the dorsal surface of the pharynx within, and to the walls on either side of the groove. This muscle is so small that it is only by means of sections that it is visible; it is, of course, not repeated on either side of the animal, as it is itself in the median line.

The lateral intrinsic muscle (130) runs closely by the lateral walls of the pharynx, and is attached dorsally and ventrally to its walls. This muscle cannot be seen without the aid of sections.

The anterior preoral entosclerite pharyngeal muscle (98) (Pl. LXXIX. fig. 12) is a small muscle attached to the ventral surface of the anterior portion of the preoral entosclerite. It runs down almost vertically into the groove on the dorsal surface of the pharynx, to the wall of which it is attached.

The posterior preoral entosclerite pharyngeal muscle (99) is a larger muscle attached to the interior surface of the processes of the preoral entosclerite, and runs almost horizontally to the lateral wall of the pharynx, to which it is attached.
IX. Muscles to the Pericardium. (See Plate LXXVII. figs. 1, 4, 5, and Plate LXXX. fig. 15.)

There is a series of muscles attached to the ventral wall of the pericardium, running ventrally and attached to the ventral portion of the investment of connective tissue which lines the body; they lie slightly anterior to the dorso-ventral muscles, mentioned before as being attached to the tergites and sternites of the mesosoma. There is one in each of the five last segments of the mesosoma, and two in the first segment of the metasoma. Dorsally they are attached nearer to the median line than the dorso-ventral muscles, which are attached to the tergites by the side of the pericardium; but before reaching the sternal surface they cross over, and their ventral attachment is exterior to that of the dorso-ventral muscles. In the four segments in which the lung-books occur they spread out ventrally, and are attached to the surface of the venous sacs, into which the introverted lamellae of the branchial appendages (or lung-books) are sunk. These muscles are hollow, both above and below; but the middle region is solid, so that the blood does not pass from the pulmonary sinus to the pericardium through them, as might at first seem likely. They are exactly equivalent to the veno-pericardiac muscles of Limulus (68), the “brides transparentes” of M. Alphonse Milne-Edwards.

a. Mesosoma.

The pericardio-ventral muscle (131) of the second segment of the mesosoma is attached dorsally to the pericardium, running forward closely in front of the dorso-suprapectinal chondrite muscle (66); it is attached ventrally to the connective investment of the body exterior to the above-mentioned muscle.

The pericardio-ventral muscle (132) of the third segment of the mesosoma is attached dorsally to the pericardium, running down closely anterior to the dorso-ventral muscle (67); it is attached ventrally to the first lung-sac, exterior to the dorso-ventral muscle (67).

The pericardio-ventral muscle (133) of the fourth segment of the mesosoma; the pericardio-ventral muscle (134) of the fifth segment of the mesosoma; and the pericardio-ventral muscle (135) of the sixth segment of the mesosoma are similar to the pericardio-ventral muscle (132) of the third segment, and take a corresponding position in the segments to which they belong.

b. Metasoma.

The anterior pericardio-ventral muscle (136) of the first segment of the metasoma is attached dorsally to the pericardium, running closely anterior to the dorso-ventral muscle (71) of the first segment of the metasoma, and is attached ventrally to the connective investment of the body exterior to the muscle (71).

The posterior pericardio-ventral muscle (137) of the first segment of the metasoma is
exactly similar to the anterior pericardio-ventral muscle (136), except that it runs on
the posterior instead of the anterior side of the dorso-ventral muscle (71).

The pericardium is not continued into the five subsequent segments of the metasoma,
and accordingly we do not find there any muscles representing the veno-pericardiace of
the mesosoma and first mesatomatic segment.

Reference to letters in Plates LXXVII., LXXVIII., LXXIX.

i. Chelicera, first appendage.
ii. Chela, second appendage.
iii.–vi. Four ambulatory appendages.
vii.–xii. Six segments of mesosoma.
viii.–xiii. Six segments of metasoma.
A. First coxal entosclerite.
B. Second coxal entosclerite.
C. Anterior third coxal entosclerite.
D. Posterior third coxal entosclerite.
E. Anterior fourth coxal entosclerite.
F. Posterior fourth coxal entosclerite.
G. Fifth coxal entosclerite.
H. Precoxal entosclerite.
K. Postcoxal entosclerite.
L. Carino-sternal entosclerite.
N.C. Canal in plastron through which nerve-cord passes.
V.C. Ventral portion of carapace turned under anteriorly (transparent).
V.S. Vascular space in pericardio-ventral muscle.
ac. Alimentary canal.
am. Arthrodial membrane, covering the body between the chitinous plates.
ap. Anterior process of plastron.
arc. Arterial canal-aperture in posterior flap of plastron through which the dorsal vessel
runs.
cam. Camerostome or upper lip.
car. Carapace.
cce. Central eyes.
ccp. Coxal glands.
dr. Dorsal ridge of plastron.
dv. Dorsal vessel (anterior continuation of heart).
gc. Gastric canal-aperture in posterior flap of plastron, through which the alimentary
canal runs.
go. Genital operculum (seventh appendage).
lr. Lateral eyes.
l₁, l₂, l₃, l₄. Lung-sacs (blood-containing envelopes of the lung-books) in four last segments of
mesosoma.
imp. Lateral median process of plastron.
m. Mouth.
m₁. Aperture in flap of plastron through which muscle 83 passes.
m₂. Aperture in flap of plastron through which muscle 65 passes.
m₂d. Divisions between muscles.
m. Thoracic metasternite.
mf. Muscular fibres.
n. Nerve-cord.
n. Nerve-ganglion.
p. Pericardium.
pa. Postanal spine.
pec. Pecten (eighth appendage).
pf. Posterior flap of plastron.
ph. Pharynx.
pl. Plastron.
pp. Posterior process of plastron.
snp. Subneural process of plastron.
spe. Suprapectineral chondrite.
sts. Sternal sclerite on which pectines are carried
in second segment of mesosoma.
a. Cut edge of carapace.
y. Cut edge of tergites.
1. Antero-posterior muscle (prosoma).
2. Arthrodio-tergal obliquus muscle (prosoma).
31–34. Arthrodio-sternal obliquus muscles (mesosoma).
35–38. Post-stigmatic muscles (mesosoma).
AND ENDOSKELETAL SYSTEMS OF SCORPIO.

30-44. Arthrodi-tergal rectus muscles (metasoma).
49. Superficial dorso-ventral muscle (metasoma).
50. Median antero-posterior muscle (metasoma).
50 a. Arthrodi-sternal rectus muscle (metasoma).
51. Lateral antero-posterior muscle (metasoma).
52-55. Median antero-posterior muscles (metasoma).
56-60. Lateral arthrodi-sternal muscles (metasoma).
61. Dorso-chelicero-ternal muscle.
62. Median dorso-preoral entosclerite muscle.
63. Anterior dorso-plastron muscle.
64. Median dorso-plastron muscle.
65. Posterior dorso-plastron muscle.
66. Dorso-suprapelvicular chondrite muscle.
67-70. Dorso-ventral muscles (mesosoma).
71. Dorso-ventral muscle (metasoma).
72. Anterior second coxo-plastron muscle.
73. Third deuto-deuterite-plastron muscle.
74. Third postcoxal entosclerite-plastron muscle.
75. Median second coxo-plastron muscle.
76. Posterior second coxo-plastron muscle.
77. Fourth deuto-deuterite-plastron muscle.
78. Fourth postcoxal entosclerite-plastron muscle.
79. Anterior epimero-plastron muscle.
80. Fifth deuto-deuterite-plastron muscle.
81. Median epimero-plastron muscle.
82. Sixth deuto-deuterite-plastron muscle.
83. Posterior epimero-plastron muscle.
84. Sterno-subneural plastron muscle.
85. Operculo-plastron muscle.
86. Plastron suprapelvicular chondrite muscle.
86 a. Sixth coxo-plastron muscle.
87. Epimero-suprapelvicular chondrite muscle.
88. Posterior pectine suprapelvicular chondrite muscle.
89. Sterno-suprapelvicular chondrite muscle.
90. Anterior pectine suprapelvicular chondrite muscle.
91. Interior pectine suprapelvicular chondrite muscle.
92. Exterior pectine suprapelvicular chondrite muscle.
93. Anterior latero-dorsal preoral entosclerite muscle.
94. Median latero-dorsal preoral entosclerite muscle.
95. Posterior latero-dorsal preoral entosclerite muscle.
96. Anterior first-coxal entosclerite preoral entosclerite muscle.
97. Posterior first-coxal entosclerite preoral entosclerite muscle.
98. Anterior preoral entosclerite-pharyngeal muscle.
100. Exterior first-coxal entosclerite-deutomerite muscle.
101. Interior first-coxal entosclerite-deutomerite muscle.
102. Third-coxal entosclerite-deutomerite muscle.
103. Fourth-coxal entosclerite-deutomerite muscle.
104. Fifth coxo-deutomerite muscle.
105. Sixth coxo-deutomerite muscle.
106. Superior first dorso-deutomerite muscle.
107. Inferior first dorso-deutomerite muscle.
108. Second dorso-deutomerite muscle.
110. Interior first dorso-coxal muscle.
111. Superior first dorso-coxal muscle.
112. Anterior second dorso-coxal muscle.
113. Posterior second dorso-coxal muscle.
114. Third dorso-coxal muscle.
115. Fourth dorso-coxal muscle.
116. Anterior fifth dorso-coxal muscle.
117. Posterior fifth dorso-coxal muscle.
118. Anterior sixth dorso-coxal muscle.
119. Posterior sixth dorso-coxal muscle.
120. Lateral first dorso-coxal entosclerite muscle.
121. Posterior first dorso-coxal entosclerite muscle.
122. Third dorso-coxal entosclerite muscle.
123. Fourth dorso-coxal entosclerite muscle.
124. Epimero-pectine muscle.
125. Sterno-pectine muscle.
126. Anterior dorso-epimeron muscle.
127. Median dorso-epimeron muscle.
128. Posterior dorso-epimeron muscle.
129. Dorsal intrinsic muscle of pharynx.
130. Lateral intrinsic muscle of pharynx.
131-137. Pericardio-ventral (veno-pericardiac) muscles.
DESCRIPTION OF PLATES LXXVII. to LXXIX.

PLATE LXXVII.

Fig. 1. Prosoma and metasoma of Scorpio (Buthus). Dorsal aspect. The tergum of the left side has been cut away and the viscera removed in order to expose the dorso-ventral muscles. The superficial muscles of the prosoma have also been removed. Besides the muscles there are seen the plastron (Pl), the pericardium, and the lung-sacs (ls).

Fig. 2. Dorsal aspect of the mesosoma and metasoma of Scorpio (Buthus). The tergites have been removed in order to show the dorsal longitudinal muscles.

Fig. 3. Ventral aspect of the mesosoma and metasoma of Scorpio (Buthus). The sternites have been removed to show the ventral longitudinal muscles; on the left the arthrodiosternal muscles (31-34) have been removed.

Fig. 4. Diagrammatic view of a lateral dissection of the prosoma and mesosoma of Scorpio (Buthus).

Fig. 5. Ditto of the prosoma and mesosoma of Scorpio (Androctonus).

PLATE LXXVIII.

Fig. 6. Dorsal aspect of the prosoma of Scorpio (Buthus). The carapace has been removed in order to expose the muscles. On the left side the more superficial muscles are removed.

Fig. 7. Under-surface of the carapace, showing the attachments of the muscles.

Fig. 8. Mesosoma of Scorpio (Buthus). Dorsal aspect. The tergites and viscera have been removed in order to show the muscles, lung-sacs, and nerves.

Fig. 9. Mesosoma of Scorpio (Androctonus). Dorsal aspect. Tergites and viscera removed.

PLATE LXXIX.

Fig. 10. Transverse section of a pericardio-ventral muscle from the mesosoma of Scorpio (Buthus), showing vascular space (vs) cut across.

Fig. 11. Transverse section across the prosoma of Scorpio (Italicus), showing the muscles attached to the pharynx.

Fig. 12. Transverse section of the same pharynx anterior to fig. 11.

Fig. 13. Carapace of Scorpio (Buthus). Ventral aspect.

Fig. 14. Transverse section of the segment bearing the pectines, showing the supra-pectinal chondrite (spec) with muscles attached.

Fig. 15. View of a longitudinally divided prosoma of Scorpio (Buthus). All the viscera removed, and only the hard skeletal parts left (compare with woodcut, fig. 1).

Fig. 16. View of the inner sternal surface of the prosoma of Scorpio (Buthus). All the viscera removed, only the hard skeletal parts left.
ANATOMY OF SCORPIO.
ANATOMY OF SCORPIO.
PART IV. Comparison of the Muscular and Endoskeletal Systems of Limulus and Scorpio, and Consideration of the Morphological Significance of the Facts recorded.

By E. Ray Lankester.

I have not attempted to modify the descriptions of the hard parts and the muscles of *Limulus* given by Mr. Benham, and of *Scorpio* given by Miss Beck, so as to obtain a uniformity of nomenclature and numbering for these parts in the two animals. Undeniably the nomenclature which has seemed to be the simplest and most intelligible is at the same time exceedingly clumsy, but that is a reproach which is equally justified in the case of all attempts at the naming of muscles. We have before us, in Parts II. and III. of this Memoir, a systematic description of the muscles of the King Crab and the Scorpion which can serve as a basis for comparisons between the two animals.

Like all Arthropoda these animals have lost entirely the circular muscular layer of the body-wall which their Vermian Chetopod-like ancestors possessed\(^1\). This suppression of the circular muscular layer is correlated with the development of the great tergal and sternal sclerites, and the consequent incompressibility of the body. The muscles of the body-wall are entirely longitudinal or else dorso-ventral. The muscles are practically divisible into three great groups, viz. those of the body-wall just referred to, those of the limbs, and those of the viscera (pharyngeal and veno-pericardiacs, and intrinsic muscles). Those which pass from one or other part of the body-wall to the limbs are by far the most bulky and numerous group of the three, in both *Limulus* and *Scorpio*.

Neither *Limulus* nor *Scorpio* is in a primitive or archaic condition, so far as the segmentation of the body and the differentiation of its appendages are concerned. We have not to deal in either case with a simple condition, but in each with a highly specialized condition. Presumably the ancestors of the Arachnida, in which class both *Limulus* and *Scorpio* find their places, were provided with a completely segmented body, consisting of at least eighteen separately movable somites, a prostomium, and a postanal spine. Each of the eighteen segments at a remote period of the ancestry carried a pair of appendages. The musculature at this time was no doubt very simple and regular, exactly repeating itself in each successive body-ring. Assuming that dorsal and ventral sclerites had been developed on each segment, and that the coxae of the limbs were chitinized, it is yet probable that at such an early stage no representatives of the remarkable floating cartilages or "entochondrites," which form so characteristic a feature in the organization of living Arachnida, had yet been brought into existence. The simple musculature may be supposed to have consisted of—1, a series of paired dorsal longitudinal muscles passing from tergite to tergite of each successive

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\(^1\) Unless the latero-dorsal muscles of the mesosoma of Scorpions (15 to 20 in Miss Beck's enumeration) may be considered as representing that layer.
segment; 2, a similar series of paired longitudinal ventral muscles; 3, a pair of dorso-ventral muscles passing from tergite to sternite in each segment, possibly derived from the circular muscular layer external to the longitudinal which the soft-bodied fore-runners of these chitinized Arthropods must have possessed; 4, a set of muscles moving the coxa of each limb in its socket, and consisting of probably an anterior and posterior dorso-coxal from the tergite of each segment to the coxa of each of its two limbs, and a similar anterior and posterior sterno-coxal muscle passing from the sternite of each segment to the coxa of each of its two limbs; 5, a pair of muscles in each segment passing from the floor of the great dorsal blood-sinus (the pericardium) to the roof of the great ventral blood-sinus which expanded on each side over the bases of the appendages (veno-pericardiacs); 6, muscular bands radiating from the wall of the pharynx to the adjacent tergite and sternite.

The departure of both Limulus and Scorpio from such an ancestral plan is probably to be traced for a certain distance along a common path.

The confluence of the prosomium and the six anterior tergites to form a prosomatic carapace, and the suppression of appendages on the six segments of the metasoma, as well as the specialization of the six pairs of appendages of the prosoma, as elongate ambulatory and grasping organs, and of the six pairs of appendages of the mesosoma as flattened natatory and branchial organs, was common to the ancestors of both Limulus and Scorpio. This modification of form and specialization of body-regions entailed a corresponding modification of the muscular system. The dorsal and ventral longitudinal muscles of the prosoma were suppressed, as well as those of the aborted metasomatic appendages. The muscles of the prosomatic limbs acquired larger size, and became subdivided, whilst those of the mesosomatic limbs retained their simplicity.

Coming to the actual form of the living Scorpions and King Crabs, we find that the former has retained the separate chitinized segments of the mesosoma and metasoma, whilst it has modified the four posterior pairs of mesosomatic appendages so that they are no longer movable; accordingly the Scorpions retain both the dorsal and ventral longitudinal muscles of the mesosoma, whilst the muscles of the four posterior pairs of mesosomatic appendages (the lung-books) are aborted. Limulus, on the other hand, has retained both its prosomatic and mesosomatic appendages in full locomotor activity, and not only are the hypothetical ancestral muscles of the latter appendages present, but additional and very powerful muscles (the thoraco-branchials) have been developed; at the same time Limulus has undergone a very peculiar modification of the tergites of the mesosoma and metasoma resulting in the formation of what is called “the abdominal carapace.” Consequently the dorsal longitudinal muscles are entirely suppressed, with the exception of the powerful hinge-muscle (connecting the anterior and the posterior carapace) and the interentapophysial muscles, which all arise from the pair of great entapophyses of the prosoma, and are inserted into entapophyses of the mesosoma, and may be regarded as modifications of the dorsal longitudinal intersegmental muscles.
The ventral longitudinal muscles of the mesosoma are retained, whilst the metasoma is altogether in a reduced or degenerate condition.

One special feature resulting from the concentration of the skeletal covering of Limulus in two great tergal plates (the anterior and posterior carapaces) is the development of muscles connected with the limbs and other sternal parts of the mesosoma, which do not keep within the limits of the segment to which one end of such muscle may be attached, but take a long course forwards so as to receive their dorsal attachment either in the prosomatic carapace or in portions of the meso-metasomatic carapace anterior to (in other cases posterior to) the segment of their insertion. Such vertical-oblique muscles may possibly in some cases be regarded as resulting from dislocations of normal vertical muscles, which normally arise, and are inserted in the tergum and sternum of one and the same segment. But, generally speaking, it seems necessary to regard such muscles as new developments, since it is difficult to imagine the steps by which a muscle (apart from a movement of the hard pieces of tergum or sternum to which it was primitively attached) could acquire new attachments outside the segment to which it properly belongs.

The great entapophyses (Ent') of the prosoma of Limulus appear to furnish an important instance of the removal of a skeletal piece from association with the segment to which it primitively belonged, and of its incorporation by fusion with a segment in front of it. Such a transference is familiar enough in the higher vertebrata in the case of the transference of the centrum of the atlas vertebra to the next following segment, where it appears as the odontoid process of the axis-vertebra. Apparently in the same way the entapophyses of the first mesosomatic segment of Limulus have been detached from the rest of the dorsal sclerite of the first mesosomatic segment and have been incorporated with the prosomatic carapace, thus taking up a position in front of the great tergal hinge to which they were primitively posterior. The attachment of muscles to these large entapophyses, and the serial relations of those muscles and of the muscles attached to the area of the first segment of the mesosoma and of the succeeding mesosomatic segments, is decidedly in favour of the supposition that such a transference has taken place. The attachment of the external branchials of Limulus (20), and of the two most anterior of the mesosomatic dorso-ventrals (12), gives important evidence in this matter. When we adopt the view that the prosomatic entapophyses are really the entapophyses of the first or genital segment of the mesosoma, and that correspondingly the following five pairs of entapophyses belong respectively to the five succeeding segments of the mesosoma, whilst the sixth pair of entapophyses belongs to the metasoma, the interpretation of the series of muscles attached to them and to the adjacent parts of the tergum becomes intelligible. This view corresponds with that which I had put forward as the result of a study of the hard parts only, in my article "Limulus an Arachnid" (Q. J. Micr. Sci. 1881). See woodcut, fig. 1, of the tergal surface of Limulus in that article.
The hollow in-sinkings of the chitinous surface of the body, in connexion with the attachments of muscles so largely developed in Limulus, form, it may be noted, an Arachnidian character. Such cupping of the chitinous integument is seen in the Arachnid Thelyphonus. The remarkable hollow tendons of Limulus originating as stigmata at the bases of the mesosomatic appendages, and giving attachment to the great thoraco-branchial muscles, are of the same nature as the dorsal entapophyses.

These oblique or vertico-oblique muscles of Limulus (the thoraco-branchials) constitute the chief difference between the musculature of Limulus and Scorpio. They are unrepresented in Scorpio; they cannot be derived from any muscles existing in that animal or in the hypothetical common ancestor of the Arachnids. They must be regarded as new structures, special to the Limuloid modification of the type.

It may be laid down as a guiding principle in the study of phylogeny or the genealogies of animals and plants, that organs do not arise de novo, and that apparently new organs are to be traced to pre-existing organs, by the modification (division, expansion, atrophy, or other change) of which they have gradually been brought to their present condition. It is questionable, however, whether this principle can be applied to the phylogeny of muscles. Muscular tissue apparently may replace, and does actually replace, ordinary fibrous or other connective tissue, and thus a muscle may be formed where no muscle previously existed. The development of striped muscular tissue in Limulus is exuberant in a remarkable degree, and it is by no means an unwarrantable assumption that in this and in other Arthropods new muscular connexions are brought about by gradual substitution of muscular for connective tissue. This of course merely implies that muscular tissue, like connective tissue, fine blood-vessels, and nerves, is not liable to restriction in the direction and manner of its growth in strict accordance with the segmentation impressed upon an animal in early stages of its genealogical history and inherited in a more or less perfect form at the present day.

Nature of the Entochondrites.—I have come to the conclusion that the prosomatic and smaller posterior entochondrites, both of Limulus and Scorpio, are, in so far as their “body” or central part is concerned, merely the original subepidermic connective tissue of the sternal surface of the segments in which they occur, which has become thickened and cartilaginoid, and has at the same time floated off, as it were, from the sternal surface and taken up a position deeper, that is to say nearer the axis of the animal, than that which it originally occupied. This interpretation of the entochondrites is favoured by the fact that the small mesosomatic entochondrites of Limulus (and the single mesosomatic entochondrite of Scorpio) are in close relation to the sternal epidermis and lie beneath the nerve-cords, although the large prosomatic entochondrites of both Limulus and Scorpio have the nerve-cords below them. Supposing the detachment from the sternal integument of the mass of connective tissue forming the prosomatic entochondrite to have occurred at a period when the nerve-cords were still quite lateral in position (as they remain to this day in Peripatus) in the prosomatic region, although
they had converged towards the median line in the mesosoma (as we see is the case in representatives of allied groups, such as Serpula), then there would be no difficulty in accounting for the present position of the nerve-cords in relation to the entochondrites by supposing that they tended subsequently to the detachment of the prosomatic entochondrite to take up a position more and more coincident with the median ventral line, although in the mesosoma they had already taken up such a position. Accordingly the nerve-cords in the prosoma would be able to take up their present position beneath (i.e. ventrad of) the prosomatic entochondrite, whilst in the mesosomal region the nerve-cords, already occupying a median position, would necessarily remain superior (i.e. dorsad to) the mesosomal entochondrites. Such movements of masses of tissue as are here postulated are entirely in accordance with well-established conclusions. There is no doubt that the double nerve-cord of Arthropods and Chaetopods owes its double character to the fact that it originated as two widely separated lateral tracts of nervous tissue, which have gradually (in the course of ancestral development) converged towards the middle line, as is also the case in the independent phyla of the Leeches and the Molluscs.

There is also no doubt that these nerve-cords originated in the epidermis, and that in some animals they still remain actually as thickened ridges of that layer, whilst in a large majority they have become detached from that epidermal connexion (although maintaining it in their embryology), and have sunk inwards through connective tissue and muscle until they lie well within the body. There is no animal in which this detachment of the nerve-cord from its primitive relation to the epidermis is carried so far as the Scorpion, where, as seen in the sections drawn in Pl. LXXXI. figs. 1, 2, *aa*, the nerve-cord attains in the mesosoma almost an axial position. Just as the mass of tissue called nerve-cord can move from its primitive relations, so, it appears reasonable to admit, can other tissue-masses, and accordingly amongst others the dense subepidermal entochondrites. Possibly the application of this principle of the in-sinking of primitively subepidermal skeletal tissue may throw some light upon the skeletal structures of Vertebrata. At any rate it is a legitimate hypothesis in regard to the entochondrites of Arthropoda, and enables us to understand the nature of these bodies and the muscles attached to them. The muscles attached to the entochondrites are primarily the muscles attached to the midsternal region of the segments in which such entochondrites occur. This is obvious enough with regard to the small mesosomal entochondrites of Limulus, and it will be found to give an intelligible explanation of the muscles attached to the great prosomatic entochondrite.

It is to be noted that the inter-entapophysial ligaments which run on each side, right and left, along the dorsal surface of Limulus, passing from one entapophysis to the next, are of similar nature and origin to the entochondrites. They represent a tract of detached subepidermal connective tissue belonging to the tergites, just as the entochondrites represent subepidermal connective tissue of the sternites.
In connexion with this matter it is important to observe that the attachment of all muscles in all Arthropods, apparently to cuticular plates or sclerites formed by the epidermis externally, is really an attachment to subepidermic connective tissue. No muscle ever comes into direct relation with epidermic cuticle, even when that cuticle is in the form of a hollow ingrowth (entapophysis) or a solid ingrowth (entosclerites of Scorpio). The epidermic cuticle is always clothed internally with fibrous connective tissue, and this is the intermediary of the attachment of muscle and sclerite. Accordingly it is not difficult to conceive of the connective tissue in any special case assuming large proportions and dense substance, and if supported otherwise than by its adhesion to an epidermic sclerite, losing by degrees all connexion with such a sclerite.

Applying these considerations to the case of Limulus and Scorpio, we come to the conclusion that the muscles attached to the entochondrites are:—1st, representatives of the serial longitudinal intersegmental muscles of the ventral series; 2nd, representatives of the serial dorso-ventral muscles; 3rd, more especially the primitive sterno-coxal muscles of the limbs; and 4th, the primitive sterno-buccal muscles.

In both Limulus and Scorpio the prosomatic entochondrite or plastron, as it is more shortly called, represents the midsternal area of several segments fused—probably, in both cases, of all the prosomatic segments; though possibly in Scorpio the first segment is not included, since muscles to the chelicere do not arise from the plastron in Scorpio, and a longitudinal muscle (84) extends from its anterior subneural processes on each side to be inserted into a small postoral sclerite. Probably also the plastron of Scorpio includes the midsternal area of the genital (or first mesosomatic segment), since there is no separate entochondrite to that segment as there is in Limulus, whilst there is such a distinct entochondrite to the next or pectinigerous segment. This view is further borne out by the fact that a pair of muscles (the operculo-plastrals 85) similar to the muscles (the internal branchials 48) which pass from the entochondrite into each of the mesosomatic appendages of Limulus (represented also in the pectinigerous segment in Scorpio) pass from the hinder part of the prosomatic plastron of Scorpio to the genital operculum.

Relative Condition of the Mesosomatic Appendages in Scorpio and Limulus: Lung-books and Gill-books.—The six flattened, mesially fused, mesosomatic appendages of Limulus are represented by two pairs of appendages and four pairs of respiratory lamelligerous cavities in Scorpio. The diminutive size of the genital operculum of Scorpio as compared with that of Limulus accounts for its incomplete musculature; but such muscles as it has (the operculo-plastrals 85) agree with the more primitive among the muscles of the same appendage in Limulus. A similar statement is true of the pectines or second pair of mesosomatic appendages of Scorpio as compared with the second pair in Limulus. The four pairs of lung-books of Scorpio are not entirely devoid of muscles; the post-stigmatic muscles passing from the posterior edge of the stigma of each lung to the posterior border of the sternal region of the same segment
appear to me to correspond to the internal branchials (48) of the four corresponding pairs of limbs in *Limulus*.

The view which I advocated in my essay "*Limulus an Arachnid,*" as to the mode of conversion of an external lamelligerous appendage into the hollow lamelligerous lung of *Scorpio,* no longer commends itself to me. A much simpler and, as it appears to me, a thoroughly satisfactory explanation of the relationship of the two organs has suggested itself in the course of the investigations here recorded, and is supported also by embryological data. In the essay above referred to, I suggested that by the enlargement of the hollow stigmata connected with the thoraco-branchial muscles of an ancestral *Scorpio,* resembling *Limulus* in having branchigerous appendages on the mesosoma and thoraco-branchial muscles, the branchigerous appendage might come to lie in the pit or hollow of the tendon, and eventually the hollow might enclose it. The conversion of the in-sunken appendage into a hollow air-holding sac and the corresponding conversion of the surrounding pit into a closed blood-holding space, involved serious difficulties which were indeed fatal to the hypothesis. When I found that the muscle (veno-pericardiac) attached to the apex of each lung-sinus in *Scorpio* had no possible relation to the thoraco-branchial muscles of *Limulus,* but was represented in *Limulus* by exactly similar veno-pericardiac muscles, I gave up my overstrained hypothesis. I trust that the failure of my previous suggestion will not unduly prejudice those interested in this subject against that which I now advance. Since my memoir "*Limulus an Arachnid,*" Dr. MacLeod of Brussels has published some speculations on this subject, in which he puts forward an ingenious theory of his own as to the mode in which the lamelligerous appendage of a *Limulus*-like animal might be converted into the lamelligerous lung-book of an Arachnid. I will not enter into a discussion of Dr. MacLeod's hypothesis, but will merely point out that inasmuch as it deals with not the less modified lung-book of *Scorpio,* but the more modified lung-book of the Araneina, it is unsatisfactorily elaborated. The lung-book of *Scorpio* has a definite axis carrying the leaf-like lamellae, and corresponding to the axis of the same animal's pecten. Such an axis is not present in the Araneine lung-book, and yet must be accounted for as a primary structure in any theory as to the origin of these organs.

The hypothesis which I now put forward is perfectly simple, and leaves, I think, nothing to be desired. In *Limulus,* as in *Scorpio,* there is on each side of the sternal surface a great blood-sinus in free communication with the lamelligerous organs. Let us suppose such to have been the case in the common ancestor of these two animals, and let us suppose that this ancestor possessed six pairs of mesosomatic appendages, of which five were lamelligerous and intermediate in form between the pectens of *Scorpio* and the recent *Limulus* appendage. Now suppose that in the *Scorpio* branch of the family the mesosomatic appendages grew relatively smaller and smaller, were no longer locomotor organs, but purely respiratory, and served for aerial rather than aquatic respiration. If we imagine the four hinder pairs of these reduced appendages to have
taken on *in the embryonic condition* a very common trick of growth, viz. an inward growth of invagination, so that they grew *into* the Scorpion's body, turning their outside in, just as a glove may have all its fingers and part of the hand turned outside in—the then we should have without further alteration the exact condition of the modern Scorpion's lung-book. The appendages growing thus inwards by introversion (instead of outwards, as is normal) would simply be tucked or pushed into the great blood-sinus, which would constitute around each in-grown appendage a veinous sac just as we actually find in the Scorpion. The most familiar case of inward growth taking the place of outward growth is in the development of the *Tania*-head upon the cyst of the hydatid in such a form as *T. solium*. The head develops in a perfectly normal way, excepting that it is completely introverted, pushed outside in, and at a certain stage it becomes everted, as it should have been from the first, had it retained in growth its ancestral relations. The cause of the introverted growth of the *Tania*-head on its cyst is very probably external pressure; in fact the growing mass of tissue takes the direction of least resistance, and grows *into* the cyst instead of *out from* it. It is not at all improbable that such a condition of external pressure might in the first instance have induced the inward growth, during development, of the lung-books of the Scorpion. The development of the young Scorpion goes on at the present day under very remarkable conditions, actually in the ovary, the egg-cell never moving from its place of origin until it has grown into the fully-formed Scorpion; the pressure of the ovarian tunic upon the surface of the growing embryo must be considerable, and is at any rate a possible cause of the invagination of the four hindmost pairs of mesosomatic appendages in the first instance. Probably the lamelligerous appendages of the young Scorpions, of a certain stage in the ancestry of recent Scorpions, were everted and assumed the normal relations of appendages as external processes of the body-wall as soon as the young were born. But as the lamelligerous appendages were only required to act as aerial respiratory organs, it would be no disadvantage, but positively an advantage, that they should *remain* in the introverted condition; and this at last has become the permanent condition. This hypothesis accounts for the fact that the four pairs of lung-books do not ever appear on the surface of the embryo Scorpion as up-standing appendages. They are from the first introverted, and remain so. It also agrees with the disposition of the cuticularized surfaces of the Scorpion's lung-book as seen in the adult. The cuticularized surface remains in the in-pushed as it is in the out-growing appendage, the surface in contact with the air. Each bag-like lamella is introverted together with the axis of the limb; and one cannot better picture to oneself the relative conditions of out-growth and in-growth than by fixing a kid glove by the margin of its opening to the margin of an opening of the same size on the outside of a box. The coloured surface of the kid will represent the cuticle, the fingers the lamella, the hand the axis. Thus the glove will represent a lamelligerous appendage, standing up on the ventral surface of an Arthropod, its cavity communi-
cating with the cavity of the venous sinus of the animal, as the cavity of the glove does with that of the box.

Now, without removing the glove, push all the fingers from their tips inwards into the hand, and then the hand into the box, so as completely to turn the glove outside in. Thus the glove will represent the appendage when introverted into the venous sinus as in the modern Scorpions.

The tips of some of the introverted lamellae of the Scorpion's gill-book have acquired laterally, but not in every part, an attachment to the wall of the venous sac into which they have pushed their way. These attachments and the relation of blood-space, air-space, and cuticle in the lung-lamellae of Scorpions are shown in the transverse sections drawn in Pl. LXXXI. figs. 3 & 4.

**New or non-hereditary Muscles of Limulus.**

The muscles which, if we admit the legitimacy of the hypothesis of de novo formation of muscles, must be regarded in the case of Limulus as having come into existence subsequently to the divergence of that animal and the Scorpion from a common ancestry, and by a process of tissue-change, not by a modification of already existing muscle, are the following, viz. the whole series of dorso-ventral muscles which run obliquely from the dorsum of one segment to the sternum of another. Such are the great dorsal entapophysial-plastral (1), and its branches (83, 84, 85, 86, 87), also the ventral entapophysis plastral (2) and its slips (103 to 106); further the dorso-lateral plastro-entapophysials (53), the metaplastro-entapophysials (56), the entapophysio-metaplastrals (72); the oblique slips (74, 75, 76, 77); the ventral entapophysiopygals (9), and the whole series of branchio-thoracic muscles (18, 19).

In Scorpions it does not appear that it is necessary to assume a new origin for muscles on a similarly large scale. The muscles just noted in Limulus all have relation to the peculiar consolidation of the mesosomatic region and the combination of natatory with branchial functions in the appendages of that region of the body. In the Scorpion, on the other hand, it is the limbs of the prosoma which have become especially developed and modified as compared with the archaic plan. In Limulus the limb-muscles of the prosoma do not require the hypothesis of any new formations; they can be derived by a process of subdivision from an original hypothetical series of limb-muscles, each limb having the muscles which move its coxal segment attached to the adjacent area, either of tergum or entochondrite (plastron), which undoubtedly represents the original segment to which the particular limb belongs. Not so, however, in the Scorpion, where the muscles attached to the coxae of the prosomatic limbs are of great size and displaced to such an extent that it cannot be with any confidence asserted that each coxa has attached to it merely the modified representatives of the same series of muscles which we find repeated in each successive coxa of Limulus. The disentanglement of these muscles and their reference to the two categories of (a) primary and (b)
secondary (or newly originated) muscles, would furnish ample field for speculation and ingenuity. An important difference between the musculature of the coxo-sternal joint of the prosomatic limbs of *Limulus* and *Scorpio* is to be found in the fact that in *Scorpio*, as shown by Miss Beck, we have muscles arising from the prosomatic tergite, and inserted into the deutomerites of some of the limbs (106, 107, 108), and others arising from the ventral entosclerites also inserted into the deutomerites of limbs (100, 101, 102, 103), whereas in *Limulus* no deutomerite appears to receive any muscle from the body-wall, such muscles being confined to the protomerite (coxa).

*Muscles arising from the Plastron or Prosomatic Entochondrite in Limulus and Scorpio.*—When we exclude the obliquely-running antero-posterior muscles, which pass from the tergum of the mesosomal carapace of *Limulus* to the prosomatic plastron, namely, the great dorso-entapophysial (1) and its branches 83, 84, 85, 86, 87, those from the great entapophyses (originally part of the mesosoma) 53 and 54, and from the two following entapophyses 56, 72 (Pl. LXXV.), we find that the muscles attached to this body in both *Limulus* and *Scorpio* are practically the typical muscles of the ventral surface of the prosoma, and are strictly comparable in the two animals. At either end we find longitudinal ventral muscles (anteriorly in *Scorpio* only) connected with similar entochondrites in the following segments: dorsally are representatives of the dorso-ventral segmental muscles proper to the prosoma; and laterally muscles attached to the coxe of the prosomatic limbs. There are three pairs of vertical tergoplastral muscles in the *Scorpio* (63, 64, 65), and these correspond to the muscle 52 of *Limulus* (Pl. LXXV.), and have no other representative, their place being taken by oblique muscles, whose tergal attachment is in the mesosoma. Possibly, however, the muscle 64 of the *Scorpio* (Pl. LXXVIII. figs. 6 & 7) may be considered as the equivalent of the muscles 53 and 54 of *Limulus*, in which case we should have to suppose that in the *Scorpio*, as well as in *Limulus*, the fusion of a piece of the first mesosomal tergite with the prosomatic carapace had taken place. There seems to be no representative in the *Scorpio* of the anterior vertical tergoplastral muscles of *Limulus*, 49, 50, 51 (Pl. LXXV.), and in fact the most anterior region of the plastron in the *Scorpio*, as has been before pointed out, appears to stop short of the anterior region of the prosoma, whereas in *Limulus* it reaches anteriorly to the full limit of the ventral surface.

When we compare the muscles passing from the plastron to the limbs in *Limulus* and *Scorpio*, we find again reason to suppose that the plastron of the latter does not comprise the ventral surface of the first prosomatic segment, although it does do so in *Limulus*. In fact, we have no muscles from the plastron to the first pair of limbs in *Scorpio*, whilst in *Limulus* we have two such muscles, viz. Nos. 30 and 31. In place of these, in *Scorpio* we have muscles which arise from the preoral entosclerite (96, 97, 98). Contrariwise there are no muscles of ventral origin in *Limulus* which are inserted into
the first pair of prosomatic limbs, except those above mentioned as arising from the plastron (30 & 31).

In the case of the following five pairs of appendages, the muscles attached to them and to the plastron may be exhibited for comparison in a tabular form in the two animals; in the series referring to Limulus all are attached to some part of the large coxa; in the series referring to Scorpio—cox. signifies coxal insertion, deut. insertion into the deutomerite, and arthr. insertion into the arthrodiad membrane between the adjacent coxae or the coxa and sternal sclerite.

<table>
<thead>
<tr>
<th>Limulus.</th>
<th>Scorpio.</th>
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<tbody>
<tr>
<td>I. 30 and 31</td>
<td>none.</td>
</tr>
<tr>
<td>II. 32, 33, 34</td>
<td>72 (cox.), 75 (cox.), 76 (cox.).</td>
</tr>
<tr>
<td>III. 35, 36, 37</td>
<td>73 (deut.), 74 (cox.).</td>
</tr>
<tr>
<td>IV. 38, 39, 40</td>
<td>77 (deut.), 78 (cox.), 79 (arthr.).</td>
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<tr>
<td>V. 41, 42, 43</td>
<td>80 (deut.), 81 (arthr.).</td>
</tr>
<tr>
<td>VI. 44, 45, 46, 47</td>
<td>82 (deut.), 83 (arthr.), 86 a (arthr.).</td>
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In carrying out the comparison of the muscular relations of the plastron in Scorpio and Limulus, it is necessary, in the next place, to point out that in Scorpio, a muscle (85) passes from the hinder border of the body of the plastron into the genital operculum. No such muscle occurs in Limulus. But a similar muscle (the first of the series numbered 48 in Mr. Benham's description) passes from the second entochondrite of Limulus, or entochondrite of the genital segment, into the genital operculum. Now, in Scorpio there is no separate entochondrite in the genital segment, although there is a separate entochondrite in the next following (the pectinigerous segment) corresponding to the second mesosomatic entochondrite of Limulus; and this entochondrite of the second mesosomatic segment in Scorpio gives origin to muscles which descend into the pecten (90, 91, 92), and correspond to the muscle 48 in the second mesosomatic segment of Limulus as described by Mr. Benham. Hence it seems extremely probable that the difference between Limulus and Scorpio as to the muscle and entochondrite of the genital segment is to be accounted for by the fact that in Scorpio the entochondrite of that (the first mesosomatic) segment has fused with the great prosomatic entochondrite or plastron. This is in accordance with other indications of a tendency to draw up structures to the prosoma, noticeable in the Scorpion, e. g. nerves. Accordingly the muscle 85 of Scorpio (the operculo-plastral) is the equivalent of the internal branchial (48) of the genital segment of Limulus.

The longitudinal muscles attached to the plastron in Limulus and Scorpio belong necessarily (when we exclude the adventitious or secondary muscles descending obliquely to it from the tergites of a posterior region) to the typical ventral series. They may be compared as follows:—
Limulus.

a. Plastro-buccal, 67

Scorpio.

Absent: but represented by muscles attached to the preoral entosclerite, 99.

Part of no. 5?

b. Muscle from subneural part of plastron to entochondrite of 2nd mesosomatic segment, 86.

That part of muscle no. 5 between the 1st and 2nd mesosomatic entochondrites

c. Muscle from supraneural part of plastron to same entochondrite.

When thus examined in detail a very close correspondence is found between the muscles arising from the plastra of the two animals. Perhaps the most important conclusion to which we are led by the comparison is that the cartilaginous body known as entosternite, entochondrite, or plastron in Scorpio represents the sternal surface of one segment less in front, and of one more behind than does that of Limulus. In Scorpion it corresponds to segments 2 to 7 inclusive; in Limulus it corresponds to segments 1 to 6 only.

There are, no doubt, other relations in which the anatomical facts set forth in the systematic descriptions and figures of Mr. Benham and Miss Beck might be considered, so as to give them significance. But for the present I must leave this task, and rely upon others to make use of some of the many data given in these descriptions.

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Part V. Notes on Certain Points in the Anatomy and Generic Characters of Scorpions. 
By E. Ray Lankester. (Plates LXXX. to LXXXIII.)

a. The Venous System.

When I first observed the pericardo-ventral (or veno-pericardiac) muscles of the Scorpions, as shown in Pl. LXXX. fig. 15, \( pp^1 \), \( pp^2 \), &c., and Pl. LXXVII. figs. 1, 4, & 5; also in Pl. LXXVIII. figs. 8 & 9, I discovered that they are to a large extent hollow, being excavated funnel-wise both at their pericardial attachment and at their insertion into the wall of the venous sac-like dilatation which surrounds the sunken lung-book (see the sections, Pl. LXXIX. fig. 10, and Pl. LXXXI. fig. 2, \( ppm \)). I was led to think it possible that these hollow muscles formed a direct channel of communication between the pulmonary venous sacs and the pericardium, the blood being returned through them to the heart in an aerated condition. Although similar muscles exist in Limulus, the channel which the blood pursues on its way from the gills to the heart is quite independent of them, and in Limulus they are solid. This led me to attempt, by
means of injections, an exploration of the great veins of the Scorpions. My observations were made upon freshly-killed specimens of *Androctonus funestus*, which I obtained from North Africa for the purpose. I used as injecting material sometimes soluble Berlin blue, sometimes a mixture of wax, tallow, and turpentine coloured by vermillion. By introducing the injection at various points, especially into the venous sacs surrounding the lungs (by means of a very fine nozzle) I satisfied myself that there is no passage through the pericardio-ventral muscles to the pericardium. The chief veins leading from these dilatations of the ventral blood-sinus to the heart run up the sides of the body quite superficially, lying outside the longitudinal dorsal muscles between these and the integument. They enter the pericardium at its dorso-lateral angles right and left (Pl. LXXXI. figs. 1 & 2, *svsl*). Deeper than the longitudinal dorsal muscles is a second series of veins parallel to the first; but these do not open into the pericardium.

In a pale-coloured *Androctonus*, the position of the main venous trunks may be seen by transparency when they are injected either from the pericardium or from one of the circumpulmonary sinuses. Views of a specimen thus injected are given in Pl. LXXX. figs. 1, 2, 3. On the ventral surface (fig. 3), the injection shows at intervals near the mid-line, and the edge of the circumpulmonary sinuses are also seen. Internally it is found, on dissection, that the injection, besides occupying numerous large flattened spaces between the lobes of the gastric glands and the genital organs, is chiefly aggregated in two deep-lying latero-ventral longitudinal trunks which dilate around and enclose each in-pushed lung-book. Although the pericardium also is found to be full of the injection and the hollow pericardio-ventral muscles are half-filled (on their pulmonary side) with injection, yet no injection is found to have penetrated along the whole length of these muscles so as to reach through to the pericardium.

On the contrary, the veins connecting the pericardium and ventral longitudinal sinuses are seen when a lateral view of the specimen is taken (fig. 2) to be injected. Here we find a large vein (*svsl*) branching in the prosomatic carapace, returning some blood from the coxal glands and the limbs. In the first and second mesosomatic segments small veins (*svsl*¹, *svsl*²) are seen bringing the blood from the genital and pectinigerous segments to the pericardium. In the third, fourth, fifth, and sixth mesosomatic segments these lateral veins are much larger and extend directly from the circumpulmonary venous sacs to the pericardium. They appear also to have wide anastomotic trunks running longitudinally between them. In the first metasomatic segment, the lateral veins have a strongly marked posterior direction, and do not reach the ventral surface.

The arterial system of Scorpions (probably of *Androctonus*) was carefully described by Newport; but he was not able to give a decisive account of either the capillary or venous system, on account of the fact that his specimens were not living, but badly preserved in spirits.

In Pl. LXXX. fig. 15, I have drawn a view from the inside of an actual dissection displaying the tergum and large vessels, pericardium and muscles of *Androctonus*
occitanus (the Spanish Yellow Scorpion). It shows excellently the lateral arteries and the whole series of pericardio-ventral muscles. The blood is pumped by the contractile heart lying within the pericardium (Pl. LXXXI. figs. 1 & 2) into these lateral arteries, also into anterior and posterior arteries. The anterior arteries especially accompany the great nerves, and one main trunk is completely reflected ventrally and accompanies the nerve-cords throughout the length of the animal, giving off lateral branches (Pl. LXXXI. figs. 1 & 2). 

The arteries thus arising branch very abundantly and supply directly every organ, even every muscle, in the body. The finest branches of these arteries are entitled to be termed capillaries. I have described them and the similar vessels in Limulus, in my article on the skeleto-trophic tissues of these animals, in the Quart. Journ. Micr. Sci. for January 1884.

The capillaries of the Scorpion (and the same is true for other large Arthropoda, such as the Crayfish) do not reunite, as in Vertebrates, to form a tree of branches which gradually increase in bulk, but they open into more or less irregular spaces, often large and shallow, which surround the chief organs. These may be called, as is the custom, sinuses or lacunae; but they are truly veins with their own proper walls, though of non-cylindrical form in cross-section. In the region of the prosoma and mesosoma these spaces open into the two large longitudinal ventral veins which have the lung-sacs sunk into them at intervals in the 3rd, 4th, 5th, and 6th mesosomatic segments. A large part of the blood arriving in these great ventral sinuses or veins will come in contact with the delicate lamellae of the lung-books, and finding its way between the lamellae, as shown in Pl. LXXXI. figs. 3 & 4, it will be subject to gas-exchange. From these longitudinal ventral trunks the blood then passes in a partially oxygenated condition by the superficial lateral veins (sesl, Pl. LXXX. figs. 1, 2, 3) into the pericardium, from whence it is taken by the expanding heart (expanding by the elasticity of its walls after contraction) through its seven pairs of valvular apertures (ve, Pl. LXXX. fig. 1, where only five pairs are seen, and ve, in Pl. LXXXI. fig. 2) into its cavity and again sent on its round. The main force at work in drawing the blood from the circumpulmonary sinuses of the longitudinal ventral veins into the pericardium, is clearly enough (as in other Arthropods) the same contraction of the heart which expels the blood through the arteries. The contraction of the heart creates a diminution of the tension in the pericardium. But there can be no doubt that both in Limulus and in Scorpio the pericardio-ventral (veno-pericardiac) muscles exercise an important influence in drawing the blood from the general venous space-system surrounding the viscera into the circumpulmonary sinuses. These muscles probably contract simultaneously with the contraction of the heart, and thus, while tending to keep the pericardium distended, also distend the circumpulmonary sinuses, and cause a rush of blood into those chambers. Valvular arrangements (which, however, I cannot say I have detected) would prevent the distending circumpulmonary
sinuses from drawing upon the blood which has already entered the lateral pericardio-pulmonary veins.

It is not at all improbable that the movements of the body-wall (terga and sterna) in *Scorpio* and of the plastron (prosomatic entochondrite) in *Limulus*, and, perhaps, also in *Scorpio*, exert a considerable influence upon the flow of the blood.

b. *Generic and Subgeneric Characters of Scorpions.*

The numerous species of Scorpions which occur in all parts of the world, excepting the Arctic and Antarctic regions, and as far back in time as the Upper Silurian strata, present a most marvellous uniformity of structure, so that the attempt to divide them into families, genera, and subgenera has been a matter of great difficulty, and has led to very perplexing and contradictory results in the hands of successive systematists. The late Professor Peters appears to me to have indicated the most important divisions which may be instituted among Scorpions on structural grounds. Dr. Thorell has carried the formation of genera and subgenera too far, whilst the older system of Koch is entirely artificial and worthless. No writer on Scorpions has given consistently a clear statement or (what is more to be desired) good figures of the really important structural features of the genera, subgenera, and species proposed or recognized by him; and it is with the object of pointing out what are the important points in which Scorpions may vary that the present remarks are published. It is impossible to deal with the genera of Ehrenberg and Leach. Starting with Koch, we find that he bases his system on the number and disposition of the lateral eyes, as follows:

\[
\begin{align*}
\text{Scorpius} & \quad \text{O} \\
\text{Buthus} & \quad \text{O} \\
\text{Atreus} & \quad \text{O} \\
\text{Brotheas} & \quad \text{O} \\
\text{Telegonus} & \quad \text{O} \\
\text{Sisyphus} & \quad \text{O} \\
\text{Tityus} & \quad \text{O} \\
\text{Androctonus} & \quad \text{O}
\end{align*}
\]
The system is an absolute failure. The number and size of the lateral eyes is not even constant in the same individual (the two sides differing sometimes); much less is it so in species and still less in genera. The only generalization which can be made about the lateral eyes, is that in the Scorpions with triangular sternum, they are usually more numerous than in those with pentagonal sternum; but not even in reference to such large sections can a strictly accurate statement of the kind be made.

Peters made a great advance in recognizing the form of the sternum (or metasternite, the equivalent of the chilaria of Limulus) as a basis for a primary division of the Scorpions. He combined with the consideration of this character a reference to the dentition of the chelicera; and thus was led to establish four groups or subfamilies of the family Scorpionidae (the Linnean genus Scorpio), viz.:—

Group I. Telegonini.

Sternum linear; two or three lateral eyes; both the fixed and the movable joint of the chelicera have a single row of teeth.

Genera:—Telegonus, Koch; Cercophonius, Peters; Acanthochirus, Peters; Bothriurus, Peters.

Group II. Scorpionini.

Sternum quadrate or pentagonal; both the fixed and the movable joint of the chelicera have a single row of teeth.

Genera:—Vejovis, Koch; Brotheas, Koch; Scorpio, Linne in part (=Scorpius, Ehr.); Scorpiops, Peters; Urodacus, Peters; Hemiscorpion, Peters; Ischnurus (Sisyphus, Koch), Gervais; Opisthacanthus, Peters; Dacurus, Peters; Opisthophthalmus (Atreus), Koch; Heterometrus, Ehr. (=Buthus in part, Ehr., not Leach); Diplocentrus, Peters.

Group III. Centrurini.

Sternum triangular; movable ramus of chelicera with two rows of teeth, the fixed ramus with one row. Hands of the chelae spindle-shaped. Often a spine beneath the sting.

Genera:—Centrurus, Ehr. (not Koch, =Tityus of Koch, Atreus of Gervais, not Koch); Uroplectes, Peters.

Group IV. Androctonini.

Sternum triangular; both rami of the chelicera with two rows of teeth. No spine beneath the sting.

Genera:—Prionurus, Ehr.; Buthus, Leach.
The genera adopted by Peters appear to me to be, in most cases, unnecessary, often not even justifiable as subgenera. He has at the same time rendered great service by pointing out the confusions which have arisen in the use of the generic terms of one author by another, in new and unjustifiable senses.

Thorell has added a number of genera to the already superfluous list, and has modified Peters's classification in what appears to me to be a retrograde spirit. He recognizes four families of Scorpions, viz.:—(1) the Androctonidae, corresponding to Peters's Androctonini and Centrurini combined; (2) the Telegonidae, identical with Peters's Telegonini; (3) the Veroideae; and (4) the Pandinoidea, the last two resulting from the breaking up of Peters's Scorpionini on no assigned grounds.

Both Peters and Thorell make use of the presence or absence of a keel on the 6th metasomatic segment as a means of generic distinction, and of other characters even more trivial. The small value of such characters is shown by the fact that the common American Scorpion, the *Scorpio americanus* of De Geer, is sometimes provided with a spine below the sting, and sometimes has none.

In order to appreciate more clearly Peters's four groups of Scorpions, we may refer to four types which are figured in the Plates accompanying this memoir, viz. for the Telegonini the *Telegonus* of Tasmania, Pl. LXXXII. figs. 5, 6, and Pl. LXXXIII. figs. 5, 6; for the Scorpionini the *Scorpio cyaneus* and *S. Kochi* of Ceylon, Pl. LXXXII. figs. 1, 10, 19, and Pl. LXXXIII. figs. 9, 10; for the Centrurini the *Androctonus americanus*, Pl. LXXXII. figs. 6, 13, 17, and Pl. LXXXIII. figs. 3, 4; for the Androctonini the *Androctonus funestus* of North Africa, Pl. LXXXII. figs. 2, 14, 15, and Pl. LXXXIII. figs. 1, 2.

My observations, which relate not only to the characters made use of by Peters, but also to two points of internal structure, viz. (a) the disposition of the segmental ganglia and their great nerves and (b) the sculpturing of the lamellae of the lung-books, have led me to the conclusion that the existing species of Scorpions should be grouped in two and not in four primary divisions; the first group, or Scorpionini, corresponding to Peters's Telegonini and Scorpionini combined, whilst the second group, the Androctonini, correspond to his Centrurini and Androctonini combined.

It appears that the linear compressed sternum of the Telegonini may be regarded as only an extreme type of the broad pentagonal sternum of the Scorpionini. In both series there is but a single row of teeth in each ramus of the cheliceræ, except a single tooth of a second row on the movable ramus in some species of *Telegonus* (Pl. LXXXIII. fig. 7). But what is of far more importance is that in both Telegonini and Scorpionini the ganglia of the nerve-cord and their off-springing nerves are arranged as shown in the woodcut, fig. 2, B, whereas in the Scorpions of Peters's groups Centrurini and Androctonini these structures have the arrangement shown in drawing, fig. 2, A, C, D (p. 378). This difference may be described by saying that in the Scorpionini (incl. Telegonini) only the region of the first pair of lung-books is innervated from the
prosomatic ganglion, and the first of the two mesosomatic ganglia lies in the third mesosomatic segment, whilst in the Androctonini (incl. Centrurini) both the regions of the first and of the second pairs of lung-books are innervated from the prosomatic ganglion, and the first mesosomatic ganglion lies in the fourth mesosomatic segment. The broad first segment of the metasoma has a ganglion in both cases.

Fig. 2.

Diagrams of the arrangement of the chief nerves and ganglia in various Scorpions.

A. *Androctonus (Prionurus) funestus* and several Androctonidae.
B. *Buthus cyanus* and Euscorpionidae and Telegonidae.
C. First specimen of *Androctonus (Prionurus) occitanus*.
D. Second specimen of *A. occitanus*.

1-6, the six segments of the prosoma. 7-12, the six segments of the mesosoma. 13, 14, the two first segments of the metasoma. P₁ to P₄, the four pairs of lung-books.

This generalization is based on the examination of the nerve-ganglia of two species of Telegonini (one from Coquimbo, the other from Tasmania) of *Scorpio italicus, Scorpio cyanus*, and *Brotheas subnitens* on the one hand, and of those of *Androctonus funestus, A. occitanus, A. americanus*, and *A. hottentotus* on the other hand.

An examination of the sculpturing of the chitinous surface of the lamellae of the lung-books in the same species has shown further that all the Scorpionini (incl. Telegonini) have simple punctate ornament, whilst all the Androctonini (incl. Centrurini) have reticulate ornament in addition to punctiform. The latter is drawn in Pl. LXXXI. figs. 5 and 6, the former in Pl. LXXXI. fig. 7.
I should therefore propose to systematize the Scorpions as follows:—

Class ARACHNIDA.

Grade A. Delobranchia (Limulus and Enypterines).
Grade B. Embolobranchia.

Order 1. SCORPIONIDEA.
Order 2. PEDIPALPI.
Order 3. ARANEIDEA.

Order SCORPIONIDEA.

Fam. unic. SCORPIONIDÆ.

Subfamily I. SCORPIONIINI.

Sternum (metasternite) pentagonal, quadrate, or compressed antero-posteriorly, and divided into two narrow triangular pieces, right and left. (=chilaria of Limulus).

Nerves to the region of the first pair of lung-books descending from the prosomatic ganglion-mass. Nerves to the region of the second pair of lung-books supplied by a ganglion lying in the third segment of the mesosoma.

Ornament of the lamellae of the lung-books punctiform.

A single row of teeth to each ramus of the chelicera; rarely one tooth of a second row on the movable ramus.

Genus 1. Scorpio.

Char. Sternum pentagonal or quadrate.

Subgenus Euscorpius.

Char. Lamellæ of the pectens very few; lateral eyes two; spiracles oval; tail slender.
Type Euscorpius italicus: South Europe. (Pl. LXXXII. fig. 3.)

Subgenus Buthus (=Heterometrus, Ehr.).

Char. Lamellæ of the pectens more numerous; lateral eyes three; spiracles slit-like; tail slender.
Type Buthus cyaneus of Ceylon. (Pl. LXXXII. fig. 1.)

Subgenus Brotheas.

Char. Lamellæ of the pectens few; lateral eyes two or three; spiracles circular; tail thick.
Type Brotheas subniten; Peru. (Pl. LXXX. figs. 2, 4, 5, 7, 8, 9, 10, 11, 12.)

[I should expect to find the characters of the genera Hemiscorpius and Opisthophthalmus of sufficient importance to entitle them to subgeneric recognition.]
Genus 2. *Telegonus*.

Sternum compressed antero-posteriorly, and thus more or less completely divided into laterally expanding narrow lobes or bands.

Subgenera ? (Pl. LXXXII. figs. 4, 5.)

Subfamily II. *Androctonini*.

Sternum (metasternite) triangular.

Nerves to the regions of both the first and second pair of lung-books descending from the prosomatic ganglion-mass. The first detached ganglion of the mesosoma lies in its fourth segment, and supplies nerves to the following segment.

Ornament of the lamellae of the lung-books reticulate as well as punctiform.

A double row of teeth to either both rami of the chelicerae or to the movable ramus only.

*Genus unicum. Androctonus.*

Char. of the subfamily.

Subgenus *Prionurus*.

**Char.** Two rows of teeth to each ramus of the chelicerae; tail very thick; hand rather slender (compared with *Scorpio*).

Types: *Prionurus funestus*, Ehr.: North Africa. (Pl. LXXXII. fig. 2)

*Prionurus occitanus*; the yellow Spanish Scorpion.

Subgenus *Centrurus*.

**Char.** Two rows of teeth to the movable ramus only of the chelicera; a single tooth of a second row present in the fixed ramus sometimes; tail very long and slender, sometimes with a spine below the sting; hand very slender.

Types: *Centrurus americanus*, De Geer. (Pl. LXXXII. figs. 6, 13, 17.)

*Centrurus hottentotus*: South Africa. (Pl. LXXXII. figs. 7, 11, 18.)

The facts of geographical distribution, so far as they are known, give some importance to the divisions thus recognized. The Scorpions of the Palaearctic and Indian regions are essentially those of the genus *Scorpio*. In the Ethiopian region we have both the genera *Scorpio* and *Androctonus*, the latter making its way into Spain, and to some extent into the Indian region.

In America we have both *Scorpio* and *Androctonus*.

The species of the genus *Telegonus* appear to be confined to South America and Tasmania.

I confess to not being at present in a position to offer an opinion upon the questions of species and subgenera in very many cases. It is necessary that all the described forms
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should be re-examined, and the really important characters noted and properly drawn. The descriptions and in many cases the figures of authors who have written on Scorpions are, generally speaking, not very intelligible.

The points which it seems desirable to note in all cases and to record by enlarged drawings are as follows. I take them in what appears to me to be the order of their importance:

I. Form of the sternum, i.e. of the dark-coloured chitinized cuticle called met sternite. (Pl. LXXXII. figs. 1 to 7, a.)

II. Arrangement of the nerve-ganglia and innervation of the lung-books. (Woodcut, fig. 2.)

III. Ornament of the lamellæ of the lung-books. (Pl. LXXXI. figs. 5, 6, 7.)

IV. Shape of the spiracula. (This, like the two preceding characters, is one which has not before been made use of. In Brotheas subnitens (Pl. LXXX. figs. 9 and 10) the spiracle is circular, a form which has not been previously noticed in Scorpions.)

V. Dentition of the chelicerae in one or two rows. This is more variable than Peters seems to have thought. The sharply-cutting denticles of these organs in the Tasmanian Telegonus and in Brotheas subnitens (comp. figs. 7, 8, Pl. LXXXIII., and figs. 11, 12, Pl. LXXX.) are alike, and differ from the blunter teeth of most other forms here figured.

VI. Dentition of the chela. (Pl. LXXXIII. figs. 21, 22, 23, 24.)

The Scorpionini exhibit fine tubercles, which are disposed mainly in a line parallel with the long axis of each ramus; the Androctonini have the straight-line arrangement replaced by a series of short curves.

VII. Chitinization of the genital operculum, whether in two quite separate plates, as in Brotheas (Pl. LXXX. fig. 5), or in one imperfectly divided plate.

VIII. Proportion of the hand, whether slender, as in Androctonini, or broad, as in Scorpionini.

IX. Proportions of the whole tail compared to body, both as to length and breadth.

X. Number of lamellæ and secondary basal teeth on the pectens.

XI. Position of the central eyes.

XII. Number and position of the lateral eyes.

XIII. Keeling or smoothness of the joints of the tail.

XIV. Proportionate length of the segment preceding the sting.

XV. Presence of a spine beneath the sting.
EXPLANATION OF PLATES LXXX.-LXXXIII.

PLATE LXXX.

Figs. 1, 2, 3. Dorsal, lateral, and ventral view of the prosoma and mesosoma of an *Androctonus funestus*, in which the venous system has been injected, and is seen showing through the transparent cuticle.

_Scs_, sinus cephalicus superior; _svesl_, sinus lateralis superficialis of the prosoma; _svesl1_, sinus lateralis superficialis of the genital (first mesosomatic) segment; _svesl2–svesl6_, ditto of the second to the sixth mesosomatic segments.

In fig. 2 it is seen that the circumpulmonary sinus is placed in continuity with the vein or sinus _svesl3, svesl4, svesl5_, and _svesl6_, in each of the lung-bearing segments.

Fig. 4. Prosomatic carapace of *Brotheas subnitens*, Gervais: enlarged four diameters.

Fig. 5. Enlarged view of the sternal and pectinal region of *Brotheas subnitens*.

_a_, the pentagonal metasternite; _b_, _b_, the two totally separate sclerites of the genital operculum; _c_, median fold; _d_, sternal sclerite of the pectinigerous segment; _e_, pecten.

Fig. 7. Dorsal view of *Brotheas subnitens*, Gervais: magnified twice linear. From a specimen collected by F. Whymper, Esq., in Peru.

Fig. 8. Ventral view of the same specimen.

Fig. 9. Enlarged view of the circular spiracle of *Brotheas subnitens*.

Fig. 10. Toothing of the chela (hand) of *Brotheas subnitens*.

Fig. 11. Toothing of the chelicera of *Brotheas subnitens*; the left-hand figure is the movable ramus.

Fig. 12. View of the rami of the chelicera of *Brotheas subnitens*, to show the cutting-edge as seen from above.

Figs. 13, 14. Plastron or prosomatic entochondrite of *Scorpio (Buthus) cyaneus*, showing the attachment of the muscles. Fig. 13. Dorsal surface. Fig. 14. Ventral surface.

_A.C._, arterial canal; _G.C._, gastric canal; _n.c._, neural canal—only that part of the whole structure in front of _G.C._ and above _n.c._ corresponds to the plastron of *Limulus*; _pf_, posterior flap (unrepresented in *Limulus*); _pp_, posterior process; _lmp_, latero-median process; _ap_, anterior process; _asp_, cornua or anterior tendons of the subneural process; _snp_, the subneural process; _a_, scar of tendinous attachment of the anterior process of the plastron to the horseshoe-shaped “preoral entosclerite,” a chitinous epidermal ingrowth really dorsal in nature, though lying ventrally in front.
of the mouth. For the muscles referred to by numbers, see the list on p. 359.

Fig. 15. View from below of the pericardium, arteries, pericardio-ventral (veno-pericardiac) muscles, and dorso-ventral muscles of *Androctonus occitanus*. Magnified two diameters, and drawn from an actual dissection.

$p^1_p^8$, the series of pericardio-ventral muscles running from the pericardium to the wall of the great ventral vein or sinus of the same side; $ar^1-ar^8$, the lateral arteries of the mesosoma; $dv^1$, the lateral artery of the first metasomatic segment; $dv^1-dv^6$, the six dorso-ventral muscles of the mesosoma; $dv^6$, the dorso-ventral muscle of the first metasomatic segment.

PLATE LXXXI.

Figs. 1 and 2. Transverse sections of the mesosoma of *Scorpio italicus*, to show the venous blood-spaces and the pericardio-ventral muscles. *alax*, axial portion of the alimentary canal; *alc*, glandular ceca of the alimentary canal; *cc*, coagulum within the heart; *cv*, valve and aperture of the heart-wall; *cog*, coagulum in the pericardial blood-space; *cph*, fibrous bands from heart-wall to pericardium (ventral); *cpu*, similar dorsal bands; *cw*, heart-wall; *desl*, deep latero-dorsal vein or blood-sinus; *svsl*, superficial latero-dorsal vein (same as marked $svsl^1-s^8$ in Pl. LXXX. fig. 1); *ge*, genital follicles (testis); *lb*, lamellae of lung-book; *lem*, longitudinal ventral muscle; *lg*, ventral insertion of dorso-ventral muscle; *ldm*, dorsal longitudinal musculature; *n*, nerve-cord; *pvs*, pericardial blood-space; *ppm* (in fig. 2), the pericardio-ventral or pericardio-pulmonary or veno-pericardiac muscles passing from the pericardium to the roof of the circumpulmonary blood-sac; *ps*, the circumpulmonary blood-sac; *spa*, supramedullary artery of Newport.

Figs. 3 and 4. Transverse sections of the lamellae of the lung-books of *Androctonus funestus*, showing the blood-spaces, B, containing blood-corpuscles, *bc*, and traversed by short cell-columns, *cc* (as in *Limulus*), and the air-spaces, A, on the lining of which the cuticle is roughened (ornate).

In fig. 3 the drawing is inverted since the points $yy$ are the free ends of lamellae, which stand upwards into the blood-space, the spaces between these air-holding lamellae being open to the blood-current.

In fig. 4 the section passes through a region where the ends of the air-holding lamellae are fused to the wall of the circumpulmonary blood-sinus and to one another by the tissue $x$.

Fig. 5. Reticular ornament from the air-bathed surface of a lung-lamella of *Androctonus funestus*, near the centre of the lamella.
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Fig. 6. Similar structure combined with punctate ornament from the periphery of the same lamella.

Fig. 7. Simple punctate ornament of the lung-lamellae of Scorpio (Buthus) cyaneus. Seen also in Euscorpius italicus, in Brotheas submitens, and in Telegonus, sp.

PLATE LXXXII.

Figs. 1, 2, 3. Complete ventral surface and limbs of Buthus cyaneus, Prionurus funestus, and Euscorpius italicus.

Fig. 4. Sternal region of Telegonus, sp., from Coquimbo (British Museum).

Fig. 5. Ditto ditto, from Tasmania (British Museum).

Fig. 6. Ditto of the common American and West-Indian Centrurus (C. americanus).

Fig. 7. Ditto of the common African Centrurus (C. hottentotus).

Fig. 8. Lateral eyes of the Tasmanian Telegonus.

Fig. 9. Ditto of Euscorpius italicus.

Fig. 10. Ditto of Buthus cyaneus.

Fig. 11. Ditto of Centrurus hottentotus.

Fig. 12. Ditto of the Telegonus from Coquimbo.

Fig. 13. Ditto of Centrurus americanus.

Fig. 14. Ditto of Prionurus funestus.

Figs. 15–21. Sting and last tail-segment of species of Scorpions as marked on the Plate.

PLATE LXXXIII.

Figs. 1 to 12. Chelicerae: movable (m) and fixed (f) rami being placed side by side, of various species of Scorpions as indicated on the Plate.

a in one ramus indicates the margin which works against a in the other.

Fig. 13. Liver (gastric gland) of Androctonus (Prionurus) funestus. a, anterior division, more branched, sometimes distinguished by the name "salivary gland"; b, compact, slightly fissured, main mass of the gland. Nat. size.

Fig. 14. Liver (gastric gland) of Euscorpius italicus, Roes. Letters as in fig. 13. Magnified five diameters.

Figs. 15–20. Prosomatic tergite of various Scorpions, indicated by name on the Plate.

Figs. 21–24. Toothing of the fixed (f) and movable (m) rami of the chelae of four species of Scorpion.
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* Publications thus marked are out of print.

Continued on page 3 of Wrapper.
XIX. A Monograph of the Odontolabini, a subdivision of the Coleopterous Family Lucanidae. By Franz Leuthner, Ph.D., Member of the Imperial Royal Zoological and Botanical Society of Vienna.\(^1\)

Received and read 18th December 1883.

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Preface.

When I commenced these investigations in the autumn of 1881 nothing was further from my thoughts than the writing of this Monograph. The direction of my studies

\(^1\) Translated from the author's German manuscript by W. F. Kirby, Assistant in the Zoological Department, British Museum.
was originally suggested by a controversy which took place at a meeting of naturalists at Bern in the autumn of 1878, when Prof. Heer maintained the permanency of species in opposition to the views of Brunner von Wattenwyl, Carl Vogt, and others.

Whilst the theory of evolution has taken firm root in the higher schools of science, and is diligently studied and developed by anatomists and morphologists, it is frequently ignored, if not condemned, by systematists; though if all naturalists were to work in the same direction, it would be much to the advantage of science.

I long desired personally to investigate a question of such great interest and importance, and to study variation, the formation of races, &c., with the help of a sufficient amount of material, not derived from domesticated organisms. An unexpected opportunity soon presented itself. Herr Gustav Schneider, a dealer in objects of natural history at Basel, received a large series of a very variable Stag-Beetle from Manilla, the males of which were represented in four very different forms, which could all be connected together by intermediate variations. This insect proved to be *Odontolabis alces*, Fabr., and the various forms had been previously regarded by authors as belonging to three distinct species. On examining the literature, it appeared that since the time of Burmeister much difference of opinion has existed on the subject. Even the nearest allied species from North India stood in the catalogues under incorrect names. I studied the allied species, and found that they confirmed the conclusions at which I had arrived with regard to *O. alces*. As I could not find sufficient material in the Museums of Basel, Geneva, Vienna, &c., I decided to visit London in order to pursue my investigations with the aid of the rich collections which exist there. I had expected much from the English collections, but they far surpassed all my expectations. The collections and library of the British Museum are placed at the disposal of visitors from abroad in the most liberal manner. Materials constantly accumulated from all quarters, and I was specially encouraged to continue my efforts by Mr. H.W. Bates; and gradually brought the present Monograph of Odontolabini to a conclusion. The great variation of form in this group renders the question of species unusually interesting, but at the same time extremely difficult; and this convinced me that no reliable results could be attained without the study of an enormous amount of material, and the formulation of definite laws of variation. I therefore visited the Museum at Paris, and studied Vollenhoven's types at Leyden, and the types in the Hope Collection at Oxford; but my labours were most facilitated by the kindness of Major Parry and of Herr van Lansberge (ex-Governor of the Dutch East Indies), both of whom generously placed their rich collections of Odontolabini entirely at my disposal. The latter collection includes the types of Counts Mniszech and Castelnau, as well as some of those of Messrs. Deyrolle and Parry. I was also fortunate in obtaining rich materials from the private collections of Messrs. Bates, Distant, Forbes, Janson, Meldola, Moore, Newcombe, Pettigrew, Oberthür, and Swierstra. The amount of material thus placed at my disposal was the most extensive which could be brought together for the purpose at the present time.
I have much pleasure in acknowledging my obligations to Dr. Günther, the Keeper of the Zoological Department of the British Museum, and to the Entomologists of the department, Messrs. Butler, Waterhouse, and Kirby, as well as to the gentlemen mentioned in the last paragraph, and to Prof. Westwood in Oxford; Prof. Blanchard, Count Constantine Branicki, and Prof. Waga in Paris; Prof. Valery-Mayet and Prof. Sabatier in Montpellier; Prof. Brauer and Herr Ganglbauer in Vienna; Prof. Carl Vogt and Dr. Frey-Gessner in Geneva; Herren Schneider and Knecht in Basel; Prof. Aurivillius in Stockholm; Herr Ritsema in Leyden; but above all to Major Parry and Herr van Lansberge, without whose assistance the completion of the present treatise would have been impossible.

PART I.

Introductory Remarks.

Scientific observations in natural history imperatively require exactitude in observation, accuracy in discrimination, and precision in description. The industry of describers has made us acquainted with an innumerable multitude of forms of both animals and plants, and has placed an enormous mass of material at our disposal.

But the anxiety to give names to everything has saddled science with a burden of synonymy, partly due to authors being unaware of what had previously been published, but partly, it is to be feared, to less excusable causes, such as vanity, and the desire to write “mihi” after as many species as possible.

But the accuracy of subdivision depends on the acumen of the describer, and is also influenced by his desire to subdivide and rename, so that variable species are constantly broken up into so-called new ones. As a terrible example of this tendency, I may quote the case of a French botanist who has divided a very common plant, Draba verna, Linn., into no fewer than sixty-five new species! This shows us that a keen observer can detect many phantom species by examining a large series of any variable form, however common, although other species vary very little or not at all; and some have maintained their characters with unusual constancy for thousands of years, like the celebrated Taxodium distichum, which, as Heer states, is unvariable and has remained unaltered from the Miocene period to the present day. But such cases are rare, and a careful examination will generally detect larger or smaller differences between different specimens of known species. The tendency to variation has become sufficiently familiar to naturalists since the publication of the classical works of Darwin. Almost every large genus contains at least one species which may justly deserve the specific name of “variabilis.” Such forms, as Haeckel ironically but truly observes, are always a nuisance to monographers, as the notion of a species becomes greatly discredited by

them. However, they are most interesting to those observers who do not confine themselves to mere names, as they furnish a clue to the mystery of the Origin of Species. What do they teach us? How far are they connected, and why should they be distinguished from closely allied forms? These and similar inquiries force themselves upon the attention, and can only be answered by the examination of as large a series of specimens as possible, in order that every variation from a type may be noted, and the transitions between one form and another investigated. By this method we are often enabled to connect incredibly different forms by an unbroken series of intermediate links, while morphologists may succeed in unravelling the secrets of the origin of markings, alterations of colour, form, sculpture, &c., though frequently not without great labour and difficulty.

Several zoologists have already begun to classify and arrange their collections according to this method. My highly esteemed friend and instructor in entomology, Brunner von Wattenwyl, has been engaged for many years in the formation of a collection of Orthoptera which is unique of its kind. He has collected together as large a series as possible of different species, in different stages, and from various localities, in order to acquaint himself with their geographical distribution, as well as with the influence of climate upon them. This enables a student to perceive at a glance the various disguises assumed by a species under changed conditions of climate &c., as well as many points which would otherwise elude the observation of even the most careful investigator. Naturalists will at once perceive the great scientific importance of a collection formed on such a system.

(1) Variability of the Lucanidæ in general, with special reference to the Odontolabini.

There is perhaps no group of insects which vary to so great an extent as the Lamellicornia, and more especially the Lucanidæ. The variations within the limits of a single species are often so great that a small male is structurally different from a large male. It is therefore not surprising that differently formed males of the same species were described as distinct by the older authors. Later and more accurate observers discovered this, and Burmeister showed that a completely unbroken series often exists between the largest and smallest males, the latter of which are remarkably similar to the females. Darwin employed this discovery in a very skilful manner to elucidate his theory of Natural Selection. Since then these series have become extremely interesting, and any one who wishes to study the most remarkable variations which may occur in one and the same species, with the object of discovering the laws by which nature has modified individuals, should select the plastic group of the Lucanoid Coleoptera for his investigations. But he will soon begin to despair of arriving at definite systematic results, in this chaos of uncertain forms, in spite of the enormous amount of material which we now possess, but which, notwithstanding, is wholly insufficient for such an investigation. I myself worked for several months at

a single species (*O. alces*). Taking this as a starting-point, I studied the species which stand nearest to it morphologically, and thus gradually enlarged my horizon, until I was at length enabled to examine the whole amount of material contained in the principal European collections. I thus examined nearly 10,000 specimens of Lucanidae, and about 1000 specimens of Passalidae (a group which was formerly erroneously included in the Lucanidae), and investigated the constancy or inconstancy of their morphological characters.

The following are the conclusions at which I have arrived respecting the variability which exists within the limits of a single species:—

Although the male and female form a single whole, constituting one species, both sexes vary, but in different directions. The male varies much more in size, shape, and colour than the female, which remains more constant to the type, so that the females even of distinct genera are very similar, and are frequently very difficult to separate from one another, while their males are often very distinct.

**Female.** The females are often remarkably different from the males, both in form and size. They generally agree with them in colour; and in cases where they are differently coloured, it is much more difficult to refer them correctly to the males. Examples: *Odontolabis stevensi* (Pl. XC. figs. 1–4), *O. gazella (= *O. bicolor* e, and *O. gazella* 2) (Pl. XCVI. figs. 10, 11).

In *Cyclommatus* the females of the majority of the species are dark-coloured, and are brown or metallic like the males; but the females of *O. mniszechi*, Thoms., and *C. strigiceps*, Westw., have bicolored elytra.

In *Odontolabis brookeanus* the colour of the elytra is variable (Pl. XCV. figs. 16–18). In small specimens of *O. lacordairii* (Pl. XCIV. fig. 7) the red spots on the prothorax are wanting, and the canthus round the eyes varies in width.

The form and size of the prosternal process is variable, and the number of spines on the outer side of the front tibiae also varies. But the size of the whole insect is the most variable character.

**Male.** The males of the same species vary much more than the females:—

1. **In the total size.**
2. **In the size, form, and teeth of the mandibles** (Cladognathini and Odontolabini).
3. **In the number of apical lamelle of the antennae.** In some cases this is an important family character, but in *Lucanus cervus*¹ these vary in form and size, and there may be either 4, 5, or 6.
4. **In the shape of the head.**

(a) Enormous development of the frontal ridge in *Homoderus mellyi*, Parry ², and

² Compare H. Deyrolle, Ann. Soc. Ent. France (4) iv. p. 316, pl. iv. figs. 2, 2 α (1864); Parry, Trans. Ent. Soc. Lond. (3) li. pl. xi. fig. 6 (1864); and Westwood, op. cit. (3) i. p. 437, pl. xvi. figs. 7, 8 (1863).
in the telodont forms of *Odontolabis alces*, var. *dux* (Pl. LXXXIX. figs. 1 & 2), *burmeisteri* (Pl. XCI. fig. 5), &c.

(b) The occipital crest is more or less developed in large specimens of *Lucanus cervus*, and in all the species of Lucanini which inhabit Europe and Asia, but is absent in small specimens.

\[\text{Fig. 1.}\]

Ideal figure illustrating the modifications of the Lucanidæ.

The numbers and figures correspond to the text.

(c) The labrum. (1) In large specimens this extends straight down between the mandibles; in small specimens a true triangular epistoma often becomes visible above the labrum (*O. alces*, Pl. LXXXIX. figs. 1, 6). This epistoma is often very variable. (2) The labrum is frequently broad and quadrangular in telodont forms, but is very small in other modifications (comp. *O. brookeanus*, Pl. XCV. figs. 13, 15).

(d) The canthus, or rim round the eyes, is usually a constant character, and I hoped, like Prof. Westwood, to find it of great systematic importance. I examined it carefully in thousands of specimens of Lucanidæ, and found it variable only in a few species of Dorcini. In large males the eye is exposed (\(d'\)), but in small males and in the females it is entirely enclosed.

(e) The spine behind the eye (a generic character), which is strongly developed in large specimens, is wanting in the smallest males of *Odontolabis brookeanus* and *O. sommeri*.

(5) In the configuration of the prothorax (a specific character).

(f) In the larger males of some species the sides of the prothorax are generally
trispinose, with two deep concavities; while in the small males the sides are convex, as in the females (comp. *O. aleeus*, Pl. LXXXIX. figs. 1, 7, and *O. lacordairii*, Pl. XCV. figs. 1, 2, 5, 6, &c.).

(g) The breadth of the prothorax often varies, which considerably affects its outline, as, for instance, in *O. burmeisteri* (comp. Pl. XCII. figs. 5, 6).

(h) In many species the form of the prosternal process is also variable.

(i) In the elytra.

These are sometimes strongly convex and sometimes flattened (as in *O. latipes*).

(k) The sculpture. In the Dorcini, for example, *Eurytrachelus titan*, Boisd., *E. tityus*, Hope, and *Dorcus dehaani*, Hope, *D. parryi*, Thom., and *D. musimon*, Gené, the large males have smooth elytra; and the small males ridged elytra, like the females (pterygo-dimorphism).

(l) Coloration (*O. wollastoni*, Pl. XCIII. fig. 6, 7), &c.

(7) In the shape and armature of the front tibiae (a specific character). In the Odontolabini large (telodont) specimens have generally fewer spines than small ones (in *O. burmeisteri*, *O. aleeus*, &c.).

(8) In the armature of the four hind tibiae (a family character). In *Cladognathus giraffa* and *C. confucius* the middle spine of the hind tibiae is wanting in small males. This is likewise the case in some species of the genus *Ægus*.

Hence it follows, as an unavoidable conclusion, that every morphological character proves, when thoroughly tested, to be variable in one species or another, a result of great importance to systematic morphology.

(2) Variability and Polymorphism in the Mandibles.

Every one is well acquainted with our indigenous Stag-Beetle (*Lucanus cervus*) and with its very different female. This species varies so much in size that the older authors naturally regarded the small males as belonging to a different species, which they called *L. capreolus*, Fabr. But early in the present century, Koechlin, an entomologist residing at Mulhouse, having found a large number of specimens in one locality, endeavoured to show that the small specimens were “not a specially created species,” but only a slight variety of the large ones; and this view has been accepted by later entomologists until the present day.

If a European entomologist were to collect a long series of males of *L. cervus* for the purpose, he would be able to satisfy himself that they vary chiefly in size, and that the mandibles of the small males are formed like those of the large males; the only differences being that the terminal fork is truncated, and that the occipital crest is obsolete. This would lead him to conclude that the small males are only imperfectly developed specimens.

1 Correspondance entomologique, 1823. Remarques sur le Lucane, ou Cerf Volant.
But an entomologist who collected a long series of Cladognathus or Odontolabis in their native haunts would arrive at very different results. If collecting in Further India or the Sunda Islands, for instance, he would find such great variations in the mandibles of the males that he would be inclined at first, like the older authors, to regard them as belonging to several distinct species, till some fortunate accident enabled him to obtain a complete transitional series from one extreme form to the other, and he discovered that the same variations occurred in several allied species.

He would next discover that the middle-sized forms have generally stronger and thicker mandibles than the largest and smallest, and that these species could not be considered simply variable, like the Lucanini and Dorcini, but must be regarded as polymorphic.

Thus Neolucaurus castanopterus constantly exhibits only one form of mandibles (Pl. LXXXIV. fig. 13), N. soundersi has two forms (Pl. LXXXV. figs. 13, 16), Odontolabis siva has three forms (Pl. LXXXVI. figs. 1, 3, 6), which are much more distinct in O. brookeanus (Pl. XCV. figs. 13–15), while O. alces exhibits four forms (Pl. LXXXIX. figs. 1, 3, 5, 6).

As already mentioned, these stages are completely connected by transitional forms in a number of species (for instance, in O. alces and Heterochthes andamanensis). But in other species this never occurs. In O. brookeanus no transitional forms between A (Pl. XCV. fig. 13) and B (fig. 14) have ever been observed. Nor do we ever meet with transitional forms bridging over the gap between the telodont and mesodont forms of O. sinensis, O. cuvera, &c.

(3) The Question of Species in the Lucanidae.

Whoever studies the entire group of the Lucanidae, whether from a systematic point of view or from that of comparative morphology, should understand that we have here to deal with a plasticity of material which does not allow of our discovering such definitely fixed specific characters as we are accustomed to look for in other groups.

Wherever we seek for such characters we find them inconstant. It follows that in this family the definition of a species is more extensive than in other groups of insects, and that the descriptions must be differently arranged if they are to be of any permanent value. The old authors contented themselves with drawing up a description of a single specimen. This renders it extremely difficult, if not impossible, to identify many of their species with any certainty, as those only can fully realize who have attempted to work at historical entomology. The study of types is more important in the Lucanidae than in almost any other group, for without this assistance many riddles would remain insoluble.

As a single specimen gives us a very imperfect idea of a species, we must describe

1 Vide Parry, Trans. Ent. Soc. Lond. (3) ii. p. 66 (note).
2 Also N. laticollis (Pl. LXXXIV. fig. 1) and Odontolabis latipennis (Pl. XCVI. fig. 1).
and illustrate an entire series in order to elucidate it sufficiently. But we shall often find that our language is too poor to express our observations correctly.

In many Lucanidæ we find, as in domestic animals:—

(1) Individual forms.
(2) Varieties in form.
(3) Colour varieties.
(4) Geographical races or subspecies.
(5) Apparent monstrosities.

The extent which an author allows to a species will depend on his point of view, and on his conscientiousness.

It is difficult to ascertain the exact limits of species, race, and variety in many of our European Lucanidæ, notwithstanding the careful study which Dr. Kraatz and others have given to the subject; and the same difficulty reappears, but greatly augmented, when we come to study the multitudinous forms of the Odontolabini.

It will always remain a moot point whether O. sinensis, O. cuvera, O. delesserti, and O. burmeisteri should be regarded simply as local varieties or as independent species.

(1) Among the immense amount of material at my disposal I find specimens which appear to be more or less intermediate between O. sinensis and O. mouhoti or O. cuvera.

(2) Small males and females occur which cannot be assigned with certainty to either O. cuvera or O. delesserti.

(3) Intermediate forms occur between O. delesserti and O. burmeisteri, which establish their close relationship, and which might induce many authors to regard them as identical. But the extreme forms of apparently well-developed males and females furnish equally strong grounds for regarding them as distinct species.

Where the coloration is confined to the upper surface of the elytra, as in O. wollastoni and its allies, and the lower edge remains black in both sexes, it is still more difficult to separate the species, as we may logically look for "artificial selection," and attempt to draw a line which may not have any real existence in nature, as our supposed species may probably interbreed, and produce fertile offspring, notwithstanding their differences of colour.

I have taken much trouble in seeking for anatomical characters to decide this delicate question, but hitherto without result.

Whereas the chitinous portions of the male sexual organs of the Cetoniidæ and Carabidæ have been found by Kraatz and Thomson to furnish important characters to separate otherwise scarcely distinguishable species, I found these characters quite valueless in most of the species of the Lucanidæ, and the form and armature of the lateral valves of the penis are alike in all the Odontolabini, although I found them very differently formed in various species of Dorcini.

I nevertheless examined the male sexual organs in a large number of Lucanidæ, and

vol. XI.—Part XI. No. 2.—November, 1885.
Table showing the views of various authors respecting the relationship of different species of *Odontolabis*.

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- cinqueensis
- intermedius
- (nigritus) carinatus, Linnaeus
- carinatus, auctor
- dux, auctor
- dux, auctor
- alces, Fabricius
- belligerus, Castelnau

5 species.
arrived at very interesting results, which I will reserve for future publication, as they are rather beyond the limits of the present investigation.

The table opposite will show how difficult it is to decide such questions with insufficient material, how differently various authors have attempted to do so at different times, and how different species have been alternately separated and united from the time of Hope and Burmeister to the present day.

(4) **Odontolabis alces**, Fabr. (*a morphological study*).

Among the above-mentioned species *Odontolabis alces* deserves special study, as it is extremely interesting both from a historical and from a morphological point of view; and on account of the great mass of material at my disposal, which enabled me to study it more fully than any other species.

(a) **Evidence of the Specific Identity of O. dux**, Westw., O. alces, Fabr., and O. cumingi, Hope.

Through the kindness of Herr G. Schneider, of Basel, I have been enabled to examine 223 specimens of this Stag-Beetle, which is generally known as *O. dux*, Westw. They were received from Manilla, and 112 specimens were males and 111 females. The females varied in length from 39–52 millim., and the males from 45–99 millim., inclusive of the mandibles.

When I first examined the whole series, I was immediately struck with the great similarity of the females (Pl. LXXXIX. fig. 8), while the males appeared in four distinct forms (Pl. LXXXIX. figs. 1, 3, 5, 6), which nevertheless all seemed to belong to the same species, as they were connected together by transitional forms. This circumstance, and the large amount of material before me, naturally led me to make further investigations, as I had long been anxious to meet with such a series, in order to study the laws and limits of variability between individuals belonging to one and the same species. In this case no doubt could exist respecting the correct identification of the sexes, as they were all from the same locality.

It was only necessary, in the first instance, to ascertain whether the females all belonged to the same species. If so, there could be no doubt that the males would prove to do so also. But I went another way to work, and verified this point at a later time, when I had learned to distinguish between the females of a considerable number of species of Lucanidae, which, owing to their great resemblance, is a most difficult task.

I also convinced myself by careful examination that the smallest males (Pl. LXXXIX. fig. 7), although so similar to the females, possessed fully developed sexual organs, and were not to be regarded as sexually imperfect individuals, as some authors have suggested. By a careful selection I was enabled to pick out an almost uninterrupted series of transitional forms from the largest to the smallest males.
Afterwards, when I studied the multifarious and puzzling literature of the subject, I arrived at the following conclusions:

(1) Only the largest and apparently most highly developed form (Pl. LXXXIX. fig. 1), of which there was but one specimen in the series, agreed with Lucanus dux, Westw.¹, the type of which is in the British Museum (Pl. LXXXIX. fig. 2), and measures $4\frac{1}{2}$ inches in length; it was brought by Cuming from Manilla. "This insect," says Westwood (l.c.), "is very closely allied to Lucanus alces, but that species has a strong tooth at the base of the mandibles on the inside. Dr. Burmeister has indeed appended a note to the specimen in the British Museum collection affirming it to be a variety of that species. I am well aware of the very variable size of the teeth of the mandibles in the Lucani which has induced this opinion, but as it appears to me to be a fixed principle that gigantic male specimens of any of the cornuted insects should have the horns and teeth developed to excess, I can scarcely think that the insect before us ought to be referred to a species, the ordinarily smaller males of which are more strongly armed with teeth than the specimen here figured."

Some time afterwards I had an opportunity of examining Westwood's type in the British Museum, and saw another specimen in Major Parry's collection. I met with a fourth in the Museum of the Jardin des Plantes at Paris, and have been informed that there are several other specimens in different private collections.

(2) It was obvious that about forty specimens, differing a little in size, but which all possessed a strongly developed tooth in the middle of the mandible (Pl. LXXXIX. fig. 3), agreed with Lucanus alces, Fabr.², the description of which is as follows:—

"Caput magnum, atrum, utrinque sinuaturn, depressum, fronte retusa; maxillae [mandibulae] exserte capite longiores apice compressa, quadridentatae, et in medio interno dente valdissimo armatae. Corpus Lucano cervo magus, nigrum, glabrum; thorax utrinque bidentatus."

Fabricius quotes Petiver³, who figured the head of a gigantic specimen as long ago as 1702. I saw Petiver's rare book, and also his original specimen, in the British Museum. Olivier⁴ amplifies the Fabrician description as follows:—"Les mandibules sont plus longues que la tête; elles sont arquées, comprimées à leur extrémité, armées d'une très grosse dent vers le milieu et de quatre dentelles à leur extrémité, dont quelques-unes paroissent se diviser en dessus." He figures this form so correctly that it could not be mistaken for any other.

(3) The third form (Pl. LXXXIX. fig. 5), which is connected with the preceding by intermediate specimens, has a series of three or four irregular teeth at the base of the

³ *Jacobi Petiveri Opera Historiam naturalem spectantia,* or *Gazophylacium,* vol. i. London, MDCCXIV. pl. xlvii. fig. 15 (reprinted from the original work).
⁴ Entomologie, i. (1) p. 8, pl. ii. fig. 3a, b.
mandibles. Olivier considered it to be the female of his *L. alces*, and gave a recognizable figure of it (tome vii. pl. ii. fig. 3 b). He remarks, "La femelle ne diffère du mâle qu'en ce qu'elle est plus petite, que les mandibules sont à peine de la longueur de la tête, et qu'elles ont trois dentelures à leur base, et cinq à leur extrémité." If he had only examined the sexual organs, even in dried specimens, he would not have fallen into this error, which was pointed out by Hope in 1845. But Hope, in avoiding Scylla, fell into Charybdis, and described the insect as a distinct species under the name of *Lucanus cumingi*, Hope.

(4) The fourth form, with small scissor-shaped mandibles (Pl. LXXXIX. figs. 6, 7), has not yet been described. It appears to be quite a different species from any of the preceding, as the mandibles are here replaced by *isodontine scissors*, as they may be termed. This modification can be followed step by step, and will be discussed in the next section. In passing from the third to the fourth form, the size gradually diminishes, and the smallest specimens of the latter only measure 45 millim. in length, which is 13 millim. less than the length of the largest females.

I will now attempt to demonstrate the specific identity of the four different forms already mentioned, and to show that *O. dix*, Westw., *O. alces*, Fabr., and *O. cumingi*, Hope, are not to be considered as independent species, but are only different forms of one and the same species.

This is shown by the gradual transition from form 1 to form 4, the last of which resembles the female.

(b) *Modification of the Mandibles in the Male.*

The males of this species are less constant in form than the females. It is true that the latter, like the former, vary in size, but the different parts of the body are always uniformly developed in proportion, as is shown by the measurements of the comparative proportions of seven different specimens selected at random. The tip of the scutellum, between the elytra, is about the central point of the body of the female, as the tips of the mandibles and of the elytra are equidistant from it. This is true both of the largest and the smallest of the 111 specimens examined.

1 Hope, Catalogue of the Lucanoid Coleoptera, p. 17.
2 One or more of these four forms of mandibles reappear in the males of every species; and for convenience of reference I designate them as follows:—
   i. Forma telodonta.
   ii. Forma mesodonta.
   iii. Forms amphidonta.
   iv. Forma priodonta.
   (Cf. also p. 433.)
3 This applies only to *O. alces*. 
But if we expected the same rule to apply to the males, we should be greatly deceived. It is approximately correct for the smallest males of the priodont form, but the larger the males the larger the front half of the body (consisting of prothorax, head, and mandibles); this is due to the relatively greater development of the mandibles; and thus the length of the front of the body very considerably exceeds that of the hinder portion. The gradation will be most easily understood by comparing the accompanying table of measurements. The tip of the scutellum is the best point from which to take these measurements; the total length of the elytra has invariably been given in the systematic part of the paper (p. 445).

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I shall reverse this order in treating of the divergences of the mandibles, beginning with the smallest and proceeding to larger and larger forms, because this is simpler, more natural and intelligible, and less difficult than the opposite method.

In the smallest priodont forms of *O. alces*, which most resemble the female in the shape of their mandibles, the mandibles are about as long as the head, and shaped like a broad knife. On the inside the teeth stand in an unbroken and peculiarly regular

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1 When these investigations were undertaken in 1881, I selected a series of male specimens in which the increase was considerable, and arranged them in a regular series. But it must not be supposed that the mandibles of the amphiodont forms are always larger than these of the priodont forms. There are also mesodont forms in which the individuals are not larger than the amphiodonts. In the course of my investigations I met with telodont forms also in which the total dimensions of the individuals were less than those of the mesodont or amphiodont forms. Comp. *O. castelnaudii* (Pl. XCV. figs. 1, 2, 4) and *O. brookeanus* (figs. 13, 14, 15).
series, like the teeth of a saw (woodcut, fig. 2, no. 1). If the mandibles are only 2 or 3 millim. longer, the teeth are divided into two groups by a little gap rather beyond the middle (no. 2). The gap is more distinct in no. 3, where the mandibles are only 1 millim. longer than in the preceding; in no. 4 they become larger and larger, so that the eight originally uniform teeth are divided into two series—one of five (subsequently four) at the tip, and another of three at the base of the mandibles (forma amphiodonta).

The three obtuse teeth at the base are at first uniform (cumingi, fig. 4), but in no. 5 the first tooth has already become more prominent. The larger the mandibles, the larger this tooth becomes by inward expansion, while the two teeth at the base may remain. Among a number of specimens I found several which had only one small tooth at the base (no. 6), while the more strongly developed central tooth projected inwards and downwards like a conical appendage to the mandibles. In these large specimens the five apical teeth are generally reduced to four (no. 7); at the same time the mandibles become gradually more curved and rounded; the tip only remains flattened and compressed. If the last rudimentary basal tooth disappears, we get the true mesodont form, in which a strong central tooth projects inwards rather beyond the middle (alces, Fabr., no. 7). My materials from Manilla enable me to trace the gradual and unbroken differentiation of the mandibles to this point. In the form with longest mandibles (dux, Westw.) the middle tooth is entirely wanting (no. 9), and we find nothing but the four small apical teeth (forma telodonta).
The gap between the mesodont and telodont forms long remained unbridged. It is true that, on a careful examination, I met with mesodont forms in which the mandibles were as long as in *dux*, and in many specimens they were smooth, convex, and curved, resembling the amphiodont forms of *O. sica*, as in Petiver's specimen in the British Museum; but the central tooth was always strongly developed. Nevertheless I expected, if I could obtain more extensive materials, to discover mesodont forms with mandibles of similar form, but with only the rudiment of a central tooth. If two teeth had disappeared, why should not the third disappear too? At length I chanced to meet with what I had sought for so long in the Museum of the Jardin des Plantes (no. 8). This discovery resolved my last doubts, and completed the series to the highest form.

Diagram exhibiting the different Stages of Development of the Mandibles in *Odontolabis alces*, Fabr.

The preceding remarks are sufficient to show with what ease we can pass from the priodont to the telodont form in this species; but if we commence with the telodont form (as Prof. Westwood has done) we shall find it difficult to explain the origin of the mesodont form. The modifications of the mandibles affect not only their form, but their functions also. The mandibles of the telodont form consist of a curving pair of pincers, which can only meet at the tip. In the mesodont form the great development of the middle tooth renders the use of the mandibles as a weapon (for such must they be regarded, according to all indications) more probable, for the teeth are adapted for
grasping at the tip and for piercing in the middle. In the amphiodont form the basal teeth might be supposed, from their appearance, to be adapted for mastication. Unfortunately, no observations have been recorded from which we could guess their use. In the smallest priodont forms the pincers are converted into saw-like scissors.

If we consider that it is more than probable that the males fight for the possession of the females, we may regard the mandibles of the large forms as offensive, and those of the small ones as defensive weapons.

1 Numerous injuries were observed in specimens of _O. alects_ of all sizes; some of these consisted of deep punctures and indentations, generally in pairs, on the hard prothorax and elytra, which were evidently produced by the middle teeth of the mesodont form. In other cases the tips of the front tibiae were amputated; and in two instances saw-like impressions were noticed on the side of the elytra, evidently due to the jaws of the priodont forms. In some interesting cases these double wounds were completely cicatrized, as, for instance, in a specimen of _O. cuvera_ in Major Parry's collection (comp. the accompanying woodcut). This shows that the injuries must have been inflicted when the example had only just emerged from the pupa and was still soft. These impressions, three on each side, agree with the form of the branched telodont mandibles of this species. Such injuries occur more or less frequently in all the Lucanidae in which the males are provided with large jaws, as well as in smaller species, such as _Heterochthes andamanensis_, Westw., and even in delicate forms like _Ceruchus picus_, Weber. In the Chinese _Neolucanus nitidus_, Saund., the mandibles are broken off near the base in all the males examined (comp. p. 427).

2 Our common Stag-Beetle (_Lucanus cervus_) sucks the exuding sap of oaks, and will also feed on sugar and water or honey by day (Swammerdam). It would probably not reject soft fruit too (comp. Waterhouse, Proc. Ent. Soc. Lond. i. p. iv., 1836). It is even asserted by several authors (Westwood, Mod. Class. Ins. i. p. 157) that it kills other insects, especially smooth caterpillars, with its mandibles, in order to suck their juices.

3 This is maintained by Darwin, Schlechtendal ('Jahresbericht des Vereins für Naturokunde in Zwickau,' 1874, p. 25), Chopin (comp. Brehm's 'Illustriertes Thierleben,' 2 Auflage, Band ix. p. 74), and others. W. von Reichenau is of a different opinion ('Kosmos,' 1879, Band iv. p. 56); he disputes the fact of the animals fighting among themselves or contending for the females, and maintains that the horns of Lucanidae have not become developed by natural selection as weapons, but simply to terrify their enemies. I consider it more probable that both causes have operated simultaneously.

4 Compare Semper, 'Conditions of Existence,' pp. 366-368, fig. 96.

Fig. 3.

Elytra of a specimen of _Odontolabis cuvera_, showing injuries apparently caused by the mandibles of a telodont of the same species.
(c) Modifications of various Parts of the Body.

The varying size and shape of the mandibles affect the other parts of the body by the law of correlation of growth. They react first upon the size and shape of the head (the mouth-parts, the frontal crest, the spine behind the eyes, and lastly, the length of the antennæ), and, secondly, upon the size and shape of the prothorax, especially on its width.

1. Modifications of the Head.

If a species was a fixed and unchangeable entity, the small specimens would reproduce the characters of the large ones, but on a smaller scale. The multiform mandibles completely dominate the head. It is a generally received axiom in the anatomy of Vertebrates that the thicker the muscles which are attached to the bones, the more numerous ridges and protuberances do the latter exhibit. What a striking difference exists between the skulls of old and young vertebrate animals—for instance, between the skulls of a young and of an old Gorilla, where the muscles of the jaw are so strongly developed in old specimens that the whole appearance of the head is quite altered! The same law applies to the heads of our beetles, in which the chitinous covering of the exocranium is likewise altered and enlarged by the development of the muscles of the jaws. But in this case the impression on the external skeleton, which is unalterable in the imago (which does not moult), is fixed upon it previously in the plastic pupa-stage. (But the imago is little more than the elegant wedding-garment, as Karl Ernest von Baer has so admirably called it.) It therefore follows that the larger the mandibles, the larger must be the masseter muscles contained in the head, and especially the hinder part of the head itself.

1. In the telodont form the head is broad in front between the eyes, the clypeus is much elevated, and (for aerostatic reasons?) the frontal crest is always strongly expanded in front (Pl. LXXXIX. fig. 2).

2. In the mesodont form (fig. 3) the frontal crest is wanting, the front margin is strongly indented, and the head is narrower between the eyes, but much broader behind, where the principal muscles which move the mandibles are attached; and the line of attachment of the muscles which is thus formed may have given, through outward expansion, rise to the spine behind the eyes (the principal morphological character of the genus Odontolabis), which slopes obliquely backwards.

3. In the small amphiodont and in the smallest priodont forms, the skull becomes very flat, and the hinder part grows narrower and narrower (fig. 7), so that the head finally appears broadest in front between the eyes. The spine behind the eyes also becomes smaller and more pointed, and disappears entirely in some species, although not in O. alces (comp. O. lacordairii, Pl. XCIV. fig. 5); it is entirely absent in the female (fig. 8), in which the hinder part of the head is concealed by the prothorax, so that the eyes almost touch the front edge of the latter.

The mouth parts are considerably affected, for purely mechanical reasons. In the
largest telodont and mesodont forms (figs. 1, 3) the clypeus and the labium (with which it is united) are depressed below the mandibles (toothless at the base) as far as the mentum (comp. O. duineboodii, Pl. XC, fig. 5 a). In the amphiodont and priodont forms (figs. 5, 6) the clypeus is flat, and the labrum is contracted into a triangular epistoma above the closed mandibles, which are flattened and toothed at the base. The length of the antennae of the male, dependent upon the stronger development of the scape, is always exactly proportioned to the length of the head.

2. Modifications of the Prothorax, &c.

The changes of form in the prothorax, when carefully investigated, are found to be just as important as those of the head. While the prothorax is trispinose in large specimens, having two deep depressions on each side (Pl. LXXXIX. figs. 1, 3), the front angle disappears in the smallest priodont specimens, in which the form of the male resembles that of the female (figs. 7, 8). The narrowing of the prothorax is still more remarkable in O. burmeisteri (Pl. XCII. figs. 5, 6) than in O. alices.

The front tibiae, even in the smallest males, are always longer than in the females, owing to the longer head and mandibles. For the same reason, the pro- and mesosternal processes are also proportionately more strongly developed in the males.

(5) Evidence in favour of the Gradual Differentiation of the Male Forms by Modification of the Mandibles.

We have already shown that in O. alices an unbroken series of male forms exists, from the largest with most highly developed mandibles to the smallest, in which the mandibles resemble those of the female. The next problem which confronts the observer is whether the small priodont forms may not be specimens in which the mandibles are imperfectly developed.

The idea that the so-called degenerated forms should be regarded as neuters, was refuted by an examination of the fully developed and even comparatively large sexual organs, in which not only the chitinous parts, but also the testes and their contents (the spermatozoa) were found to be well developed in the smallest males.

As the middle-sized forms generally possess much more strongly developed and complicated mandibles, it appears very probable that the telodont form was gradually developed from the priodont form. We may suppose this to have been the case with the progenitors of O. alces, O. bellicosus, and O. siva, in the first of which the telodont form (Pl. LXXXVIII. fig. 1) is one stage lower than in O. alices, while O. siva stands another step lower, never passing, even in the highest forms, beyond the amphiodont stage (Pl. LXXXVI. figs. 1, 2). But in the case of these species it is always possible that

1 In O. brookvans the broad quadrangular labrum of the telodont form (Pl. XCV. fig. 13) is reduced to a minimum in the priodont form (fig. 15).

2 These could only be observed in the smallest males of Lucanus cervus.
the resemblance of the mandibles of the priodont form to those of the female is only accidental, and may be due to the disappearance of the gap in the middle of the mandibles (fig. 6). The species of the genus *Heterochthes* are among the most interesting known to me, as the female mandibles are entirely differently formed, like an amphiodont stage.

The female of *H. andamanensis* (comp. accompanying woodcut, fig. 4. no. 9) has an apical group of four or five contiguous teeth, and there are two anastomosing obtuse teeth at the base; these are separated by a gap from the apical teeth. There is a slight projection on the upper side of the mandibles, just above the gap.

![Fig. 4.](image)

*Stages of development of mandibles in *Heterochthes andamanensis*. No. 9, ♀; no. 8, smallest ♂ form, resembling ♀; nos. 4–6, mesodont forms; nos. 1 and 2, telodont forms; nos. 3 and 7, intermediate forms.*

The smallest male form (no. 8) stands at almost exactly the same stage as the female. The mandibles exhibit an apical group of four or five teeth, divided by a gap from the two obtuse basal teeth. On the upper side is a slight prominence, rather more developed than in the female, and situated exactly over the middle of the gap. In the next higher stage of the development of the mandibles (no. 7) the middle prominence is more strongly marked, and more or less united with the basal teeth. In the third form (no. 6) the central tooth is still more strongly developed. The basal teeth have disappeared, and there are only two or three apical teeth (nos. 5, 4) instead of three or four (mesodont form). When the mandibles are still larger (nos. 3, 2), the central
tooth gradually disappears. Finally, nothing but the front tooth remains at the tip, which becomes considerably curved inwards, like a hook (no. 1).

Here too, as in *O. alces*, we pass without a break (but from an amphiodont form which most resembles the female) to the terminal form by gradual lengthening and simplification of the mandibles. But no one will ever be able to prove the opposite, as the small forms of mandible are always more complicated in structure. A more complicated form can never arise from a more simple form by arrest of development.

The results at which we arrived through the study of *O. alces* are thus confirmed, and we are consequently obliged to regard the mesodont, amphiodont, and priodont forms as stages of the development of the mandibles, and as antiquated forms which still reappear from causes which we do not understand. The smallest male is so similar to the female that one of the most eminent entomologists, who first described *Heterochthes brachypterus*, an allied species, mistook one of these small males for a female, and described and figured it as such.

But if, instead of studying Coleoptera, in which the metamorphosis is complete, and each imago can only represent a single form, so that its history can only be studied by a phylogenetic method and by series, we were dealing with insects with incomplete metamorphoses, in which we might be able to trace the gradual development of the

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1 Trans. Ent. Soc. Lond. (3) ii. pl. x. fig. 6.
mandibles step by step from one moult to another, the above conclusion would be positively demonstrated.

I spared no trouble to seek for examples among these insects in which the full-grown male possesses enormously developed mandibles like the Lucanidae, which are normally developed in the female. As Nature works on parallel lines, I found my views confirmed in an Australian cricket (Anostostoma australasiae, Gray), in which (as shown in the accompanying woodcut, fig. 5, p. 405) the sexually-mature male has enormously long and strongly curved mandibles (nos. 1, 2). There is an apical cluster of teeth, and a broad obtuse tooth, used for masticating, at the base (no. 2, side view).

In the female the mandibles are small, and are set with serrated biting teeth on the inner side (like a priodont form, cf. no. 3). The very young larva of the male, the sex of which can be recognized at once by the absence of an ovipositor, begins at the same stage as the female in the development of the mandibles (no. 4).

The enormous mandibles of the male are apparently here also designed for grasping the female, and have been gradually developed in this manner by the survival of the fittest.

As the Orthoptera continue to take nourishment constantly throughout the whole course of their lives until their death, which soon follows coition, a total change of function in the mandibles, as in the Lucanidae (from the mandibles of the larva to the mandibles of the imago), is impossible; and when the mandibles are needed to fulfil an additional function, their increase in length necessitates the lengthening of the entire buccal apparatus (the labrum, maxilla, &c.). Only in this strange and paradoxical manner could the two objects of the mandibles be fulfilled without interfering with one another.

(6) Divergence of Species in the Odontolabini.

(Investigations into the Agreement and Difference of the Morphological Characters, as a Contribution to the Knowledge of their Mutual Relations.)

In the previous Chapter we treated of the variations which occur within the narrow limits of a single species, and must now recapitulate our results, in order to study the agreements or differences of the known species. A mere glance at one of our Plates will suffice to show any entomologist that, in comparison with the considerable variations which occur in a single species, the differences which separate one species from another are often very slight—so slight that in our comparative descriptions we are obliged constantly to use such expressions as "a little more or less," "very similar," "very closely allied," &c.; while some differences are so slight that, although perceptible to the eye, they cannot be expressed in words. Our figures, like our descriptions, cannot attain the acme of perfection, an absolute facsimile of a specimen being practically unattainable.
Diagram of the Species of the Genus Neolucanus, arranged according to their Morphological, Genetic, and Geographical Relationships.

Section 1.


Section 2.

5. *N. castanopterus*, Hope. (Nepal.)

Section 3.

6. *N. sinicus*, Saund. (China.)


11. *N. chinensis*, Banks. (China.)

12. *N. championi*, Parry. (China.)

13. *N. oberthüri*, Lenth. (China.)

Section 4.

14. *N. tanaec*, Oliv. (N. India, Silhet.)

15. *N. saundersi*, Parry. (North India.)

c. Mandibles priodont (always unforked).

1. Always priodont in small specimens of the same species.
2. Forked at the tip in large specimens.

c. Mandibles with a perpendicular tooth at the tip and at the base.
1. Neolucanus.

Following Parry's example, I have endeavoured to divide the species of each genus into small sections, according to their actual affinities, both on practical and theoretical grounds; but I have slightly modified Parry's arrangement by commencing with species in which the males most resemble the females and ending with those in which the sexes are most dissimilar (comp. the preceding diagram, p. 407).

The first section contains small species presenting very slight sexual differences, as is the case with Neolucanus laticollis (Pl. LXXXIV. fig. 1♂, fig. 3♀), and I therefore leave them unnoticed. The sexual differences are equally slight, both in the mandibles, the canthus of the eyes, the shape of the head and prothorax, and in the comparative length of the front tibiae.

Nothing can be said of the sexual differences of Neolucanus lansbergii, Neolucanus muntjac, and Neolucanus cingulatus, as only one sex of each is known. The geographical distribution and great similarity of these species render it probable that they are all very closely allied.

The second group may be more profitably studied. In the North-Indian Neolucanus castanopterus the mandibles are priodont in all the specimens examined by Parry, Bates, and myself; and the male (Pl. LXXXIV. fig. 13) and female (fig. 14) exhibit very slight differences in the head and canthus. But the most nearly allied species, Neolucanus swinhoïi (Pl. LXXXIV. figs. 15, 15b♂, 16♀), from Formosa, is not only larger, but further differentiated; as in all the largest telodont forms, the mandibles are forked at the tip. But the smaller specimens (fig. 15b) retain the priodont form of their progenitors. In the female the slight difference from the male mandibles necessitates the remarkable widening of the canthus (for defensive purposes?) which gives the head such a peculiar triangular form. The slight variations in the shape of the prothorax and elytra are unimportant. The coloration of the whole insect and a slight but important morphological character—the hairiness of the mentum in the males—are quite constant. In Neolucanus castanopterus the chestnut-brown elytra are marked with a black transverse basal band (figs. 13, 14), which is nearly obsolete in Neolucanus swinhoïi. The allied species Neolucanus pallescens (Pl. LXXXV. fig. 2) and Neolucanus parryi (Pl. LXXXV. fig. 4) illustrate this. In the former the elytra are dark brown, with only a trace of a narrow pale border, which runs from the tip to the middle, where it ceases. In the allied Neolucanus parryi there is a triangular mark in the middle of each elytron in both sexes. This coloration is repeated, somewhat modified, in the female of Neolucanus marginatus (Pl. LXXXV. fig. 3), whereas the supposed male (fig. 1) is dark chestnut-brown. The differences of these species are very slight, apart from their constant local colour-variations. The hairy mentum in the males of these species is so characteristic that I rightly concluded, before the discovery of the male of Neolucanus parryi, that it would also exhibit it. If fig. 1 is really the male of Neolucanus marginatus (which its analogy with Odontolabis stevensi renders probable), the gap between this species and Neolucanus lama (fig. 14)
and *N. saundersi* (fig. 15), the largest species of *Neolucanus*, would be bridged over in a very unexpected manner. The females of the two latter species (figs. 9, 11, 12) are so variable that it is not easy to separate them, though the males are more easily distinguishable. In *N. lama* the mandibles are always priodont in small males, but they are forked at the tip in larger ones. In *N. saundersi* they are more developed. The priodont form (fig. 16) much resembles that of *N. lama* ♂. In rather larger specimens a gap appears in the middle, and an amphiodont form is thus developed. The basal teeth, traces of which are visible on both sides in fig. 15 (Parry's type), are absent in another specimen in the British Museum, only the apical teeth remaining. Oddly enough, in large specimens an upright tooth is developed at the base of the mandibles\(^1\), which is indicated as a mere rudiment in the smaller priodont forms.

*Neolucanus* *championi* (fig. 8 ♂, fig. 6 ♀), *N. sinicus* (fig. 7 ♂, fig. 5 ♀), and *N. obertthüri* exhibit only unimportant differences in size and shape, and are chiefly distinguished by their colour.

The large species of *Neolucanus* lead us, without any very wide interval, to the first section of the genus *Odontolabis*, Hope.

### II. Odontolabis.

In this genus, *O. siva*, Hope, and its allies exhibit the least diversions in the females. Their resemblance to the last species of *Neolucanus* is very remarkable; they are found in the same localities, and are very easy to mistake for one another. But the similarity of the small males (Pl. LXXXVI. fig. 6, and Pl. LXXXV. fig. 15) is not without significance, as it has led experienced coleopterists to treat *O. siva* and *N. lama* as one species! The similarity in form and colour between certain parallel species of *Neolucanus* and *Odontolabis*, which inhabit similar localities, is so great that we are sometimes reminded of the well-known cases of true mimicry in Lepidoptera noticed by Bates and Wallace.

\(^1\) The intelligent observer will ask why this genus should develop so remarkable a structure (so similar to the genus *Pristogenius*, Motsch.), which one would think would not be developed, owing to mechanical obstacles. But we shall find the explanation in a direction where we should least have expected it. The female mandibles are flattened, and the right mandible, when closed, partly overlaps the left. Their structure allows them to expand very widely, and the concavity behind the inner teeth exactly corresponds to the rounded epistoma-like clypeus (Pl. LXXXIV. fig. 16, Pl. LXXXV. fig. 9). At the point of the upper surface where the right mandible overlaps the left, we frequently find a projection which prevents their further closing. The length and thickness of the male mandibles render it impossible for them to overlap, except at the tip, and the pressure of the mandibles may have given rise to a projection which gradually developed into a large tooth, which would be produced on the opposite side by the law of bilateral symmetry. The base of the mandibles is exposed to similar friction, where the upper side touches the frontal margin (apart from the probability of the mandibles being also used for protection when the animals are fighting). Rudiments of these teeth are found in the males of *N. swinhoi* (Pl. LXXXIV. fig. 15) and other species.
DR. F. LEUTHNER ON THE ODONTOLABINI.

The parallel species known to me are as follows:

<table>
<thead>
<tr>
<th>Odontolabis</th>
<th>Neolucanus</th>
<th>Locality</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. O. siva (Pl. LXXXVI. figs. 5, 6).</td>
<td>N. lama (Pl. LXXXV. figs. 14, 15).</td>
<td>N. India.</td>
</tr>
<tr>
<td>2. O. sinensis (Pl. XCI. fig. 3).</td>
<td>N. parlescens (Pl. LXXXV. fig. 2).</td>
<td>China.</td>
</tr>
<tr>
<td>3. O. cuvera (Pl. XCI. fig. 9).</td>
<td>N. marginatus (Pl. LXXXV. fig. 3).</td>
<td>N. India.</td>
</tr>
<tr>
<td></td>
<td>N. parryi (Pl. LXXXV. fig. 4).</td>
<td>Siam and China.</td>
</tr>
</tbody>
</table>

But as it can hardly be supposed that it would be advantageous for Neolucanus to mimic in form and colour Odontolabis (with its much more strongly developed mandibles) in order to repel insectivorous foes, we are obliged to look for another explanation, and to recognize in their great resemblance a proof of their common origin (comp. pp. 482–83).

(i.) Group of O. alces.

The fact that so eminent an entomologist as Prof. Burmeister united O. siva, O. bellicosus, and O. alces, clearly suggests that these three species are closely related.

Map I.—Map of the Indo-Malayan Region, showing the Distribution of the Species allied to Odontolabis alces and O. stevensi.

Although O. siva (1) occurs without any important modifications in North India, China, and Formosa; Nias (a), Sumatra and Borneo (b), Celebes (c), Java (2), and Luzon (3) all possess their own characteristic species, which undoubtedly originated from a continental species, which was gradually modified into distinct species in these islands through isolation. This appears very probable both from the great similarity of the females
Diagram of the Species of the Genus *Odontolophus*

- **♂ black.**
  - **I. alces group.**
    - a. 1. *O. platynotus*, Hope. (China.)
    - b. 2. *O. siu*, Hope. (India, China, Formosa.)
    - 3. *O. gracilis*, Kaup. (Nias.)
    - **♀ similar.**
      - 4. *O. dalmani*, Hope. (Sumatra, Borneo.)
      - 5. *O. bellicosus*, Cast. (Java.)
      - 6. *O. celebensis*, Lansb. (Celebes, Sangir.)
      - 7. *O. alces*, Fabr. (Luzon.)

- **♀ mandibles simple.**
  - 8. *O. camelus*, Oliv. (Mindoro.)

- **♂ mandibles simple.**
  - 26. *O. latipennis*, Hope. (dejeani, Reich.)
    - Malacca.
    - Sumatra.
    - Banka.
    - Borneo.


- **B. ♀ Males.**
  - 28. *O. exatus*, H. (Calcon)

- 29. *O. carinatus*, Linn. (India, Cey.
  - 29 b. *O. cingalensis*, Parry. (Ceylon.)
is, arranged according to their Morphological, Genetic, and Geographical Relationships.

**♂ Mandibles Polymorphic.**

A. ♂ Mentum hairless.

Q bicolorous.

---

III. *burmeisteri* group.

11. *O. sinensis*, Westw. (China.)
12. *O. cuvera*, Hope. (N. India.)

---

II. *stevensi* group.

9. *O. stevensi*, Thom. (Celebes.)
10. *O. duivenbodii*, Deyr. (Sangir.)
14. *O. delesserti*, Guér. (S. India.)
15. *O. burmeisteri*, Hope. (Travancore.)

---

IV. *wollastoni* group.

16. *O. wollastoni*, Parry. (Malacca, Sumatra.)
17. *O. vollenhoveni*, Parry. (Borneo.)
18. *O. bulegingi*, Voll. (Sumatra.)
19. *O. lacordairii*, Voll. (Sumatra.)

---

V. *castelnaudi* group.

1. ♀ hairy.

22. *O. castelnaudi*, Parry. (Malacca, Sumatra, Borneo.)
23. *O. sommeri*, Parry. (Sumatra, Banka.)
24. *O. brookeanus*, Voll. (Borneo.)
25. *O. lowii*, Parry. (Borneo.)

**Incertae sedis.**

30. *O. striatus*, Deyr. (Malacca, Borneo.)
   ♂ var. *cephalotes*. (Borneo.)
and from the gradual modification of the male mandibles in the species 1, 2, 3, on the one side, and in *O. gracilis* (a), *O. dalmani* (b), and *O. celebensis* (c) on the other. In the former species the females are so similar in form that, although I have examined hundreds of specimens, I am hardly able to determine them with certainty unless the exact locality is recorded. In the females of *O. gracilis* and *O. dalmani* the prothorax is almost trispinose, as in the males. The strongly developed pro- and mesosternal processes and the shape of the mandibles render it probable that these species are offshoots of *O. bellicosus*. It will always remain uncertain whether they should be regarded as constant local races of *O. bellicosus*, or as distinct species. In the Chinese dwarf form, *O. platynotus* (Pl. LXXXVIII. figs. 9–12), the prothorax is similar in form in both sexes. In the larger males of *O. sica* a front angle is developed; but in the males of the other species the prothorax is always distinctly trispinose.

If we compare the forms of the mandibles of the males with each other we obtain the following results:—

In *O. platynotus*, *O. sica*, *O. gracilis*, *O. dalmani*, and *O. celebensis*, the two basal teeth are persistent, even in the terminal forms. In *O. bellicosus* (Pl. LXXXVIII. fig. 2) we find three basal teeth, but in the largest specimens the first projects more inwards, and the others disappear, so that the terminal form leads towards a mesodont form. In *O. alces* this development proceeds further, and a fourth form makes its appearance in which all the basal and central teeth disappear, and only the apical teeth remain.

<table>
<thead>
<tr>
<th>Species</th>
<th>Priodent</th>
<th>Amphidont</th>
<th>Mesodont</th>
<th>Telodont</th>
<th>Number of spines</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. O. platynotus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>4-5</td>
</tr>
<tr>
<td>2. O. sica</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. O. gracilis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. O. dalmani</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. O. celebensis</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>2-3</td>
</tr>
<tr>
<td>6. O. bellicosus</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. O. alces</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0-1-2</td>
</tr>
</tbody>
</table>

This differentiation of the mandibles is correlated with the diminution of the spines of the front tibiae, which seems to confirm the above phylogenetic origin of the species (comp. p. 391, § 7).

In the smallest priodont forms of *O. alces* (Pl. LXXXIX. fig. 7) the front angles of the prothorax disappear, and only the middle spine projects. The analogy of this form leads me to regard *O. camelus* (Pl. XCVI. figs. 7, 8) as nearest related to the present group, although it is certainly an abnormal form.
(ii.) *Group of O. stevensi.* (Plate XC.)

The connection between the black male and the bicolorous female of *O. stevensi* from Celebes was long suspected, but not proved until the discovery of the closely allied *O. duivenbodii*, in which the elytra are tricolorous in both sexes, and which occurs in the neighbouring island of Sangir. But the latter coloration is not exactly new, for it arises from the disappearance of the black pigment on the middle of the elytra, as in *Neolucanus cingulatus* (2°). Notwithstanding the differences in the prothorax (figs. 7, 8), the males exhibit much similarity in the structure of the head, and in the form of the mandibles; but in the largest forms (figs. 5, 6) the latter are differentiated, so that in the latest evolved species they are apparently more simplified than the parent species, and resemble those of *O. alces*, var. *dux*.

(iii.) *Group of O. burmeisteri.* (Plates XCI, XCI.)

This group comprises a very natural assemblage of species—(1) *O. sinensis* (China), (2) *O. mouhoti* (Siam), (3) *O. cuvera* (N. India), (4) *O. delesserti*, and (5) *O. burmeisteri* (Travancore). Their common origin is palpable, both sexes being equally differentiated. Their differences, however, depend more on colour than on form. In the group of *O. alces* the uniform black colour of the elytra, especially in the females, renders their determination a task of great difficulty; but in the present group it is more especially the females which enable us to separate the species satisfactorily by their characteristic and constant markings. In *O. sinensis* (Pl. XCI, fig. 4) there is only a narrow reddish-brown border to the elytra, both above and below. In *O. cuvera* (Pl. XCI, fig. 10) this is pale brownish-yellow, and much broader, but the under-surface of the rim of the elytra is always black. This is also the case in the much larger female of *O. delesserti* (Pl. XCII, fig. 4), whereas in the female of *O. burmeisteri* (Pl. XCII, fig. 9), in which the black portion of the elytra is still narrower, the under-surface of the recurved rim of the elytra is again yellow, as in *O. sinensis*. The male and female of each species agree in the colour and markings of the elytra, but the under-surface is frequently different. Thus it is in

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>O. sinensis</em></td>
<td>yellow</td>
<td>yellow</td>
</tr>
<tr>
<td><em>O. mouhoti</em></td>
<td>yellow</td>
<td>?</td>
</tr>
<tr>
<td><em>O. cuvera</em></td>
<td>yellow</td>
<td>black</td>
</tr>
<tr>
<td><em>O. delesserti</em></td>
<td>black</td>
<td>black</td>
</tr>
<tr>
<td><em>O. burmeisteri</em></td>
<td>yellow</td>
<td>yellow</td>
</tr>
</tbody>
</table>

Whether this enables the sexes to recognize each other, as it enables us to separate the species, cannot be decided. *O. sinensis* (Pl. XCI, figs. 1–3) and *O. cuvera* (figs. 7–9) agree in the forms of the male mandibles, and in the strong spines of the front tibiae.
Notwithstanding the conspicuous differences in size and colour of *O. delesserti*, this South-Indian species differs little from the former species in structure. The mandibles of the telodont form are larger than in *O. cuvera*, and there are two rather widely separated spines at the base (Pl. XCII. figs. 1, 1 b). I know of no mesodont form parallel to that of *O. cuvera*; fig. 2 is more like *O. mouhoti* (Pl. XCII. fig. 5) from Siam. The greatest development of the mandibles is found in *O. burmeisteri* (Pl. XCII. fig. 5 a, b), which, like the telodont form of *O. delesserti*, has two basal teeth. The central branch, which is dichotomous in the latter species, is simple, and nearer the middle in *O. burmeisteri*. The individuality of the telodont mandibles is so great in *O. burmeisteri* that it is impossible to meet with two exactly alike. The specimen figured differs considerably

Map II.—Map of the Indo-Malayan Region, showing the Distribution of the Species allied to *Odontolabis burmeisteri* and *O. wollastoni*.

from Hope's type and figure in possessing a strong ridge on the inner side of the mandibles, while in other specimens in the British Museum (as fig. 5 b) the mandibles
are rounded, and less strongly curved. The diminution in the spines on the front tibiae in *O. delesserti* proceeds further in *O. burmeisteri*, and they may even disappear entirely in the telodont form. This and the great variability of the extreme form, combined with geological facts, render it probable that we are dealing with a younger offshoot in which the characters have not become so stable as in the northern species.

The occurrence of the two last species in the same localities may lead to the production of hybrids, for I have seen individuals which it was difficult to assign to either species. This applies both to the small males and to female specimens.

The differences between the species of this group are so slight that Prof. Westwood regarded them as only geographical varieties. A large amount of material has enabled me to separate them (comp. anteà, p. 9). But it is obvious that continental species can never be so sharply defined as insular species.

The great similarity of the females and the uniform character of the coloration of the elytra bridge over the gap between the continental *Indian burmeisteri* group and the insular *wollastoni* group.

(iv.) *Group of O. wollastoni.* (Plates XCIII., XCIV.)

The males of this group are distinguished by the luxuriant development of their mandibles, and by the strongly marked and coarsely shagreened sculpture of their broad heads. The species here admitted are—(6) *O. wollastoni*, (7) *O. vollenhoveni*, (8) *O. ludekingi*, and (9) *O. lacordairii*, which inhabit Malacca, Sumatra, and Borneo. The two first species agree in the shape of the mandibles, and are only distinguished by their different colour. In *O. wollastoni*, which occurs in Malacca and Sumatra, the black triangular patch on the elytra is broad, nearly as in *O. cuvera*, but is less constant in form, and either extends in a point to the tip of the elytra (Pl. XCIII. figs. 5, 6), or it is broader (fig. 7), and ceases suddenly before the tip (in Parry's type) as in *O. sinensis* (Pl. XCI. fig. 1 c). In the Bornean *O. vollenhoveni* (Pl. XCIII. figs. 1-4) it is reduced to a narrow black stripe on the suture; but the head is marked with red in the male, which immediately distinguishes it from the preceding species. It occurs in south-eastern Sumatra in company with *O. lacordairii* (Pl. XCIV.). In *O. lacordairii* the red colouring is more extended, not being limited to the elytra, but occurring on the pectus and on the under-surface of the femora in the male, and on the prothorax in the female. *O. ludekingi* is distinguished by a narrow pointed stripe on each of the elytra; but only a few specimens are known. It occurs in the same locality as the two preceding species. Its peculiarly shaped mandibles, of which only small forms are known with certainty (Pl. XCIII. figs. 10, 11), at once resemble those of *O. lacordairii* (compare Pl. XCIII. figs. 10, 11, with Pl. XCIV. figs. 3, 4 c) and *O. wollastoni*, which, together with the two differently coloured females of *O. lacordairii*, render it probable that it is a hybrid between *O. wollastoni* and *O. lacordairii*. 
My prolonged morphological studies have led me to the conclusion that the remarkable species *O. gazella*, Fabr., is nearly related to the above species, notwithstanding its great apparent differences. In *O. gazella* the mandibles are always monstrously developed both in large and small males for some reason which cannot yet be even guessed at (Pl. XCVI. fig. 10). The large head, the broad prothorax, the long incurved front tibie channelled in front, and the strongly developed prosternal process make it probable that this species is derived from one in which the mandibles were normally developed as in other species, and afterwards, during the insect's competition with other species, developed into these extraordinary pincers. This view is supported by a unique specimen in Herr van Lansberge's collection, in which the mandibles are bilaterally and symmetrically developed, and have an inner branch in the middle (Pl. XCVI. fig. 10 b). The great pugnacity of this insect is manifested by the many wounds which it has received in conflict with other males. The canthus is bitten away, the central tooth of the right mandible is broken off, and there is an indentation at the tip. These injuries have certainly been caused by the mandibles of another individual, as the shape and character of the injuries clearly indicate. The necessity for defensive organs may have resulted in the widening of the canthus in both sexes. I have been led to this conclusion by the following considerations:—

1. The geographical distribution corresponds to that of the last-mentioned species. 2. Similarity of the females. 3. Resemblance of the amphiodont forms of *O. wollastoni* and *O. ludekingi* (Pl. XCIII. figs. 9, 11) in the shape of the head and in the structure of the mandibles. 4. In all these species the rim of the elytra is black on the underside. 5. The front margin of the prothorax in *O. lacordairii* (Pl. XCIV. fig. 2) has a tendency to become narrowed in front. 6. In all the small forms the legs are curved, and the front tibie are channelled. 7. The canthus, if we imagine the excavation to be filled up, would agree in all these species. Finally (8), agreement in the form and size of the prosternal process.

The characters of *O. gazella* being once permanently fixed, it becomes easy to understand how this species may have given rise to insular races, which were but slightly modified at first; and how a geographical subspecies, *O. inaequalis*, Kaup, distinguished by the uniform dark colour of the elytra, might become differentiated in the island of Nias (Pl. XCVI. fig. 12). In this form the mandibles (fig. 12 a, b) remain apparently unaltered, but the number of spines on the front tibie is reduced. Unfortunately the female of *inaequalis* is still unknown, and we do not know whether its coloration has become modified like that of the male.

(v.) Group of *O. castelnaudi*.

Although this group appears at first sight to contain very dissimilar species, a thorough examination shows them to be more closely related to one another than their external appearance, and sometimes variable coloration, might lead us to expect. In
order to facilitate their study, we will divide them into three sections, and begin with the second. The different male forms are arranged on Pl. XCV. so as to admit of easy comparison.

A. Mentum hairy.

O. aeratus.

O. carinatus, Linn.

B. Mentum hairy.

O. castelnaudi.

O. sommeri.

O. brookeanus.

O. lowii.

C. Mentum hairless.

O. latipennis.

O. fratellus.

The females of this section (Pl. XCV. figs. 5, 10, 16) agree in appearance and colour with those of the two preceding groups. The coloration reminds us of *O. euvera* and *O. wollastoni*, in *O. sommeri* (figs. 10, 11); in the variety (fig. 12) the yellow colour already extends to the sides of the prothorax, and is still more variable in *O. brookeanus* (figs. 16, 17, 18). In *O. castelnaudi*, which is nearly twice as large, the elytra are almost entirely yellow, owing to the disappearance of the triangular spot, the last remains of which are seen in a small stripe at the base and another on the suture (fig. 5).

In the males the black triangular spot on the elytra is reduced to a narrow black line on the suture, and the pale coloration extends to the sides of the prothorax, and even to the head and to the under-surface of the body. Apart from the immediately obvious similarity of the males, they present the following morphological resemblances, viz.: a large broad head, a short and very broad prothorax, long curved fore legs, with few spines, and in the telodont forms, a broad quadrangular epistoma-like clypens. A character peculiar to all the species of this group is the hairy mentum, and in the three last species the gula is also hairy. Notwithstanding the difference of the mandibles in the telodont forms (figs. 1, 13) (which are at present insufficiently known in all the species) they are remarkably similar, both in the priodont (figs. 8, 15), amphiodont (figs. 4, 7, 9, 14), and mesodont (figs. 2, 3, 6). This resemblance can only be accounted for by a common origin and hereditary descent, with a tendency to modification—a view which is likewise confirmed by their geographical distribution, for *O. sommeri* occurs in Banka (and Sumatra), and is intermediate between *O. castelnaudi* and *O. brookeanus*, which occur in Sumatra and Borneo, between which islands Banka is situated; and *O. lowii*, which is most nearly related to *O. brookeanus*, likewise occurs in Borneo.

The amphiodont form of *O. castelnaudi* (Pl. XCV. fig. 4) easily leads us on to the male form of *O. latipennis* (Pl. XCVII. fig. 1) belonging to Section C. The shape of
Map III.—Map of the Indo-Malayan Region, showing the Distribution of the Species allied to Odontolabis castelnaudi.

1. O. castelnaudi, Parry.
2. O. sommeri, Parry.
3. O. brookeanus, Tollh.
4. O. lowii, Parry.
5. + O. latipennis, Hope.
6. O. fratellus, Leuthn.
7. O. acatus, Hope.
8. O. carinatus, Linn.

the head is nearly the same as in O. castelnaudi and O. brookeanus, and the shape of the mandibles is very similar. The broad prothorax is very similar, and the front tibiae are long and strongly curved. The whole body, including the elytra, is apparently dark brown; but, on a closer examination, the suture proves to be deep black, while the elytra are otherwise deep chestnut-brown. In the female, however, the black shoulder-spots make the two colours of the elytra easily perceptible. We can readily perceive from O. gazella and O. inaequalis how easily this change of colour may have arisen. The variations of the prothorax which occur in the Bornean O. castelnaudi (Pl. XCV. fig. 3) reappear in O. latipennis, in the small Banka race of which the prothorax is much narrowed in front (Pl. XCVI. fig. 3); and this is still more remarkable in O. fratellus from Manilla (Pl. XCVI. figs. 5, 6). In the latter species the colour is almost uniform deep black in both sexes. The geographical distribution (compare Map III.) agrees with their probable origin. It is perfectly parallel to that of O. gazella.

The gap between Sections A and B appears at first to be insurmountable; and it appeared so considerable to the descriptive morphologists that they separated Section A as a separate subgenus under the name of Calcodes.
Much uncertainty existed for a long time about the systematic position or, rather, affinities of *O. aratus*. Hope was misled by the unusual metallic colour of this species, and placed it in his ‘Catalogue’ (p. 5) between *Cyclommatus tarandus* and *Anoplocnemus*; and Prof. Westwood considered it to be nearest allied to his *Lepidodes rotundicollis* (= *Cacostomus squamosus*, Newm.), an Australian species. Prof. Burmeister first recognized *O. aratus* as an *Anoplocnemus* (*Odontolabis*), while Thomson and Parry (the one immediately, and the other in the second and third editions of his catalogue of Lucanidae) referred it to Westwood’s subgenus *Calcodes*.

The more our knowledge was increased by the discovery of new species, the easier it became to perceive the real affinities of *O. aratus*. If we pass over its metallic lustre and small size, and pay attention to the structure of the female, we are obliged to admit that its morphological characters agree perfectly with those of Section B. The strongly curved mandibles in the telodont form (Pl. XCVII. fig. 4) and the small elevation between the apical group of teeth and the central tooth, are very similar to those of its allies, *O. castelnaudi* and *O. sommeri*, which occur in adjacent countries. It is likewise related to them by the broad clypeus and hairy mentum (only observed and described by Westwood), the long curved front tibiae, considerably widened on the inside at the tip, and the very hairy tarsi of all the legs.

As Parry had already suspected, *O. carinatus*, Linn. (*nigritus*, Deyr.), which occurs both on the east coast of India and in Ceylon (comp. Map III. p. 417), is nearly related to the present group. The form of the head (owing chiefly to the absence of the spine behind the eyes in the male) and the long front tibiae have led to its being placed in the genus *Calcodes*, Westw., with *O. aratus*. Traces of its relationship to its eastern progenitor may be found in the remarkable hairiness of the mentum and gula (fig. 12, c) and the thick silky hair of the tarsi; but the considerable deviation of the male mandibles, the disappearance of the broad quadrangular clypeus in the telodont form (Pl. XCVII. fig. 11), and its uniform pitchy black colouring, are the results of long-continued isolation.

*Species incertae sedis.*

*O. striatus* is a most exceptional form among the Odontolabiini (Pl. XCVII. figs. 1–3), and its relationship with any of the preceding groups is very obscure. The long and strangely shaped mandibles of the male, only the most highly developed form of which

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1 The metallic lustre (which is very slight in the female) appears strange at first sight, but is not sufficiently remarkable to justify the formation of a new genus. It is occasionally met with in the Lucanidae, as, for instance, in *Cyclommatus* (where it is frequently wholly absent in the female), and also occurs in *Chiasosynathus* and *Lamprina*. Several authors have supposed that this metallic lustre is due to the direct effect of the sun’s rays, as these beetles are active in broad day; but it is certain that this lustre, although unaffected by acid, disappears when dead specimens are exposed to sunlight. Specimens of the beautiful gold-shining *Chiasosynathus*, which were exhibited for thirty years in the gallery of the British Museum, have become quite brown and bleached, like their less brightly coloured allies.
is at present known, the short, broad, and very spinose front tibiae, the hairy covering, and the remarkable striation of the elytra in alternate hairy and hairless lines (traces of which likewise occur in hairy specimens of *O. carinatus*, var. *cingalensis*, fig. 13), prevent our hazarding any conjecture respecting its actual affinities.

III. *Heterochthes*.

Although the males (Pl. LXXXIV. figs. 5-7 and 9-11) much resemble those of the genus *Odontolabis* in the development of the mandibles, the shape of the mandibles in the female (figs. 8, 12) is very different from that which occurs in either of the preceding genera, and stamps this as a completely isolated form. The female is relatively larger than in *Neolucanus* or *Odontolabis*, as is seen by the comparatively broader head, the hinder portion of which is broader, and projects somewhat from the prothorax, which renders the head more quadrangular.

The female mandibles exhibit a gap which separates the obtuse basal from the apical teeth. This is not altogether new, for the gap is present in the females of other Odontolabini; but the inner base of the mandibles is less strongly developed, and the flattened articulation is concealed by the semicircular epistoma. The latter is almost entirely absent in the female of *Heterochthes*, and the result is that the basal part of the mandibles, which is generally protected, is much enlarged. The two species of *Heterochthes* exhibit very slight differences in the females, but in the males the differences are much more conspicuous. The male forms of *H. brachypterus* are insufficiently known, but do not appear to develop a central tooth producing a mesodont form as in *H. andamanensis*. The two species are, as Professor Westwood has already pointed out, nearest allied to *Neolucanus laticollis* from Java, to which they bear, as higher-developed forms, the same relation as some of the species of *Odontolabis* to certain species of *Neolucanus*.

PART II.

DESCRIPTION OF THE GENERA AND SPECIES OF ODONTOLABINI.

LUCANIDÆ.

Subdivision ODONTOLABINI.


Clava of antennæ triarticulate, the leaflets being flat, but considerably produced, extremely finely pubescent. Clypeus comparatively small. Eyes divided in both sexes by a canthus, which is remarkably broad in the female. Mandibles polymorphic, varying very considerably in size and shape. Anterior tibiae in the males often considerably longer than the four hinder ones, very frequently curved, and their external armature very variable. The four posterior tibiae invariably unarmed in both sexes.
This subdivision includes the three genera:

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<th>♀</th>
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<th>Head.</th>
<th>Mandibles.</th>
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<tbody>
<tr>
<td>I. Neolucanus</td>
<td>normal.</td>
<td>normal.</td>
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<td>serrated, often forked at the tip.</td>
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<tr>
<td>II. Odontolabis</td>
<td>considerably longer.</td>
<td>with a spine behind the eyes.</td>
<td></td>
<td></td>
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<tr>
<td>III. Heterochthes</td>
<td>longer.</td>
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<td>multiform. amphiodont.</td>
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(1) **Neolucanus**, Thoms.

еті new; *Lucanus*.


**Male.** Front of the body (inclusive of the mandibles) scarcely longer than the hinder portion. Head broad, flattened, front margin strongly emarginate. Canthus extending entirely round the eyes. No protuberances on the sides of the head behind the eyes. Mandibles not much longer than the head, serrated on the inside, often vertically forked at the tip, and generally somewhat curved upwards. Prothorax as broad as or broader than the elytra, front edge strongly emarginate on each side, the sides straight, or only slightly curved, the hinder angles pointed. Prosternal process rounded off, not projecting behind, and generally channelled. Legs of uniform length, front tibiae short, dentate on the outside, middle and hind tibiae unarmed.

**Female.** Hardly different from that of *Odontolabis*; mentum generally furnished with a strong crescent-shaped ridge.

Hope divided his genus *Odontolabis* into two sections, according to the presence or absence of protuberances behind the eyes; but he proposed no generic name for his second division. Thomson soon supplied the omission by proposing the very inexpressive name *Neolucanus*, which the law of priority compels me to retain, although Parry’s name is much more correctly formed, besides expressing the intimate relationship of this genus with *Odontolabis* (comp. diagram of the species, p. 407).

**Section I.**

1. **Neolucanus laticollis**, Thunb. (Plate LXXXIV. figs. 1, 2, ♂; fig. 3, ?.)


*Lucanus glabratu*, Hope (De Haan, MS.). Cat. Lucan. Col. p. 18. (Assam?)

**Male.** Pitchy black, shining; head quadrangular, flattened, with a strong semicircular concavity in front, and the sides nearly straight; canthus oblique; mentum sparingly clothed with reddish-brown hair; lower part of the cheeks shining, with
scattered punctures; prothorax, front edge strongly indented on each side, sides and hinder margin nearly straight; prosternal process rounded; elytra strongly convex, arched, of a long oval shape; front tibiae rather broad, with four spines above the terminal fork; mandibles shorter than the head, each with four or five small irregular teeth on the inner side.

**Female.** Pitchy black, shining; elytra much longer than the front part of the body; head broad, moderately convex, front coarsely punctured; canthus as broad as the eyes; mentum strongly and coarsely punctured; prothorax flattened, shaped as in the male; prosternal process canaliculated; front tibiae broad, with three or four spines above the terminal fork; middle and hind tibiae with a small hook-shaped projection on the inside at the tip.

**Locality.** Java.

Number of specimens examined eighty.

**Measurements.**

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<td>38</td>
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<td>4·5 &quot; 8·5</td>
<td>4</td>
<td>7 &quot; 13·5</td>
<td>18 &quot; 13·0</td>
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This species occurs only in Java, and not, as Hope believed, in Assam. The males vary but little in size. Their mandibles are always simple and priodont.

2. (?) *Neolucanus lansbergi*, sp. n. (Plate LXXXIV. fig. 4.)

**Male.** Unknown.

**Female.** Most resembling that of *N. laticollis*, from Java, in shape and size. Head broad, quadrangular, moderately convex, coarsely shagreened in front, finely behind; canthus rounded off, nearly as broad as the eye; mentum coarsely punctured, without hair; gula with an enamel-like lustre; prothorax broader than in *N. laticollis*, the sides rather more oblique, strongly convex, and very finely punctured; under-surface with an enamel-like lustre; prosternal process but slightly developed; elytra long, oval, rounded off both at the shoulders and at the tip, strongly convex; uniform jet-black, with a dark reddish-brown spot on each elytron, commencing about 4 millimetres behind the shoulder and ending near the tip; it is pointed in front and rounded behind; the outer side is parallel with the black borders of the elytra; the inner side is straight, and runs diagonally from the shoulder to the tip; rim of the elytra black beneath; front tibiae straight; terminal fork well developed, and two or three straight and well-developed spines on the outside.

**Habitat.** Eastern Sumatra.

Unique, in the collection of Herr van Lansberge, after whom I have much pleasure in naming it.


"Male. Castaneus, nitidus, mandibulis capiti æqualibus, sursum læviter incurvis, intus parum excavatis, serrato-dentatis, capite antice emarginato, prope oculos bituberculato, angulis ante oculos rotundatis, prothorace lateribus rotundato, angulis posticis oblique truncatis, elyris tenne et sparsim punctulatis, pedibus grosse punctatis, et parce flavo-pilosis, tibiis anticus extus bidentatis; intermediis et posticis inermibus; tarsi obscurioribus.

"Longitudo corp. cum mandib. 21·5 mm."

Female. Unknown.

Habitat. Sarawak, Borneo.

I was unfortunately unable to obtain the unique male specimen existing in the Museum at Genoa for examination, and therefore copy Gestro's description without pledging myself to its accuracy. This Bornean species seems to be closely allied to N. cingulatus, Parry, from Malacca.

4. Neolucanus cingulatus, Parry. (Plate LXXXV. fig. 10, &.)

Neolucanus cingulatus, Parry, Trans. Ent. Soc. Lond. (3) ii. p. 20, pl. iv. fig. 3, enlarged & (type).

Male. Unknown.

Female. Uniform reddish brown; elytra tricolorous (pale red, dark nut-brown, and yellow).

Head brown, front emarginate, with two dots on the inner side of the eyes; canthus oblique, as broad as the eye; upper surface with large scattered punctures; mentum flattened, hairless, coarsely punctured, lower part of the cheeks with large scattered punctures; gula very finely punctured; mandibles small, coarsely shagreened; prothorax broad and flattened, the front edge strongly emarginate on each side, front angles rounded off, sides nearly straight as far as the middle spine, and somewhat emarginate beyond; hind margin nearly straight, with acute angles; upper side rather dull and very finely punctured; underside with an enamel-like lustre; prosternal process rounded off, carinated; elytra of a long oval shape, rounded off at the tip, reddish brown, each with a long yellow spot, commencing near the shoulders, pointed in front and rounded behind, not extending either to the suture or to the tip; the lower recurved rim of the elytra reddish brown, and the entire under-surface and legs of the same colour; front tibiae broad, with two spines above the terminal fork.

The type (from the Count of Castelnau's collection) is now in Herr van Lansberge's possession.

Habitat. Malayan peninsula.
Measurements.

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<th>Total length</th>
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Major Parry confused two species under the name of *N. cingulatus*. One occurs in Malacca and the other in Siam (Laos). The former agrees perfectly well with his fig. 3, and the latter with part of his description:—“Nigro-castaneus, nitidus, sub-parallelus, elytris singulis vitta obliqua flavâ ab humero ad apicem notatis.”

The original, from which the above-mentioned figure was taken, was admirably painted by Migneaux, rather above the natural size, and came into possession of Major Parry through the agency of the late Count Mniszech, who did so much for the study of the Lucanidae. It agrees perfectly with the type from the collection of Count de Castelnau, which was kindly lent me for examination by its present owner, Herr van Lansberge, and thus enabled me to clear up all doubts relating to this species, and to make a careful description of it. Unfortunately the specimen remains unique, and the male is still unknown; but it appears to be most nearly allied to Gestro’s *Neolucanus muntjac*, from Borneo.

The other species from Siam, which I propose to call *N. parryi*, is allied to *N. castanopterus*, Hope, and *N. swinhoei*, Parry.

Section II.

5. *Neolucanus castanopterus*, Hope. (Plate LXXXIV. fig. 13, ♂ (a, mentum); fig. 14, ♀ (b, mentum).)


Westwood, Cab. Or. Ent. pp. 22 and 54, pl. x. fig. 5 (♂), and pl. xxvi. fig. 6 (♀); Parry,

Trans. Ent. Soc. Lond. (3) ii. p. 78.


Male. Uniform black, except the reddish-brown elytra; head and prothorax dull, with extremely fine punctures; underside and elytra shining; head broad, quadrangular, front edge emarginate; canthus narrow, the sides of the head convex behind in large specimens; mentum thickly clothed with brown hair; mandibles straight, triangular, scarcely as long as the head, the tips curved inwards, with five or six irregular teeth on the inside; upper side shining; prothorax but little convex; front edge and sides rounded, hind margin nearly straight; elytra long and very convex, the tips rounded; reddish brown, with only the base and scutellum black; the lower reflexed rim black; front tibiae broad in front, with from three to five spines above the terminal fork.

Female. Colour similar to that of the male; head quadrangular, canthus narrow, straight; mentum with a slightly developed crescent-shaped crest; prothorax broad;
front edge only slightly emarginate, sides rounded, hinder margin straight; elytra long, the sides parallel; the tip rounded; front tibiae very short and broad, with five or six spines above the terminal fork.

_Habitat._ North India, Darjiling.

Number of specimens examined: males sixty-three, females twenty.

**Measurements.**

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<td>♂ ......</td>
<td>36</td>
<td>5 by 10</td>
<td>6</td>
<td>8 by 14</td>
<td>19 by 14</td>
</tr>
<tr>
<td>♀ ......</td>
<td>34</td>
<td>5 „ 9</td>
<td>5</td>
<td>8 „ 15</td>
<td>19 „ 15</td>
</tr>
</tbody>
</table>

The tips of the mandibles are never forked, even in the largest males.

6. _Neolucanus swinhoei_ (Parry), Bates. (Plate LXXXIV. fig. 15 a, b, ♂; fig. 16, ♀.)


_Male._ Very like _N. castanopterus_, but larger and broader, elytra broader and flatter, canthus broader, mandibles longer than the head, forked at the tip in large specimens; in small ones as in _N. castanopterus_, but dull and shagreened, with seven or eight teeth on the inside; mentum thickly clothed with brown hair; elytra coloured as in _N. castanopterus_, the sides not parallel, but gradually narrowing to the tip; front tibiae narrower in comparison, with four or five spines above the terminal fork.

_Female._ Larger than _N. castanopterus_, and similarly coloured, but much more unlike it than the male; broader, head entirely different from that of _N. castanopterus_ ♀ in shape; triangular, canthus broad, obliquely projecting outwards; mentum coarsely shagreened, with strongly developed crescent-shaped crest; prothorax longer, the front edge strongly emarginate; elytra as in the male, gradually narrower to the tip; front tibiae slender, with three or four spines above the terminal fork.

_Habitat._ Formosa.

Two males and two females, in the collections of Parry and Bates.

**Measurements.**

<table>
<thead>
<tr>
<th></th>
<th>Total length</th>
<th>Head</th>
<th>Mandibles</th>
<th>Prothorax</th>
<th>Elytra</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
</tr>
<tr>
<td>♂ ......</td>
<td>45</td>
<td>6 by 12</td>
<td>9</td>
<td>10 by 18</td>
<td>23 by 18.5</td>
</tr>
<tr>
<td>♀ ......</td>
<td>34</td>
<td>5 „ 9</td>
<td>5</td>
<td>8 „ 15</td>
<td>20 „ 15.0</td>
</tr>
</tbody>
</table>

7. _Neolucanus parryi_, sp. n. (Plate LXXXV. fig. 4, ♀.)


_Male._ Shining black; elytra resembling those of _Odontolabis cuvera_, Hope, chestnut-brown, with a black triangular spot; head broad, emarginate in front, straight on the
sides; upper side dull; mandibles short, shining, forked at the tip, and with six or seven small teeth on the inside; mentum thickly clothed with brown hair; prothorax broad, the front edge strongly emarginate, the sides very slightly convex as far as the middle spine, which is rounded off; behind this the sides are slightly emarginate; the hinder edge is waved; prosternal process well developed, obtuse; elytra of a long oval form, rounded at the shoulders and at the tip, pale chestnut-brown, with a triangular black spot commencing at the shoulders, and gradually decreasing and coalescing with the narrow black borders of the elytra; rim of the elytra black beneath; front tibiae narrow, with four or five spines on the outside above the terminal fork.

Female. Resembles Neolumbanus marginatus, Waterh. (fig. 3), and Odontolabis cuvera; uniform black; elytra bicolorous.

Smaller and broader than N. marginatus, with the thorax and elytra more convex; head broad, flat, emarginate, and strongly shagreened in front, upper side dull, canthus oblique and then rounded, nearly as broad as the eye; mandibles short; mentum with a crescent-shaped crest, strongly shagreened and hairless; prothorax broad, dull, strongly emarginate on each side in front, the front angles pointed, the sides slightly convex, and broadest in the middle; middle spine rounded, the sides behind it somewhat emarginate; hind margin nearly straight, hinder angles pointed; prosternal process rounded, and rather pointed behind, carinated in small specimens; elytra remotely oval, strongly convex, and rounded at the tip; the black triangle which begins at the shoulder rapidly narrows hindwards, and coalesces towards the tip with the rather broad black border, which renders the intermediate yellowish brown stripes linear; underside of the recurved elytra jet-black; front tibiae long and narrow, with four spines above the terminal fork; underside of the femora with fine scattered hairs.

Habitat. Province of Kouey Cheou, in China, collected by l'Abbé Largeteau; Laos (Siam), collected by M. Mouhot.

One male (type), in the collection of M. Oberthiir, of Rennes; two females (types), in Major Parry's collection.

**Measurements.**

<table>
<thead>
<tr>
<th></th>
<th>Total length</th>
<th>Head</th>
<th>Mandibles</th>
<th>Prothorax</th>
<th>Elytra</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
</tr>
<tr>
<td>♂ ...... 44</td>
<td>6 by 12·0</td>
<td>8</td>
<td>10 by ?</td>
<td>13 „</td>
<td>?</td>
</tr>
<tr>
<td>♀ ...... 34</td>
<td>6 „ 10·5</td>
<td>5</td>
<td>9 „ 15</td>
<td>19 by 15·6</td>
<td></td>
</tr>
</tbody>
</table>

Two females of this species, from Siam, stood in Major Parry's collection for a long time as females of his N. cingulatus. Shortly before the completion of this paper, I received a male (unfortunately damaged), through the kindness of M. R. Oberthiir, of Rennes, from a Chinese province further north than Siam. It reached me just in time for the description to be here included, but too late to be inserted in the Plates, which were already drawn on the stone. I cannot better express my thanks to Major Parry for the many kindnesses which I have received at his hands than by naming this interesting species after him.

**Female.** "Pitchy black, with the sides of the thorax pitchy; elytra pitchy black, each elytron with a broad ochraceous stripe extending from the shoulder almost to the apex; this stripe is narrow at the shoulder, then somewhat suddenly widens, and remains of an equal breadth for about half of its whole length, and then gradually narrows to the apex, thus leaving the elytra narrowly bordered with black, and with a somewhat triangular patch of the same colour covering the disk; the suture is pitchy; the anterior tibiae are furnished on the outer edge with three sharp teeth, and the apex is bifurcate; the posterior tibiae are longitudinally canaliculate, the channels are four in number on the outer side, deeply and closely punctured; on the inner or under side there are two longitudinal rows of deep punctures, one of them forming a slight channel at the base; the space between this row and the channel next to it of the four above mentioned is very convex, and has only four or five punctures; in the second row the punctures are separated from each other; the space between these two rows is convex and impunctate; the head is sparingly but deeply punctured on the underside between the eye and the gula, the gula itself is very shining, with scarcely any visible punctures. The abdomen has the sides and apical segment punctured, the central part smooth, with a few minute punctures visible with a magnifying power.

"Habitat. Northern India. British Museum."

The following is Mr. Waterhouse’s description of the specimen which he presumes to be the male of the above species. The specimens are from the same collection.

"Black, with the thorax, elytra, sterna, and abdomen pitchy. Very similar to *N. lama*, but much less convex. The thorax particularly is less arched in the middle, so that there is a much more gradual incline to the lateral margins, and these in consequence appear more expanded; the sides are much more converging in front, the width at the angle before the basal emargination being 18 millim., and at the anterior angles 11 millim.; in *N. lama* the difference is 18 millim. posteriorly and 13 millim. at the anterior angles in an example of the same development; the anterior margin is much less bowed than in *N. lama*.

"Hab. Lacken, Sikkim (9000 feet)."

**Measurements.**

<table>
<thead>
<tr>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>( \sigma )</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
</tr>
<tr>
<td>42</td>
<td>7·5 by 11</td>
<td>8·0</td>
<td>9 by 20·0</td>
<td>26·0 by 19·0</td>
<td></td>
</tr>
<tr>
<td>( \varphi )</td>
<td>6·0 ,, 11</td>
<td>6·5</td>
<td>9 ,, 16·5</td>
<td>21·5 ,, 16·5</td>
<td></td>
</tr>
</tbody>
</table>

9. Neolucanus pallescens, sp. n. (Plate LXXXV. fig. 2, \( \sigma \).)

**Male.** Intermediate between *N. swinboii* and *N. nitidus*, similar in size and form, uniform black, with the exception of the elytra; head similar to *N. swinboii*, eyes
comparatively smaller, canthus broad, triangular, under-surface of the head dull, cheeks much more finely punctured, mentum thickly clothed with brown hair; mandibles dull, forked at the tip, with eight teeth on the inner side; prothorax shaped as in *N. swinhoii*, but much narrower in front, which renders the sides oblique as far as the rounded middle projection, behind which they are slightly emarginate; hinder border nearly straight, pointed at each side. Prosternal process nearly obsolete, elytra similar in shape and convexity to *N. swinhoii*, but varying from dark chestnut-brown to black; from the shoulders runs a pale brown border, about 2½ millim. broad, resembling that of *Odontolabis sinensis*. Recurved rim of the elytra as well as the legs black; front tibiae narrow as in *N. swinhoii*, with four spines above the terminal fork.

*Habitat.* China (no special locality indicated).

**Measurements.**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total length.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
</tr>
<tr>
<td><em>σ</em> .......</td>
<td>42</td>
<td>6 by 11</td>
<td>9</td>
<td>9·5 by 16·5</td>
</tr>
</tbody>
</table>

Herr van Lansberge found a single male (type) of this interesting transitional form among a series of *Odontolabis sinensis*. The female is unfortunately still unknown.


*Male.* Uniform black. Prothorax and elytra shiuing; head broad, quadrate, emarginate in front; eyes small; canthus nearly straight, rather broad, sides of the head behind the eyes strongly swollen; mentum broad, quadrangular, thickly clothed with reddish brown hair; mandibles wanting; prothorax much longer than the head, but scarcely broader than the elytra; the front edge strongly emarginate on each side; sides at first nearly straight, but afterwards strongly rounded as far as the hinder angle; hind margin nearly straight; prosternal process well developed, strongly projecting beneath; elytra long, oval; shoulders rounded, and the sides then gradually rounded to the tip; front tibiae narrow, with four or five spines above the terminal angle.

*Female.* Unknown.

*Habitat.* China (no special locality indicated).

**Measurements.**

<table>
<thead>
<tr>
<th></th>
<th>Head.</th>
<th>Prothorax.</th>
<th>Elytra.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total length (without mandibles).</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
</tr>
<tr>
<td><em>σ</em> .............</td>
<td>35</td>
<td>7 by 11·5</td>
<td>9 by 17</td>
</tr>
</tbody>
</table>

Male types in Major Parry’s collection without mandibles.
Section III.

11. Neolucanus sinicus, Saund. (Plate LXXXV. fig. 7, ♂ ; fig. 5, ♀.)

*Odontolabis sinicus* (Reiche), Saund. Trans. Ent. Soc. Lond. (2) iii. p. 48, pl. iv. fig. 2, ♂ , fig. 3, ♀.

**Male.** Head black, prothorax and elytra greyish brown, dull, underside and legs darker; head broad, quadrangular, flattened, front margin nearly straight; canthus broad in front and narrower behind; mentum hairless; mandibles as long as the head, curved outwards, forked at the tip (except in small specimens) with eight small teeth on the inner side; prothorax longer than the head, front edge strongly emarginate on each side, front angles pointed, sides a little convex, and then obliquely truncated; hind margin straight; elytra much narrower than the prothorax, long, oval, and pointed behind; front tibiae slender, with four spines above the terminal fork.

**Female.** Rather darker coloured than the male. Head flattened, dull black; canthus oblique, broad, projecting outwards; mentum coarsely punctured; prothorax deeply excavated on each side in front, slightly curved and slightly emarginate behind on the sides; hinder margin straight; elytra strongly convex, truncated at the shoulders; front tibiae broad, with four or five spines above the terminal fork.

**Habitat.** China (Shanghai).

Number of specimens examined: ten males and six females. (Type in the collection of Major Parry, other specimens in various collections.)

**Measurements.**

<table>
<thead>
<tr>
<th></th>
<th>Total length</th>
<th>Head</th>
<th>Mandibles</th>
<th>Prothorax</th>
<th>Elytra</th>
</tr>
</thead>
<tbody>
<tr>
<td>♂ (type)</td>
<td>34</td>
<td>5.5</td>
<td>8</td>
<td>7.5 by 14</td>
<td>17-5 by 13.5</td>
</tr>
<tr>
<td>♂ (protand)</td>
<td>26</td>
<td>4-5 by 7</td>
<td>5</td>
<td>5-5 „ 10-5</td>
<td>14-5 „ 10-5</td>
</tr>
<tr>
<td>♀</td>
<td>24-5</td>
<td>3-5 „ 7</td>
<td>3-5</td>
<td>6-0 „ 12</td>
<td>15-5 „ 12</td>
</tr>
</tbody>
</table>

12. Neolucanus championi, Parry. (Plate LXXXV. fig. 8, ♂ ; fig. 6, ♀.)


**Male.** Uniform dull black; coxae and tibiae paler, otherwise resembling *N. sinicus*, but rather narrower.

Front tibiae narrow, with four or five spines on the outer side, above the terminal fork, which are always more strongly developed than in *N. sinicus*; mandibles shaped as in the preceding species.

**Female.** Uniform black; prothorax and elytra shining; head dull, otherwise as in *N. sinicus*.

**Habitat.** China (Hong Kong).

Four males and one female (types) in Major Parry's collection.
13. **Neolucanus oberthueri**, sp. n.

Nearest to *N. championi*, Parry; uniform dull black, except two crescent-shaped yellow spots on the hinder half of the elytra.

**Fig. 6.**

**Male.** Head with the frontal margin straight, broadest in front, and becoming gradually narrower towards the neck; canthus as broad as the eye, oblique; mentum dull, hairless, much shorter than in *N. championi* (1·5 by 3·5, and 2 by 3·5); prothorax as broad as or rather broader than the elytra; front edge less emarginate on the sides; front angles acute; sides less convex, middle projection rounded; hinder margin nearly straight, with acute angles; the front and hind borders thickly clothed with yellowish hair, especially on the underside; prosternal process rounded, canaliculated, obtuse behind; elytra long, oval, moderately convex, shoulders and tip, especially the latter, rounded off, dull black, with a crescent-shaped spot about 2 millim. broad, beginning on the second half of the elytra, convex on the outside and straight on the inside, and ending at the tip of the elytra, just before the suture; recurved rim of the elytra black; front tibiae short, with four or five spines on the outside, above the terminal fork; underside rather paler; legs finely punctured, shining; mandibles large, forked at the tip, with nine teeth on the inside; a ridge runs from the upper fork along the upper part of the inner border.

**Female.** Head broad, triangular when the mandibles are closed; epistoma rounded; upper side convex, strongly punctured; canthus as broad as the eye, oblique in front, and straight behind; mentum strongly and coarsely shagreened, with an elevation on each side; prothorax with the sides rounded, and the hinder angles pointed; elytra long, oval, rounded at the shoulders and tip, and marked with yellow crescents as in the
male; front tibiae broad, with four or five blunt spines above the slightly developed terminal fork.


Measurements.

<table>
<thead>
<tr>
<th></th>
<th>Total length</th>
<th>Head</th>
<th>Mandibles</th>
<th>Prothorax</th>
<th>Elytra</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
</tr>
<tr>
<td>♂</td>
<td>34.5</td>
<td>6 by 10</td>
<td>8.5</td>
<td>8 by 14</td>
<td>17 by 14.0</td>
</tr>
<tr>
<td>♀</td>
<td>32.0</td>
<td>5 &quot; 9</td>
<td>4.0</td>
<td>8 &quot; 14</td>
<td>19 &quot; 14.5</td>
</tr>
</tbody>
</table>

I have much pleasure in dedicating this new and interesting species to M. Réne Oberthür, the well-known coleopterist at Rennes.

Section IV.

14. Neolucanus lama, Oliv. (Plate I.xxxv. figs. 14, 15, ♂; figs. 11, 12, ♀.)


Lucanus angulatus, p., Hope, Cat. Luc. Col. p. 17 (Silhet, Khasia hills).

♀. Lucanus lama, Oliv. Entom. i. no. 1, p. 14, pl. iii. fig. 8 (figure not quite correct).

Male. Uniform pitchy black, elytra paler.

Head shorter than the prothorax, broad, front edge strongly emarginate, flattened, dull; canthus triangular, broadest in front of the eye; clypeus with triangular epistoma; mentum short, broad, quadrangular, clothed with thick red matted hair; prothorax strongly convex, broad, the front edge strongly emarginate on each side, front angles pointed or slightly rounded, sides slightly convex, middle spine obtuse; sides behind emarginate; hind margin only slightly curved, ending in a fine point on each side; elytra long, oval, shining; front tibiae as long as the hind ones, narrow, with five spines on the outside above the terminal fork. Upper side coarsely punctured.

Mandibles in large specimens longer than the head, straight, slightly incurved at the tip, and vertically forked; inner side with nine irregular teeth, crowded together, and without gaps. In small specimens the tip is not forked (fig. 15).

Female. Pitchy black, elytra paler; head broad, convex, dull, emarginate in front, with large scattered punctures; mandibles with three strongly marked teeth on the inside; canthus broad, oblique in front, and then straight, strongly punctured; mentum with a strong raised semicircular crest, open in front; prothorax strongly convex, front edge strongly emarginate, the front angles rounded off, sides oblique, projecting in the middle, and emarginate behind; hind margin waved with acute angles; prosternal process rounded; elytra long-oval, strongly convex; shoulders rounded; front tibiae with four or five spines above the terminal fork.

Habitat. Silhet, Khasia Hills.

Number of specimens examined: sixty-three males and twenty-eight females. (In Major Parry’s and other collections.)
Measurements.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>millim.</td>
<td>millim.</td>
<td></td>
<td>millim.</td>
<td>millim.</td>
</tr>
<tr>
<td>♂ Parry's coll. (type)</td>
<td>63-0</td>
<td>9·5 by 16·0</td>
<td>15·5</td>
<td>13·5 by 25</td>
<td>32 by 24·0</td>
</tr>
<tr>
<td>&quot;</td>
<td>63·5</td>
<td>8·5 &quot; 16·5</td>
<td>15·0</td>
<td>14·0 &quot; 25</td>
<td>33 &quot; 23·0</td>
</tr>
<tr>
<td>&quot; (priodont)</td>
<td>53·0</td>
<td>8·0 &quot; 15·0</td>
<td>13·0</td>
<td>12·0 &quot; 21</td>
<td>27 &quot; 21·0</td>
</tr>
<tr>
<td>&quot; (angulatus, Hope)</td>
<td>40·0</td>
<td>5·5 &quot; 11·5</td>
<td>8·0</td>
<td>8·5 &quot; 17</td>
<td>23 &quot; 17·0</td>
</tr>
<tr>
<td>♂</td>
<td>51·5</td>
<td>8·0 &quot; 15·0</td>
<td>8·0</td>
<td>12·0 &quot; 22</td>
<td>30 &quot; 23·0</td>
</tr>
<tr>
<td>&quot;</td>
<td>46·0</td>
<td>7·0 &quot; 13·5</td>
<td>7·5</td>
<td>10·5 &quot; 20</td>
<td>27 &quot; 20·5</td>
</tr>
<tr>
<td>Brit. Mus. coll.</td>
<td>39·0</td>
<td>5·5 &quot; 10·5</td>
<td>0·6</td>
<td>0·9 &quot; 13</td>
<td>23 &quot; 16·5</td>
</tr>
</tbody>
</table>

It has seldom happened that so much confusion has arisen in consequence of describing a female, as in the case of Olivier’s *Lucanus lama*. Burmeister, as Parry has shown, erroneously referred a number of totally different species (of true Lucanidæ) to it. I entirely agree with Hope and Parry in regarding it as a female of the present species.

The smaller the specimens the narrower they become in proportion, and the smallest of both the male and female forms (Pl. LXXXV. fig. 12), which Hope considered to be a distinct species, and named *Lucanus angulatus*, are remarkably unlike the large ones.

15. Neolucanus Saundersi, Parry. (Plate LXXXV. figs. 13 (b, mentum), 16, ♂; fig. 9 (b, mentum), ♀.)

*Neolucanus saundersii*, Parry, Trans. Ent. Soc. Lond. (3) ii. p. 20, pl. ix. fig. 3.


*Male.* Very similar to the last species. Prothorax rather broader in the type, but of about the same breadth as in *N. lama* (♂), in a second specimen of the same size in the British Museum. The only differences are in the mandibles. On the underside they are straighter, flattened, and not curved outwards. On the upper side they are rounded, with four or five teeth at the tip; besides these there are two large, round, straight teeth, 2 or 3 millim. long, projecting outwards, one near the tip, and the other near the base of the mandibles; mentum longer than in *N. lama*, somewhat emarginate in front, and more hairy; the labrum is straight, and entirely fills up the space between the mandibles; it is clothed with brown hair in front; prosternum transversely carinated in front of the prosternal process.

*Priodont form* (in British Museum). Mandibles rather longer than the head, very like those of *N. lama* (without the two vertical teeth), and with six teeth on the inner side. It may be distinguished from *N. lama* by the longer and more quadrate mentum.

*Female* (♀). Very similar to that of the last species, but larger and broader, entirely pitchy-black; prothorax, elytra, and whole under-surface shining; head and mandibles dull; head twice as broad as long, strongly convex, front edge strongly emarginate;

1 Trans. Ent. Soc. Lond. (3) i. p. 453.
clypeus raised, strongly punctured, wrinkled, slightly convex, nearly straight; canthus as broad as or broader than the eye, and strongly and coarsely punctured; mandibles short, strongly convex on the outer side; upper and under sides flattened, coarsely granulated, with a long tooth at the tip and three small ones in the middle; mentum long, with a crescent-shaped crest; prothorax broader in front than in N. lama, the front edge strongly emarginate on each side; front angles somewhat rounded, the sides slightly curved; middle projection rounded, behind which the sides are somewhat emarginate; hind margin nearly straight; elytra oval, with the shoulders rounded, dark nut-brown, with a distinct black stripe on the suture; front tibiae long and narrow, with six spines above the terminal fork.

_Habitat._ North India.

Two males and two females in the collection of Major Parry and the British Museum.

**Measurements.**

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
</tr>
<tr>
<td>♂, type (Parry)</td>
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<td>8·5 by 16·5</td>
<td>15</td>
<td>12 by 24</td>
<td>31·5 by 25</td>
</tr>
<tr>
<td>♂ (Brit. Mus.)</td>
<td>61</td>
<td>8·5 , 16</td>
<td>15</td>
<td>12 ,, 23</td>
<td>31 ,, 23·5</td>
</tr>
<tr>
<td>♀, type (Parry)</td>
<td>57</td>
<td>8·5 , 16</td>
<td>8·5</td>
<td>12 ,, 24</td>
<td>33 ,, 26</td>
</tr>
<tr>
<td>♀ (Brit. Mus.)</td>
<td>52</td>
<td>8 ,, 15</td>
<td>8·5</td>
<td>11·5 ,, 23</td>
<td>29 ,, 22·5</td>
</tr>
</tbody>
</table>

(2) _Odontolabis_¹.

(_μοῖος_, tooth; _λαβύρ_, forelegs.)


**Male.** Head large, quadrangular, flattened, with an occipital crest, but in large specimens the frontal crest is often prominent; the labrum often projects between the mandibles, above which it frequently forms an epistoma; mandibles polymorphic, the largest being as long as the head and thorax together, and the smallest only as long as the head; eyes entirely enclosed by a canthus, behind which is a straight or curved spine; sides of the prothorax generally with spines, which are frequently rounded at the tips; prosternal process generally prominent, and the mesosternal process likewise often well developed; front tibia much longer than the four hind tibiae, straight or incurved, and provided with a terminal fork, and with several spines on the outer side; the four hind tibiae unarmed; all the tarsi hairy.

**Female.** Resembles the female of _Neoluecanus_. Mentum generally flattened; prosternal process usually well developed (p. 434).

Most of the species of _Odontolabis_ are large and flattened insects, with large and variously formed mandibles in the male. The number of the spines on the front tibiae (although not constant) is of considerable importance in the discrimination of species.

¹ Although the name _Odontolabis_ is feminine, I have not thought it necessary to make the specific names agree with it, as the English authors have invariably used masculine names.
The head has no occipital crest, as in _Lucanus_, and no cephalic prominences, as in _Hexarthrius_; but the frontal ridge is strongly developed in large specimens; in small ones the head is flattened. The eyes are large, and separated by a cauthus of variable width, but narrowest in large specimens. The spine behind the eye is very characteristic, but is scarcely developed in _O. carinatus_ and _O. cratus_. The clypeus is deeply emarginate, and distinctly separated from the front. The labrum projects between the mandibles, as far as their shape will allow, and it is frequently contracted into a true epistoma. The mandibles are large, and differently developed, varying both in shape and size. Sometimes there is an unbroken series of forms of mandibles, from the smallest, which resemble the female, to the largest and most highly developed; but in other cases they exhibit several forms which cannot be connected by intermediate links.

In order to facilitate comparison I have distinguished the four forms of mandibles which are most frequently differentiated as follows:—

1. _Forma telodonta_ (τέλος, end; δόντα, tooth). The most highly developed form; the terminal form 1. (Pl. LXXXIX. fig. 1.)

2. _Forma mesodonta_ (μεσός, middle). In this form a strongly developed tooth projects inwards from the middle of the mandibles. (Pl. LXXXIX. fig. 3.)

3. _Forma amphiodonta_ (αμφί, on both sides). Mandibles with teeth at the tip and at the base only. (Pl. LXXXIX. fig. 5.)

4. _Forma priodonta_ (πρίον, saw). Inner side of the mandibles toothed. (Pl. LXXXIX. figs. 6, 7.)

The second and third forms may occur conjointly (_amphio-mesodonta_), and the fourth form may be either regularly (isodont) or irregularly (anisodont) toothed. (Pl. XCII. fig. 8.)

The prothorax is generally broad, and is often provided with two or three lateral spines (as in _O. alces_ and others). It frequently happens that the middle spine only is developed, the sides being rounded off in many species.

The prosternal process is generally well developed, as in _O. alces_ and _O. dalmani_, and projects distinctly downwards and backwards. The elytra are broad, with the sides margined, and are generally smooth and shining, and are most frequently black, although sometimes bicolorous or tricolorous. The elytra are hairy in _O. dalmani_, and sometimes in _O. carinatus_; in _O. striatus_ the lines on the elytra are alternately smooth and hairy. _O. cratus_ exhibits a metallic lustre. The tibiae of the long front legs are long and straight or slightly curved inwards.

The small males with priodont mandibles are often so similar to the females that they have been frequently described as such by various authors; but they may always

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1 Comp. p. 397 (anteil).
be distinguished by the comparatively larger head, the larger antennæ, the much longer and narrower front tibia, and the comparatively longer hind tarsi. They are sexually well developed, and the chitinous parts of the male organs are nearly as large as in the largest males.

The females are less variable, and the species are so similar to each other that they can only be distinguished by minute characters, and even then, in many cases, only when the exact locality is known. Without localities they are valueless for scientific purposes. The females are considerably smaller than the males; they are consequently of a more rounded-oval shape. The head and mandibles are short, the canthus is generally very broad, and the occiput is so much contracted that the eyes nearly touch the front margin of the prothorax. When the mandibles are closed the head appears almost triangular. The spine on the cheeks, so conspicuous in the males, is entirely absent in the females. The upper side of the head is generally more coarsely punctured, and there is a rounded epistoma distinct from the labrum. The mandibles are short and strongly curved inwards. There is a sharp tooth near the tip, and three (which are generally unequal) on the inner side. The mentum is generally coarsely shagreened. The prothorax is not broader than the elytra, and the sides are shaped as in the male. The front tibiae are scarcely longer than the others, and are comparatively broad; the terminal fork is but slightly developed, and the outer side is spiny. The males and females agree in coloration, except in *O. stevensi*, in which the male is entirely black, and the female has bicolorous elytra.

The species are distributed over India, China, and the Malay Archipelago. We have scarcely any information respecting their habits; but Mr. H. O. Forbes informs me that *O. wollastoni*, a species with bicolorous elytra, flies by day in Sumatra, and the Rev. S. J. Pettigrew has observed that *O. burmeisteri* likewise flies by day in Travancore.

This genus has been divided by authors into several subgenera. Thomson, in his Catalogue (Ann. Soc. Ent. France (4) ii. pp. 394, 395), distinguishes between *Odontolabis* and *Anoplocnemus*, and Parry and Westwood separate *Calcode*, which I cannot accept for want of sufficient characters, unless I should proceed on the principle of treating every small subsection as a distinct subgenus. I have therefore arranged the species in natural groups, which I designate by the name of a representative species, a practice which has long been in use among lepidopterists. (Comp. Diagram of the Species, p. 410.)

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1 The more carefully we investigate the species of a genus the more difficult it becomes to define either its limits or its characters. This leads to its being divided into so-called subgenera, which frequently include only a single species. The number of subgenera consequently increases enormously in proportion to the increase in our knowledge of species, until the best dictionary is scarcely sufficient to provide them with new names. Hence we may perceive that a genus is nothing more than a term of convenience the definition of which may be altered at pleasure to include new species as they are discovered.
Section I.

1. Odontolabis platynotus, Hope. (Plate LXXXVIII. figs. 9-11, ♂; 12, ♀.)

♀ Lucasus platynotus, Hope, Cat. Luc. Col. p. 18.
♂ Odontolabis emarginatus (Reiche), Saund. Trans. Ent. Soc. Lond. (2) iii. p. 40, pl. iii. fig. 4 (telodont form; figure bad).
Odontolabis evansi, Westw. Trans. Ent. Soc. Lond. (2) iii. p. 201, pl. x. fig. 5.

♂. Uniform dull black; under-surface rather shining; head broad, convex, front edge emarginate, sides oblique; canthus oblique, slender; a conspicuous promi-
nence behind the eyes; prothorax broader than the head and elytra, front edge strongly emarginate on each side, the sides slightly curved and then strongly indented, the hinder margin waved; lower external margin transversely wrinkled in the larger specimens only (compare fig. 10 b); prosternal process pointed; elytra flattened or slightly convex, broad at the base, and much narrowed towards the tip; front tibiae moderately long, widened in front, with five spines above the terminal fork.

Mandibles.

1. Forma telodonta.—Mandibles nearly as long as the head and prothorax together, slender, strongly curved inwards, with four teeth at the tip and two at the base (fig. 9, O. evansi, Westw.).

2. Forma amphiodonta.—Mandibles shorter and straighter, with five teeth at the tip and two at the base (fig. 10).

3. Forma priodonta.—Mandibles straight, as long as the head, slightly curved inwards at the tip, with seven unequal teeth on the inner side (fig. 11).

♀. Uniform dull black; under-surface shining; head slightly convex; canthus broad; prothorax rather broader than the elytra, its front edge deeply emarginate on each side; front angles acute; the sides but slightly waved as far as the middle spine, and then somewhat emarginate; the hind margin waved; elytra strongly convex and pointed at the extremity as in the male; front tibiae slender, with five spines above the terminal fork.

Number of specimens examined: fourteen males, nine females. Hope Collection, ♀ type, Oxford; British Museum, &c.

Habitat. China.

Measurements.

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3 ± 2
When Hope described this species he had only the female before him, two specimens of which, supposed to be from North India, are in the Museum at Oxford. It was not until many years afterwards that Saunders brought the male to Europe, and described it under the name of *O. emarginatus* (Reich. Ms.), being probably misled by the erroneous habitat; and almost at the same time Westwood published the telodont form under the name of *O. evansii*. Parry recognized the specific identity of these forms, which I am enabled to confirm by examination of the types.

2. **Odontolabis siva**, Hope. (Plate LXXXVI. figs. 1–6, ♂; 7, ♀.)


(Type!)  

**Male.** Deep uniform black, head and prothorax dull, elytra with an obsidian lustre; head short and broad, upper side generally impressed; front edge straight or slightly emarginate, with no frontal crest; clypeus with triangular epistoma; canthus straight, narrow; the spine behind the eyes prominent and generally straight; prothorax broad, longer than the head, front edge very deeply emarginate on each side; sides nearly trispinose, but the front spine very slightly indicated: in the priodont form the front angles are rounded off; under-surface of the prothorax with the sides smooth or with a longitudinal elevation; prosternal process generally round or triangular; mesosternal process very slightly developed; front tibiae not much longer than the four hinder tibiae, with the terminal fork strongly developed, and with three, four, or five spines on the outer margin above it; upper side with distinct rows of punctures.

**Mandibles.**

1. **Forma telodonta** (figs. 1, 2).—Mandibles as long as the head and prothorax together, narrow, convex, rounded or flattened (fig. 2), flattened at the base and tip, with three or four small teeth at the tip and two obtuse teeth at the base.

2. **Forma amphiodonta** (figs. 3, 4).—Type! *O. siva*, Hope (true!). Mandibles as long as the head, broad, with five small teeth at the tip and two at the base.

3. **Forma priodonta** (figs. 5, 6).—Mandibles as long as the head, the sides convex; upper surface rounded and under-surface flattened; inner side with eight unequal teeth, crowded together, and without gaps; canthus frequently rather wide, the spine behind the eyes but slightly developed; prothorax rounded on the sides in front, as in the female (compare figs. 6, 7).

**Female.** Uniform black, head and prothorax dull, elytra shining; head broad, upper.
side convex, strongly punctured; canthus broad; prothorax very broad, moderately convex, its front edge moderately emarginate on each side; the front angles acute; the sides S-shaped as far as the middle spine, and then strongly emarginate; hind margin waved; prosternal process rounded off and but slightly developed; elytra broad, oval, with the sides strongly curved outwards; upper side moderately convex; front tibiae with from four to six spines above the terminal fork.

Number of specimens examined: sixty-eight males and fourteen females, in various European collections.

Habitat. North India (Silhet) to China and Formosa.

Measurements.

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This large species, which is rather common in collections, has been mistaken by authors for Lucanus carinatus, Linn., although it does not at all agree with the description of that species. I found it under this name in the various collections of Vienna, Paris (Jardin des Plantes), Leyden, and London (British Museum), and in the collections of Messrs. Parry, Bates, and others. This shows the slight importance which is attached to the identification of species, and the careless manner in which errors are transmitted from one collection to another. Reiche (followed by Thomson) regarded this species, misled by the incorrect locality, as a variety of Castelnau's L. bellicosus. Major Parry mistook the smallest male priodont specimens of O. sira (fig. 6) for Olivier's L. camelus and therefore placed it with the misnamed L. carinatus of Reiche and Thomson. Consequently these very distinct species were completely
forgotten, and were subsequently redescribed under the names of *O. nigritus* and *O. gouberti*.

Hope's type in the Oxford Museum was said to come from Java (Cat. Luc. Col. p. 16), but this contradicts p. 5, where Silhet (Khasia Hills) is correctly given as the locality, as is proved by the label on the specimen, which I was enabled to examine through the kindness of Prof. Westwood. The same error is repeated in the registers of the British Museum, as well as in the Leyden Museum, which latter received a specimen from Hope himself. As the female of *O. siva* is very difficult to distinguish from that of *O. bellicosus*, Cast., the females are much more frequently mixed in collections than the males. A recent consignment from Java, which I lately examined in the Leyden Museum, contained only forms of the latter species, which are easily distinguishable in the male sex.

The range of *O. siva* extends from North India (Silhet) across South China to Formosa. In the last locality it varies slightly from continental examples in both sexes, but so slightly that Messrs. Parry and Bates have been unwilling to treat the Formosan insect as a distinct species.¹

3. **Odontolabis gracilis**, Kaup. (Plate LXXXVII. figs. 1, 2, c; fig. 3, 3.)


**Male.** Intermediate between *O. siva* and *O. bellicosus*, but nearest allied to *O. dalmani*, Hope. The whole body shining black, without hairs; head extremely finely punctured, quadrangular, the sides straight, spine behind the eyes directed forwards; canthus narrow; prothorax trispinose as in *O. bellicosus*, the middle spine most prominent; outer margins of prothorax beneath coarsely wrinkled; prosternal process very strongly developed (figs. 1a, 2b); mesosternal process similar, projecting forwards, and stronger than in *O. bellicosus* or *O. dalmani*, but similar to *O. celebensis*; front tibiae with two or three spines above the terminal fork; all the legs with distinct rows of punctures.

**Mandibles.**

1. *Forma telodonta.*—Mandibles long, straight, rounded, flattened at the base and tip. Tip curved inwards with five small teeth; base with two (fig. 1).

Two specimens in the British Museum, and one in Major Parry's collection.

2. *Forma amphiodonta.*—Mandibles rather longer than the head, with five small teeth at the tip, and two or three at the base (fig. 2).

One specimen in the British Museum.

3. *Forma priodonta.*—At present unknown.

**Female.** Shining black like those of *O. bellicosus* and *O. siva*; head broad, strongly

sculptured; canthus broad, as in O. dalmani; prothorax strongly convex and shining, the sides dull; upper surface extremely finely punctured; sides of the prothorax nearly trispinose, the front angles strongly developed, as in O. dalmani (♀); prosternal process rounded, spatulate; mesosternal process more strongly developed than in O. bellicosus or O. dalmani; front tibiae long, narrow, with four spines above the terminal fork; hind legs very long, especially the tibiae.

One specimen in the British Museum.

Habitat. Island of Nias (west of Sumatra).

### Measurements.

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<td>12 „ 20</td>
<td>23</td>
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<td>Amphiodont.</td>
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<td>9 „ 17</td>
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<td>9 „ 15.5</td>
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Dr. Kaup described this species in 1868 from two males from Nias. One of these he gave to Major Parry, who regarded it as a large variety of O. bellicosus with fully developed mandibles¹, a view in which Kaup himself concurred when he subsequently visited England. When I examined Kaup’s type in Major Parry’s collection in the winter of 1882 I found that this telodont male agreed better with O. siva and O. dalmani in the shape of the head and mandibles than with O. bellicosus. I was confirmed in this opinion by a series of three males and one female which the British Museum received from Nias with two male specimens of O. inaequalis; and which Mr. C. O. Waterhouse kindly permitted me to examine. The mandibles of the three telodont specimens are exactly similar. The configuration of the prothorax and the unusually strongly developed pro- and mesosternal processes are equally constant.

4. ODONTOLABIS DALMANI, Hope. (Plate LXXXVII. figs. 4–6, ♂; fig. 7, ♀.)

Anoplоценемус rubescens, Blanch. MS.  

Male. Very like that of the preceding species (O. gracilis), but smaller. Head, prothorax, elytra, and sometimes the legs clothed with fine brown hairs; under-surface of the body smooth, or only very slightly hairy; head quadrate, and rather flattened; front edge strongly and semicircularly emarginate, the sides straight; canthus narrow; spine behind the eyes projecting slightly forwards; prothorax trispinose on the sides (twice deeply emarginate); under-surface of prothorax with the outer margin

¹ Trans. Ent. Soc. Lond. 1870, p. 57.
smooth; prosternal and mesosternal processes but slightly developed (fig. 4 a); elytra olive-brown, finely punctured, and thinly clothed with brown hair; front tibiae with two spines above the terminal fork.

**Mandibles.**

1 & 3. *Forma telodonta* and *Forma priodonta.—* At present unknown.

2. *Forma amphiodonta.—* Mandibles longer than the head, three-cornered, upper side flattened, distinctly punctured, long and straight, with five teeth at the tip, and two or three at the base.

_Female._ Quite hairless, very like that of the preceding species, but more slender; prothorax with two, or often three, lateral spines like the male; prosternal process flattened; elytra long and narrow; front tibiae narrow, with three or four spines above the terminal fork.


_Habitat._ Sirdang (Sumatra) and Sarawak (Borneo).

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<td>52</td>
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<td>Three females</td>
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I diligently sought for as many specimens as possible, but was unable to meet with either the telodont or the priodont form.

Although _O. gracilis_ (♀) from Nias appears to be very distinct from Bornean specimens of _O. dainani_, in which the whole body is hairy, it is impossible to draw a sharp line between Bornean and large Sumatran specimens, either in one sex or the other. The Leyden Museum possesses an amphiodont male (64 millim. in length), without locality, which appears to be intermediate between the two forms. Its upper surface is smooth, and very sparsely hairy. The prosternal and mesosternal processes are strongly developed; and the under-surface of the prothorax is longitudinally striped on the sides as in _O. gracilis_. The short rounded mandibles are compressed, and much resemble those of _O. siva_, but there are three basal teeth (not two), and five apical ones; the spine behind the eyes projects slightly forward; and the front tibiae have two or three spines above the terminal fork.

Total length 64 millim., head 11 by 20, prothorax 13 by 25, elytra 32 by 24½, mandibles 15.
5. *Odontolabis bellicosus*, Cast. (Plate LXXXVIII. figs. 1–3, ♂; fig. 5, ♀.)


*Odontolabis bellicosus*, Parry, Trans. Ent. Soc. (3) ii. p. 76.


Var. *Lucanus serrifer*, Hope, l. c.


♀ *Lucanus ursus*, Cast. l. c. p. 171, pl. xvi. fig. 2 (bad figure).

**Male.** Uniform deep black, head, prothorax, and legs dull, very finely punctured; elytra pitchy black, with a bright obsidian lustre; head shorter than the prothorax, broad, quadrangular, narrow in front, oblique on the sides, wider towards the spine, which is straight and horizontal; frontal edge always emarginate, with no raised crest; prothorax broad, trispinose, with two deep concavities; under-surface smooth, the lateral margin coarsely wrinkled; prosternal process rounded, well developed; mesosternal process not prominent; front tibia long and narrow, with three well-developed spines above the terminal fork.

**Mandibles.**

1. *Forma telodonta* (fig. 2).—Mandibles as long as the head and prothorax together, flattened, the sides nearly straight, more or less incurved at the tip, with three or four small teeth; near the base they are thickened on the inside, and armed with three teeth, of which the third from the base is most developed.

2. *Forma amphiodonta* 2.—Mandibles longer than the head, the sides straight; four or five small apical teeth, separated by a gap from the three basal teeth (*O. vishnu*, Hope).

3. *Forma priodonta* (fig. 3).—Mandibles rather longer than the head, straight, and slightly curved inwards, with from eight to ten isodont and crowded teeth, without gaps; head flattened; under-surface of the border of the prothorax smooth, not sculptured (*O. serrifer*, Hope).

**Female.** Very like that of *O. ursus*, Hope, but more slender, uniform black; elytra strongly shining; head broad, convex, strongly and coarsely punctured; canthus broad; mentum coarsely shagreened, somewhat raised on each side; mandibles very strongly sculptured; prothorax as broad as the elytra, the central spine strongly developed.

1 In two specimens in the collections of Herr van Lansberge and the Jardin des Plantes (fig. 1) the two basal teeth have disappeared (fig. 1). These approach a true mesodont form, which is most developed in *O. alces* (Pl. LXXXIX. fig. 3).

2 By an oversight, the amphicodont form was not figured. It most resembles the same form of *O. celebensis* (Pl. LXXXVIII. fig. 7).

Vol. XI.—Part XI. No. 8.—November, 1885.
pointing backwards, upper side very convex; prosternal process generally flattened; elytra long, oval, strongly convex; front tibiae long and narrow, with four or five spines above the terminal fork.


Habitat. Java (Ardjoeno).

<table>
<thead>
<tr>
<th>Measurements.</th>
<th>Total length</th>
<th>Head</th>
<th>Mandibles</th>
<th>Prothorax</th>
<th>Elytra</th>
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<td>11 ,, 22</td>
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</tbody>
</table>

1, Paris Museum; 2, 4, 5, British Museum; 3, 6, Parry's collection; 7, 8, Leyden Museum.

This species was first described by Castelnau in 1840. He described the largest male form, and gave a very inaccurate, but recognizable figure, with which the engraver appears to have taken great liberties. Everything is represented too angular, the head is badly drawn, and the front tibiae are entirely incorrect. The same may be said of the figure of the female, which Castelnau described on the same page under the name of Lucanus ursus. The prothorax is very badly drawn, and does not at all agree with the description, "côtés du corselet un pen sinuex avec une petite dent." The front tibiae are inaccurately drawn, and the spines on the outside are entirely absent. Five years later Hope enriched science with two new species—Lucanus vishnu and L. serrifer, the types of which are now at Oxford, but which, as Parry rightly determined, are simply the amphiodont and priodont forms of the present species from Java. This species also is frequently named O. carinatus, Linné, in collections. The female stood in the British Museum with O. sica, so that I had the drawing made from a specimen, on the locality of which I could depend, in Mr. Distant's collection. I subsequently found a series of specimens in the Leyden Museum collected by Heckmeyer and Reinwald in Ardjoeno. They are very similar to the females of O. sica and O. alces, and can scarcely be distinguished from them.

6. ODONTOLABIS CELEBENSIS (Lansb.), sp. n. (Plate LXXXVII. figs. 6-8, ęż.)

Male. Similar to the preceding species, but constantly smaller in all its forms; elytra pitchy black, very shining; mandibles, head, and prothorax dull, except in
small priodont specimens, in which they are likewise shining. Head apparently more quadrate, and the sides straight; the spine behind the eyes is oblique in large specimens, and straight in small ones. The mandibles differ from *O. bellicosus* in being always more curved, and are more like those of *O. siva*, but there are three basal teeth, which are sometimes fused into two in large specimens; in the amphiodont forms three are distinctly visible. The prosternal process is well developed, and projects strongly in front and beneath. The mesosternal process is enormously developed, even in the smallest specimens, and projects strongly in front (as in *O. gracilis*); front tibiae with three spines above the terminal fork.

**Mandibles.**

1. *Forma telodontata.*—Mandibles longer than the head, slender, more curved than in *O. gracilis* and *O. bellicosus*, with four or five small apical teeth, strongly expanded inwards at the base, with two or three obtuse teeth (fig. 6).

2. *Forma amphiodonta.*—Mandibles similar to those of *O. bellicosus*, with five apical and three basal teeth (fig. 7).

3. *Forma priodontata.*—Mandibles as in *O. bellicosus*, but the upper surface strongly punctured (fig. 8).

**Female.** Unknown.

**Habitat.** Celebes and Sangir (in Herr van Lansberge's collection).

**Measurements.**

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<td>17</td>
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<td>29 „ 21</td>
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<tr>
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<td>13</td>
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<td>6 „ 12</td>
<td>7-5</td>
<td>8 „ 16</td>
<td>21 „ 16</td>
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</table>

I first met with this interesting form, which I consider likely to prove a well-marked local form of *O. bellicosus*, in the Museum of the Jardin des Plantes in 1882, where it was mixed with small specimens of *O. bellicosus*. I subsequently received a large series from Celebes and Sangir through the kindness of Herr van Lansberge, whose MS. name I have retained.

7. *Odontolabis alces*, Fabr. (Plate I.XXXIX. figs. 1–7, c; fig. 8, 2.)


*Lucanus alces*, Oliv. Ent. i. (1) p. 8, pl. ii. fig. 3 a, b (recognizable).


3 r 2

**Male.** Uniform dull black, elytra less shining than in the other species, head large, longer than the prothorax, front edge strongly emarginate; the sides straight, or oblique in front; canthus narrow; spine behind the eyes obtuse; the lower parts of the cheeks coarsely wrinkled or pitted; prothorax twice as broad as long, its front edge strongly emarginate on each side; the sides trispinose (with two deep concavities); the middle spine never so prominent as in *O. bellicosus*; in the smallest priodont specimens the front spine is obsolete; prosternal and mesosternal processes very prominent; elytra long, oval, slightly shining; front tibiae long, with one or two spines above the terminal fork.

**Mandibles.**

1. *Forma* telodonta.—Mandibles as long as the head and prothorax together, rounded, convex within, and curved downwards, with only four apical teeth (figs. 1, 2). Head with raised crest.—(*O. dux*, Westw.)

2. *Forma* mesodonta.—Mandibles shorter, rounded, with four apical teeth, and a strong tooth beyond the middle, projecting downwards:—a. With no basal teeth (fig. 2) (*O. alces*, Fabr., type); b. One or two basal teeth (fig. 4).

3. *Forma* amphiodonta.—Mandibles rather longer than the head, broad, flattened, with four or five apical and three obtuse basal teeth of equal size separated from the former by a semicircular gap (fig. 5).—(*O. cumingi*, Hope.)

4. *Forma* priodonta.—Mandibles as long as the head, flattened, similar to those of *O. bellicosus*, with eight or nine crowded teeth, without gaps, on the inside of the mandibles (figs. 6, 7, the latter with prothorax like the female).

**Female.** Uniform deep black; mandibles, head, and sides of prothorax shagreened. Elytra dull, extremely finely punctured; head broad; upper side moderately convex; canthus broad; mentum wrinkled, slightly expanded on each side; mandibles with three or four irregular teeth on the inside; prothorax very convex, strongly emarginate in front, the front angle generally obtuse, the sides slightly S-shaped as far as the middle spine, and then emarginate; hind margin waved; prosternal process variable, generally round, but often flattened; front tibiae with four or five obtuse spines above the slightly developed terminal fork; elytra convex long, oval; the shoulders acute, or somewhat obtuse.

**Habitat.** Luzon (Manilla).

Number of specimens examined: 320. 223 specimens (112 males and 111 females) in a single consignment.
Measurements.

<table>
<thead>
<tr>
<th>Total length</th>
<th>Head</th>
<th>Mandibles</th>
<th>Prothorax</th>
<th>Elytra</th>
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<td>7 · 12</td>
<td>6</td>
<td>8·0 · 17</td>
<td>21 · —</td>
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</table>

The enormous series of this species which I obtained for examination has enabled me to prove the specific identity of O. alces and O. dux, which Professor Burmeister had already suspected.

But Burmeister went much too far. He was not satisfied with uniting O. carinatus, Linn., O. camelus, Oliv., O. bellicosus, Cast., and its female O. ursus, Cast., but he even included Lucanus gladatus, De Haan (= Neolucanus laticollis, Thunb.), the female of which is L. puncticeps, De Haan, in the same series. Shortly afterwards Reiche¹ recognized the error of Burmeister, and separated O. alces, as used by Burmeister, into O. carinatus, Linn., and O. bellicosus, Cast., but confused everything afresh by uniting

¹ Ann. Soc. Ent. France (3) i. p. 73 (1853).
O. alces, Fabr., with O. carinatus, Linn. He considered O. siva and O. vishnu, Hope, to be only varieties of O. bellicosus, to which he also referred O. cumingi, Hope. Parry, the leading authority on the Lucanidae, came nearer the truth in regarding O. cumingi, Hope, as only a variety of O. dux, Westw.; he also ventured to refer Petiver's insect to the same species. But he united O. alces, Fabr. and Olivier, with O. carinatus, Linn., a species which remained doubtful until very recently. In the first part of this paper (pp. 395-403) I have given conclusive evidence of the identity of O. alces, Fabr., and O. dux, Westw.; and as O. dux, Westw., is only a very rare form of O. alces, Fabr., the latter name must be retained for this species.

8. Odontolabis camelus, Oliv. (Plate XCVI. figs. 7, 8, ♂; 9, ?.)

♀. Lucanus camelus, Oliv. Ent. i. Sect. i. p. 22, pl. v. fig. 19 (bad, but recognizable).


Anoplomenus carinatus, p., Reiche, Ann. Soc. Ent. France (3) i. p. 73.


Male. Resembles O. inaqualis and O. latipennis in general appearance. Uniform black, head coarsely punctured, prothorax and elytra shining; mandibles strongly incurved, with four or five irregular obtuse teeth at the tip, separated by a gap from two small overlapping obtuse teeth at the base; upper side of the mandibles, in large specimens, channelled from the base to the tip; but this channel is much shallower and less conspicuous in small specimens.

Dull, finely granulated, head broad, flattened as in O. gazella (♂) and O. latipennis, but narrower behind; frontal edge nearly straight, and very slightly emarginate; canthus broad before the eyes, but rapidly narrowing behind, the spine behind the eyes rather further from them than usual, and finely pointed, directed obliquely backwards towards the neck; mentum hairless; front margin of the gula strongly swollen, cheeks with fine scattered punctures; prothorax slightly convex, very finely punctured, more than twice as broad as long, with a single pointed and very prominent lateral spine (this is obtuse in small specimens, which renders the prothorax apparently narrower); hind margin of the prothorax waved; prosternal process strongly developed and projecting vertically downwards; elytra scarcely broader than the prothorax, slightly shining, very finely punctured, and widened a little beyond the shoulders; front tibiae very long, narrow, nearly straight, slightly channelled on the upper side, the terminal fork slightly developed, with two slender spines on the outside in large specimens and three in small ones, which are but slightly developed, and project forwards.

Female. Uniform black, head and prothorax dull, elytra with a satiny lustre. Head very convex, canthus broad, as in O. gazella ♂; prothorax convex, similar to that of
small females of *O. latipennis*, but the central spine is finely pointed; elytra narrowed behind; front tibiae narrow, hardly curved, the terminal fork straight, and with three or four very small and slightly developed spines on the outer side.

Number of specimens examined: nine males and four females, in the collections of Messrs. Parry and van Lansberge and in the Paris Museum.

**Habitat.** Philippines (Mindoro).

**Measurements.**

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<td>8.0</td>
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<td>23.0</td>
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</table>

Although this species may be easily recognized by its large head, small curved mandibles, and short prothorax, and was briefly but recognizably described and figured by Olivier (though unfortunately without any indication of locality), it has always been misunderstood and unrecognized by authors. Burmeister is chiefly responsible for the error, as he included this species also among the varieties of *O. alces*. Reiche, who divided Burmeister's *O. alces* into two species, sunk *O. camelus* as var. *minor* of his *O. carinatus*, in which he has been followed by Parry and Thomson. The priodont form of this doubtful *O. carinatus*, auct. (compare Pl. LXXXVI. fig. 6), is really very like Olivier's figure, so that they might easily have been confounded at that period, though the peculiar characters of *O. camelus* should have made this impossible. When *O. camelus* was once referred to *O. carinatus*, auct., it was long considered as such, and was at length erroneously redescribed by C. O. Waterhouse, on the authority of Parry and Deyrolle, as *O. gouberti*. Under this name I found it in the Museum of the Jardin des Plantes and in various other European collections. A small specimen, from Mindoro, in Herr van Lansberge’s collection, had a narrow prothorax (fig. 8), and I was involuntarily reminded of Olivier's figure. It agreed precisely with his description, and when I afterwards examined the type of *O. gouberti* in Major Parry’s collection, in company with Mr. Waterhouse, we were both convinced of their identity, and he withdrew his name.

**Section II.**

9. **Odontolabis stevensii**, Thoms. (Plate XC. figs. 1–3, ♂; 4, ♀.)

♂ ♀. *Odontolabis stevensii*, Thoms. Ann. Soc. Ent. France (4) ii. p. 414 (1862); Parry, Trans. Ent. Soc. Lond. (3) ii. p. 76, pl. v. fig. 2, ♂, fig. 5, ♀; op. cit. 1872, p. 84, pl. i. fig. 6, ♂ (monstrosity).
Male. Uniform black, with a satiny lustre, very finely punctured. Head broad, flattened, front edge straight, or very slightly emarginate, canthus before the eyes broad, but very narrow round them; spine behind the eyes rounded or pointed, head much narrowed behind; prothorax short, broader than the head, strongly emarginate on each side in front, the sides straight and oblique as far as the middle spine, which is rounded off; hind margin strongly waved; prosternal process strongly developed, straight, and inclining downwards; elytra narrower than the prothorax, moderately convex; front tibiae long and straight, with two or three slender spines on the outer side above the slender apical fork.

Mandibles.

1. *Forma telodonta*.—Mandibles as long as the head and prothorax together, very long and slender, forked at the tip, with three small teeth on the front branch and a long simple hinder one. Front margin of the head straight and slightly swollen; epistoma broad, triangular. Head rather convex, with large coarse pits on the sides behind the eyes. Rim of the prothorax beneath conspicuously wrinkled (fig. 1). Two specimens.

2. *Forma mesodonta*.—Mandibles as long as the head, and strongly curved, with four or five teeth at the tip, followed by a middle tooth projecting downwards, which is obtusely conical, and a similar one near the base. Head more flattened, front margin not swollen, but somewhat emarginate, and without the pits behind the eyes. Rim of the thorax beneath slightly or not at all sculptured (var. *bidentata*, fig. 2). Two specimens.

3. *Forma amphiodonta*.—Mandibles broader, flattened, with five teeth at the tip, and an obtuse one at the base. One specimen.

4. *Forma priodonta* (fig. 3).—Mandibles shorter than the head, rather flattened, with six or seven crowded teeth, without gaps. Front edge strongly emarginate, with triangular epistoma above the closed mandibles. Three specimens.

Female. Resembles the females of *O. gazella* and *O. latipennis*; uniform black, except the elytra. Head flattened, coarsely granulated in front only; canthus broad; prothorax flattened, very broad, sides somewhat curved as far as the middle spine, and not indented beyond; elytra broad, oval, flattened, bicolorous, straw-coloured, with a broad black mark beginning at the shoulders and not narrowing much towards the tip, where it unites with the narrow black margin; rim of the elytra black beneath; front tibiae broad, slightly curved inwards, and with four or five spines on the outer side above the slightly developed terminal fork; four hind tibiae straight, and less strongly incurved than in *O. gazella*.

Number of specimens examined: eleven males and three females, in the collections of Messrs. Parry and van Lansberge and of the Jardin des Plantes &c.

Habitat. Celebes (Menado), collected by Mr. A. R. Wallace.
Measurements.

<table>
<thead>
<tr>
<th></th>
<th>Total length</th>
<th>Head</th>
<th>Mandibles</th>
<th>Prothorax</th>
<th>Elytra</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
</tr>
<tr>
<td>Parry (telodont)</td>
<td>82</td>
<td>16:0 by 28</td>
<td>27</td>
<td>11 by 23</td>
<td>32 by 26</td>
</tr>
<tr>
<td>Luttgart (mesodont)</td>
<td>62</td>
<td>12:0 &quot; 23</td>
<td>14</td>
<td>10 &quot; 24:5</td>
<td>30 &quot; 25</td>
</tr>
<tr>
<td>Luttgart (amphiodont)</td>
<td>51</td>
<td>11:0 &quot; 21</td>
<td>12</td>
<td>10 &quot; 24</td>
<td>28 &quot; 23</td>
</tr>
<tr>
<td>Luttgart (amphiodont)</td>
<td>47</td>
<td>8:0 &quot; 15</td>
<td>7</td>
<td>10 &quot; 22</td>
<td>22 &quot; 23</td>
</tr>
</tbody>
</table>

10. Odontolabis duivenbodii, Deyr. (Plate XC. figs. 5–8, ë; 9, ë.)

ë. Odontolabis duivenbodii, H. Deyrolle, Ann. Soc. Ent. Belg. ix. p. 25, pl. i. fig. 1 (very inaccurate figure).


Male. Very like O. stevensi. Chestnut-brown; head and mandibles darker brown. Head agreeing with O. stevensi in form and sculpture; prothorax reddish brown, narrower, the sides straighter, middle spine rounded off; mandibles more variable than in O. stevensi; elytra flattened, tricolorous, outer margin yellow, followed by a narrow black stripe from the shoulder to the tip, and the space between this and the suture is reddish brown; rim of the elytra beneath black; front tibiae long and straight, with two or three spines above the terminal fork.

Mandibles.

1. Forma telodont (fig. 5).—Mandibles as long as the head and prothorax together, long and slender, with only two or three very small apical teeth. Epistoma broad, triangular.

2. Forma mesodont.—(a) Mandibles as above, with a rather long tooth beyond the middle (fig. 6); (b) Mandibles with two well-developed middle teeth (var. bidentata) (fig. 7).

3. Forma amphiodont.—Mandibles hardly as long as the head, broad, strongly curved, with five apical teeth and an obtuse basal tooth.

4. Forma priodont.—Mandibles broad, scissors-shaped, with eight or nine irregular teeth on the inner side. Epistoma triangular (fig. 8).

Female. Very like that of O. stevensi; brown, except the elytra. Head as in O. stevensi; prothorax likewise of similar form, but conspicuously narrower; elytra tricolorous, the intermediate stripe, which is black outside and brown inside, begins at the shoulder, and narrows gradually to the tip; under-surface uniform dark rust-brown; front tibiae as in O. stevensi, but not so broad, with three or four very small spines above the terminal fork; four hinder tibiae straighter.

Number of specimens examined: ten males and five females.

Habitat. Sangir.
Measurements.

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td></td>
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<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
</tr>
<tr>
<td>Lansberge (telodont)</td>
<td>. . . . . . .  70</td>
<td>13.0 by 24</td>
<td>23</td>
<td>10.0 by 23</td>
<td>29 by 23</td>
</tr>
<tr>
<td>&quot; (mesodont)</td>
<td>. . . . . . .  70</td>
<td>13.0 &quot; , 24-5</td>
<td>23</td>
<td>10.0 &quot; , 24-5</td>
<td>30 &quot; , 23-5</td>
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<tr>
<td>Muysch (type of var. bidens)</td>
<td>. . . . . . .  68</td>
<td>12.5 &quot; , 24</td>
<td>19</td>
<td>10.0 &quot; , 24</td>
<td>29 &quot; , 23</td>
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<tr>
<td>Lansberge (proodont)</td>
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<td>9.5 &quot; , 19</td>
<td>26 &quot; , 21</td>
</tr>
<tr>
<td>. . . . . . .</td>
<td>. . . . . . .  46</td>
<td>7.0 &quot; , 12</td>
<td>5.5</td>
<td>9.0 &quot; , 18</td>
<td>23 &quot; , 19</td>
</tr>
</tbody>
</table>

Deyrolle described a single male example from Celebes, but the real locality of this species is now known to be not Celebes (Menado) but the neighbouring island of Sangir. In addition to the fifteen specimens contained in the collections of Messrs. Parry and van Lansberge, I have examined series of this species in the museums of Leyden and Paris.

Section III.

11. Odontolabis sinensis, Westw. (Plate XCL figs. 1–3, ő; 4, ő.)

Lucanus gazella, var. sinensis, West. Cab. Or. Ent. p. 54, pl. xxvi. figs. 2, 3, ő, fig. 4, ő (good figure).


Male. Deep black, only the outer margin of the elytra reddish brown; mandibles, head, and prothorax dull, finely punctured. Head quadrangular, canthus narrow, behind the eyes is an obtuse horizontal spine; lower part of the cheeks pitted; sides of the prothorax with only one concavity, bispinose, the spines produced into a fine point; rim of the prothorax smooth beneath; prosternal process pointed, variable; elytra shining, black, with a reddish-brown border both on the upper and under surfaces; on the upper surface this border is generally no broader than beneath, but it happens sometimes, though very rarely, that it is broad enough to cover half the elytra; front tibiae with from three to five teeth above the terminal fork.

Mandibles.

1. Forma telodontata.—Mandibles as long as the head and thorax together, gently curved, flattened, the tip deeply forked, the front branch generally with three and the hinder with two teeth. About two thirds of the length from the tip stands a tooth slightly projecting forwards. Base of the mandibles unarmed. Head with the frontal margin strongly convex. Labrum depressed between the mandibles (fig. 1).

2. Forma mesodontata.—Mandibles as long as or rather longer than the head, flattened, and rather compressed, with four or five unequal teeth at the tip. In the middle is a strong rounded tooth projecting downwards, and those on the opposite sides nearly
touch when the mandibles are closed. *One small tooth at the base of the mandibles.* Head with the front margin not convex. Labrum frequently projecting downwards between the mandibles, but generally with a triangular epistoma above them (fig. 2).

3. *Forma priodonta.*—Mandibles about as long as the head, flattened, straight, and slightly incurved at the tip (the right mandible generally rather more strongly developed than the left), with six or seven small unequal teeth. Labrum resembling an epistoma (fig. 3).

*Female.* Deep black, except the outer margin of the elytra. Head nearly twice as broad as long; upper surface convex, strongly punctured; canthus very broad; mandibles short, with three or four small teeth on the inside; upper and under surface strongly punctured; mentum flattened, coarsely punctured; prothorax with two lateral spines; upper surface flattened or only slightly convex, dull, finely punctured, the sides more strongly S-shaped in front than in *O. cuvera*; both spines pointed; elytra twice as long as broad, black and shining, finely punctured, with a reddish-brown border about 2 millim. in breadth; on the upper side it is seldom so broad as to occupy nearly half the elytra; rim of the elytra beneath always reddish brown; front tibia with three longitudinal ridges and rows of punctures; outer side with four or five spines above the terminal fork.

The males vary in size from 34 to 79 millim., and the females from 34 to 48 millim.

Number of specimens examined: about seventy-eight males and twenty-eight females, in different collections.

*Habitat.* China (Shanghai, Lilong, Hongkong).

<table>
<thead>
<tr>
<th>Measurements.</th>
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<tbody>
<tr>
<td>millim.</td>
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<tr>
<td>79</td>
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<tr>
<td>78</td>
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<tr>
<td>73</td>
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<td>60</td>
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<td>57</td>
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<td>49</td>
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<tr>
<td>34</td>
</tr>
<tr>
<td>48</td>
</tr>
<tr>
<td>34</td>
</tr>
</tbody>
</table>

The alteration of the name of the species, which has hitherto been regarded as *O. gazella*, Fabr., was unavoidable when I found, on examining Fabricius's type of his *Lucanus gazella* (compare Pl. XCI. fig. 6) in the Banksian collection of the British Museum, that this female example from Siam was totally distinct from Westwood's

1 This collection was formerly in the possession of the Linnean Society.
L. gazella (sinensis), being the female of O. bicolor, Oliv., which occurs in Siam (Assam (?), Nepal?), Malacca, and Borneo. Westwood speaks of this type as follows:—“This specimen is a female, and differs only from the insect represented in the accompanying plate, fig. 4, and M. Guérin’s figure of his Lucanus delessertii (Voy. de Delessert, Ins. pl. xii. fig. 3), in having the black colour precisely occupying half of each elytron, being thus intermediate between these two specimens (sc. O. gazella sinensis and O. cuvera). I observed also that the spine terminating the posterior tibiae is more bent upon the base of the tarsi even than in my fig. 4. I have seen no male which will agree with this intermediate female in the colouring of the elytra &c.” (Comp. p. 465.)

No doubt can exist respecting the authenticity of the Fabrician type, as it entirely agrees with the description of Fabricius and with the figure of Olivier, and I have therefore retained Westwood’s name for the present species.

12. Odontolabis cuvera, Hope. (Plate XCI. figs. 7, 8, 9, d; 10, q.)

Odontolabis cuvera, Hope, Trans. Linn. Soc. xix. p. 105, pl. 10. fig. 3 (forma telodonta; very good figure).
Odontolabis prinsseppii, Hope (forma mesodontata), Cat. Lucan. p. 16 (Khasia Hills).
Odontolabis gazella, var. cuvera, Westw. Cab. Or. Ent. pl. xxvi. fig. 5 (very good figure).
Odontolabis delessertii, Hope, Cat. Lucan. p. 16.

Male. Similar to that of O. sinensis. Deep black, or dark chestnut-brown, but elytra yellow, with a V-shaped black or chestnut-brown mark beginning at the shoulders and extending evenly to the tip; rim of the elytra yellow beneath; head and thorax as in O. sinensis, but more finely punctured on the upper side, and shining; front tibiae in large specimens with five and in smaller ones with from three to five teeth above the terminal fork.

Mandibles.

1. Forma telodonta.—As in O. sinensis.—Var. cuvera, s. str., Hope (fig. 7).
2. Forma mesodonta.—Only differs from O. sinensis in the colour of the elytra.—Var. prinsseppii, Hope (fig. 8).
3. Forma priodonta.—As in O. sinensis (fig. 9).—Var. saundersi, Hope.

Female. Resembles that of O. sinensis in shape. Head more finely punctured; prothorax more convex above, much more finely punctured, and shining; sides bispinose, the spines not so pointed as in O. sinensis; outline different from that of O. sinensis; elytra narrower, sulphur-yellow, with a black V-shaped mark as in the male, the rim of the elytra black beneath; front tibiae with only three or four spines above the terminal fork.
Number of specimens examined: sixty-one males and fifteen females, in different collections. The males vary in size from 46 to 77 millim., and the females from 33 to 39 millim.

*Habitat.* North India (Silhet, Assam).

**Measurements.**

<table>
<thead>
<tr>
<th></th>
<th>Total length</th>
<th>Head</th>
<th>Mandibles</th>
<th>Prothorax</th>
<th>Elytra</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
</tr>
<tr>
<td>Telodont</td>
<td>77</td>
<td>15:0 by 23</td>
<td>24</td>
<td>12:0 by 25</td>
<td>30:0 by 26</td>
</tr>
<tr>
<td>Mesodont</td>
<td>67</td>
<td>13:5 &quot; 20</td>
<td>22</td>
<td>10:0 &quot; 22</td>
<td>26:5 &quot; 23</td>
</tr>
<tr>
<td>Priodont</td>
<td>61</td>
<td>13</td>
<td>17</td>
<td>10:0 &quot; 21</td>
<td>26:0 &quot; 22</td>
</tr>
<tr>
<td></td>
<td>58</td>
<td>12</td>
<td>13</td>
<td>10:0 &quot; 20-5</td>
<td>27:0 &quot; 22-5</td>
</tr>
<tr>
<td>2 ..........</td>
<td>46</td>
<td>11</td>
<td>12</td>
<td>10:5 &quot; 20</td>
<td>26:0 &quot; 20</td>
</tr>
<tr>
<td></td>
<td>39</td>
<td>6:5 by 12</td>
<td>5</td>
<td>9:0 &quot; 18</td>
<td>23:0 &quot; 19</td>
</tr>
<tr>
<td></td>
<td>33</td>
<td>6:0 &quot; 10</td>
<td>4:5</td>
<td>8:5 &quot; 15</td>
<td>19:0 &quot; 16</td>
</tr>
</tbody>
</table>

This species is closely allied to the last, from which it only differs in the colour of the elytra. It was first described by Hope as *O. cuvera*, in 1845; three years afterwards he described the mesodont form as *O. prinseppii*, and changed the name of *O. bicolor*, Saund., to *O. saundersi*. Hope's *O. delesserti* is quite distinct from Guérin's species; and I have convinced myself, by an examination of the types in Oxford, that they are only a small male and female of the present species from Assam.

13. **Odontolabis mouhoti**, Parry. (Plate XCI. fig. 5, ♂.)

*Odontolabis mouhotii*, Parry, Trans. Ent. Soc. Lond. (3) ii. p. 14, pl. i. fig. 1 (figure inexact).

**Male.** Intermediate between *O. sinensis* and *O. cuvera*. Uniform black, with the exception of the pale yellowish-brown elytra. Head large, front edge semicircularly emarginate, clypeus depressed, canthus narrow, oblique, the spine behind the eyes placed rather behind the canthus; beyond the spine the head narrows to the neck; mandibles as long as the head, slightly incurved, upper surface flattened, the right and left sides asymmetrical, the right with four or five small irregular apical teeth, followed by a round obtuse middle tooth and an obtuse basal tooth; on the left side these are less developed; prothorax rather broader than in *O. sinensis*, but similar in form; elytra broad, upper side pale brownish yellow, except a small straight black stripe on the suture, somewhat broader at its base on the scutellum, and extending to the shoulders; rim of the elytra yellow beneath; front tibiae long and narrow, with three spines on the right tibiae and four on the left above the terminal fork.

**Female.** Unknown.

**Habitat.** Cambodia.

A single specimen (the type) in Herr van Lausberge's collection (formerly in Count Castelnau's).
Measurements.

<table>
<thead>
<tr>
<th></th>
<th>Total length</th>
<th>Head</th>
<th>Mandibles</th>
<th>Prothorax</th>
<th>Elytra</th>
</tr>
</thead>
<tbody>
<tr>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
</tr>
<tr>
<td>♂</td>
<td>64</td>
<td>13 by 22.5</td>
<td>15</td>
<td>11 by 23</td>
<td>28 by 27</td>
</tr>
</tbody>
</table>

This interesting species, the unique specimen of which is an irregular mesodont form, is a native of Siam. Future observations alone can decide whether it is a discoloured specimen of *O. sinensis*, or whether the difference in the colour of the elytra is constant in Siam, as the somewhat differently formed mandibles might lead us to expect.

14. *Odontolabis delesserti*, Guér. (Plate XCII. figs. 1–3, ♂; fig. 4, ♀.)

*Lucanus bicolor*, var. *delesserti*, Guérin in Delessert, Souvenirs d’un Voyage dans l’Inde, 2e partie, p. 48, pl. xii. fig. 3 (a pretty figure; but not quite correct).


Male. Very like *O. cuerea*, but larger; body uniform black, except the elytra. Head quadrangular, with very prominent eyes, caudus narrow; the spine behind the eyes straight and well developed; mentum rectangular, thrice as broad as long; mandibles variable in size and shape; prothorax as in *O. cuerea*; upper surface dull and rugose; prosternal process obtuse, and generally rounded off; elytra sulphur-yellow, with a triangular black mark, beginning at the shoulders, where it is broad, and gradually narrowing to the tip; rim of the elytra black beneath; scutebellum smooth, semicircular; front tibiae with from one to three spines above the terminal fork.

Mandibles.

1. *Forma telodontia*.—Similar to that of *O. cuerea*, but larger, and with two well-developed teeth at the base (figs. 1, 1 b).

2. *Forma mesodontia*.—Head and prothorax dull, finely punctured. Rim of the elytra black beneath (fig. 2).

3. *Forma priodontia*.—Head and prothorax dull, finely punctured. Rim of the elytra black beneath. Front tibiae with two rows of fine punctures, and only two spines above the terminal fork (fig. 3).

Female. Very similar to that of *O. cuerea*, with which it agrees in the colour of the body and elytra. Head more coarsely wrinkled, and the prothorax more convex; elytra broader and shorter, the black triangular spot extends at the base to the very shoulders, and narrows gradually towards the tip; the outer margin is black above, and often widens somewhat at the tip; rim of the elytra black beneath; front tibiae with three or four strongly developed spines above the terminal fork.

Number of specimens examined: five males and four females, in the collections of Messrs. Parry, Moore, and Pettigrew.

Habitat. Neilgherries, Malabar, and Travancore.
Measurements.

<table>
<thead>
<tr>
<th>Total length</th>
<th>Head</th>
<th>Mandibles</th>
<th>Prothorax</th>
<th>Elytra</th>
</tr>
</thead>
<tbody>
<tr>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
</tr>
<tr>
<td>1.</td>
<td>85</td>
<td>16·0 by 25·5</td>
<td>29</td>
<td>12·0 by 27</td>
</tr>
<tr>
<td>2.  { Telodont \</td>
<td>84</td>
<td>14·0 &quot; 24</td>
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<td>12·0 &quot; 25</td>
</tr>
<tr>
<td>3.  { Mesodont \</td>
<td>74</td>
<td>12·5 &quot; 20</td>
<td>24</td>
<td>10·5 &quot; 22</td>
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<tr>
<td>Priodont \</td>
<td>43</td>
<td>10·0 &quot; 18</td>
<td>14</td>
<td>10·5 &quot; 22</td>
</tr>
<tr>
<td>{ 44</td>
<td>7·5 &quot; 14</td>
<td>6·5</td>
<td>10·0 &quot; 19·5</td>
<td>25 &quot; 21</td>
</tr>
<tr>
<td>{ 37</td>
<td>6·0 &quot; 11</td>
<td>5</td>
<td>8·0 &quot; 16</td>
<td>21 &quot; 17</td>
</tr>
</tbody>
</table>

This insect was collected by Delessert in the Neilgherry Mountains, and was described by Guérin as *Lucanus bicolor*, var. *delesserti*, from a female specimen, but it long remained an uncertain species. As the females of the Odontolabini are very similar, and are very difficult to distinguish from one another, it was sometimes regarded as the female of *O. bicolor* (Guérin and Burmeister) and sometimes as that of *O. gazella* or *cuvera* (Westwood and Thomson), until the careful examination undertaken by Major Parry, with the assistance of Count Niższeck, determined it to be distinct. I found male forms in Major Parry's collection, but they have hitherto remained undescribed. There is a female in the same collection, from the Neilgherry, which agrees very well with Guérin's figure in colour and markings.

15. Odontolabis burmeisteri, Hope.  (Plate XCII. figs. 5–8, \( \delta \); fig. 9, 2.)

**Male.** Uniform black, the elytra excepted. Head quadrangular, with very prominent eyes, the spine behind the eyes obtuse, and only slightly prominent; lower part of the cheeks pitted with large deep punctures, or coarsely wrinkled; mentum quadrangular, rather longer than in *O. delesserti*; mandibles variable in size and shape; prothorax as long as the head, or shorter, smooth and shining, the middle spine less prominent than in the allied species; prosternal process (viewed from above) long, linear; elytra longer and narrower than in *O. delesserti*, sulphur-yellow, with a triangular black spot commencing rather within the shoulders, and gradually narrowing towards the tip; rim of

\(^1\) Handbuch d. Entomologie, v. p. 360.
\(^2\) Oriental Entomology, p. 54.
the elytra always yellow beneath; scutellum triangular, generally bisected by a median line; front tibiae spineless, or with from one to three spines above the terminal fork.

Mandibles.

1. *Forma telodontata.*—Mandibles longer than the head and prothorax together, very long, rounded, and slender, the tip armed with five small irregular teeth, which are forked into two groups, as in the preceding species; in the middle is a straight rounded tooth, and there are two small teeth at the base, the first of which is sometimes forked. Head with enormously developed and raised frontal margin. Seven specimens (one Brit. Mus., six from Rev. S. J. Pettigrew’s coll.). *O. hurmeisteri*, type form (fig. 5).

2. *Forma mesodontata.*—Mandibles as long as or rather longer than the head, broader and more compressed than in no. 1, with a strongly developed central tooth, that on the right side most developed. The terminal series of five or six small teeth shows a tendency to bifurcate on the right side, but not on the left side, where from six to eight small equal-sized teeth succeed each other regularly. Base with two or three obtuse teeth. On the left side the central tooth is nearer the base, and may almost coalesce with the two basal teeth (fig. 6). Two specimens (exactly alike) from Pettigrew’s collection.

3. *Forma priodontata.*—Mandibles as long as the head, and very slightly curved, flattened, the right side rather more strongly developed and broader than the left, with from seven to eight small irregular teeth. Head flattened, canthus rather broader than in the preceding forms.

N.B. The prothorax is rather narrower (compare measurements). Lower border of the prothorax not wrinkled, but finely punctured, as in *O. delesserti*.

One specimen, British Museum (fig. 7) with male pattern of elytra, fig. 8 smallest male, from Parry’s collection, with female markings.

*Female.* Like the male, it attains a truly gigantic size. It more resembles *O. cuvera* in appearance than *O. delesserti*, which occurs in the same locality. The canthus is very strongly developed, and much broader than in either *O. cuvera* or *O. delesserti*; prosternal process as in male, very long and rounded. The pattern of the elytra is very characteristic; the black space on the dark sulphur-yellow ground-colour is no longer a straight triangle, but tongue-like, broadest at the base, and narrowed towards the middle, and its outer edge runs for a short distance parallel to the suture, and grows suddenly narrower at the tip; the rim of the elytra is yellow beneath in all the specimens which I have examined; scutellum triangular, with a central raised line; front tibiae with four spines above the terminal fork.

*Habitat.* Travancore and Malabar.
**Measurements.**

<table>
<thead>
<tr>
<th>Measurements</th>
<th>Total length</th>
<th>Head</th>
<th>Mandibles</th>
<th>Prothorax</th>
<th>Elytra</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
</tr>
<tr>
<td><strong>Telodont</strong></td>
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<td>40</td>
<td>14·0 by 30</td>
<td>36 by 30</td>
</tr>
<tr>
<td></td>
<td>99</td>
<td>17·0 &quot; 26</td>
<td>40</td>
<td>13·5 &quot; 28·5</td>
<td>36 &quot; 30</td>
</tr>
<tr>
<td></td>
<td>83</td>
<td>14·0 &quot; 21</td>
<td>32</td>
<td>11·0 &quot; 23</td>
<td>30 &quot; 25</td>
</tr>
<tr>
<td><strong>Mesodont</strong></td>
<td>79</td>
<td>16·0 &quot; 25</td>
<td>23</td>
<td>13·0 &quot; 27</td>
<td>34 &quot; 26·5</td>
</tr>
<tr>
<td></td>
<td>75</td>
<td>15·5 &quot; 23</td>
<td>21</td>
<td>12·0 &quot; 25</td>
<td>32 &quot; 26</td>
</tr>
<tr>
<td><strong>Proodont</strong></td>
<td>62</td>
<td>12·0 &quot; 19</td>
<td>14</td>
<td>11·0 &quot; 22</td>
<td>29 &quot; 23</td>
</tr>
<tr>
<td></td>
<td>53</td>
<td>8·5 &quot; 16</td>
<td>8</td>
<td>11·5 &quot; 22·5</td>
<td>29 &quot; 23·5</td>
</tr>
<tr>
<td></td>
<td>40</td>
<td>6·5 &quot; 12</td>
<td>6</td>
<td>9·0 &quot; 17</td>
<td>23 &quot; 18·5</td>
</tr>
</tbody>
</table>

This South-Indian species was described by Hope, in 1841, from a single male example, and was long regarded by Westwood, Burmeister, and Parry as a mere variety of *O. ouvra*.* Subsequently Major Parry and Mr. C. O. Waterhouse obtained specimens of both sexes from Travanore, and were thus enabled to recognize it as a distinct species. Through the kindness of Messrs. Janson and Moore, and especially of Mr. Kirby, who put me into communication with the Rev. S. J. Pettigrew, who lived for some time in Travanore, I was enabled to examine eleven male and five female examples.

**Section IV.**

16. **Odontolabis wollastoni**, Parry. (Plate XCIIL figs. 5, 6, 7, 9, δ; fig. 8, η.)

δ η. *Odontolabis wollastoni*, Parry, Trans. Ent. Soc. Lond. (3) ii. p. 14, pl. iii. fig. 1 (δ telodont); pl. ii. fig. 2 (δ amphiodont), fig. 3, η.

**Male.** Uniform black, except the bicolorous elytra. Head often as broad as the prothorax, the sides with coarse shagreened punctuation; canthus broad, divided by an indentation into two folds in front of the eyes, the spine behind the eyes set very far back, and often rounded off; prothorax with the front edge deeply emarginate on each side, sides S-shaped as far as the middle spine, and then strongly emarginate; prosternal process conspicuous, projecting vertically downwards; elytra orange-yellow, with a triangular black mark, rapidly narrowing before the tip; rim of the elytra black beneath; front tibia long and straight, with one or two very slender spines above the terminal fork.

**Mandibles.**

1. **Forma telodonta.**—Mandibles longer than the head, rounded, strongly curved, and bifurcated at the tip, with three or four small teeth on the front branch; a rudiment of an obtuse tooth on the upper side at the base. Front margin of the head very convex (fig. 5).

2. **Forma mesodonta.**—(a) Mandibles not forked at the tip, with three or four teeth; beyond the middle is a very prominent tooth, pointing downwards, above which are four or five small teeth. A strong obtuse basal tooth (var. *pectinata*, fig. 6). (b) Mandibles...
as in a, but the small teeth which follow the central tooth are divided into two groups. The prothorax of the specimen figured is much narrower (fig. 7).

3. *Forma amphiodonta* (irregularis).—The right mandible is always more strongly developed, the five or six small teeth at the tip are divided by a gap from the two obtuse basal teeth (fig. 9).


**Variations in Colour.**

The colour of the upper side of the elytra is not constant. There are males of all forms in which the black mark is pointed towards the base (figs. 5, 6, 9). In others this mark is broad almost to the tip in all forms, and then suddenly disappears, as in fig. 7, and in the type figured by Parry. As both forms occur together, both in Malacca and Sumatra, they cannot be regarded as constant local races, as in *O. volkenhoveni*, and I was obliged to treat them as belonging to the same species. The four forms of mandibles described evidently also belong to the same species.

**Female.** Uniform black, except the bicolorous elytra. Head slightly convex, smooth, only slightly punctured on the front margin; canthus strongly developed, as broad as the eye; prothorax strongly convex, the front edge strongly emarginate, the sides strongly S-shaped as far as the central spine, and deeply emarginate behind; hinder margin as broad as the shoulders, and waved; elytra orange-yellow, shining, with a black triangular mark beginning just inside the shoulders, gradually narrowing and ceasing abruptly about 4 or 5 millimetres from the tip; rim of the elytra black beneath; front tibiae straight, slightly incurved, with three or four spines above the well-developed terminal fork.

Number of specimens examined: eleven males and eight females, in the collections of the British Museum, Leyden, Amsterdam (from Lahat, Sumatra), and of Messrs. Parry and van Lansberge.

**Habitat.** Malacca, Sumatra.

**Measurements.**

<table>
<thead>
<tr>
<th>Total length (millim.)</th>
<th>Head length (millim.)</th>
<th>Mandibles length (millim.)</th>
<th>Prothorax length (millim.)</th>
<th>Elytra length (millim.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Parry's type (Malacca), ♂</td>
<td>67</td>
<td>22</td>
<td>9-0 by 19</td>
<td>25 by 20</td>
</tr>
<tr>
<td>2. Parry's coll. (Malacca)</td>
<td>54</td>
<td>12-5</td>
<td>8-5 &quot;</td>
<td>24 &quot;</td>
</tr>
<tr>
<td>3. Sumatra (telodont)</td>
<td>68</td>
<td>24</td>
<td>10-0 &quot;</td>
<td>27 &quot;</td>
</tr>
<tr>
<td>4. Sumatra (pectinata)</td>
<td>70</td>
<td>22</td>
<td>10-0 &quot;</td>
<td>27 &quot;</td>
</tr>
<tr>
<td>5. Sumatra (pectinata)</td>
<td>70</td>
<td>24</td>
<td>10-0 &quot;</td>
<td>28 &quot;</td>
</tr>
<tr>
<td>6. Sumatra (amphiodonta irregularis)</td>
<td>62</td>
<td>13</td>
<td>9-0 &quot;</td>
<td>25 &quot;</td>
</tr>
<tr>
<td>Parry's type (Malacca)</td>
<td>38</td>
<td>6-5</td>
<td>8-0 &quot;</td>
<td>21 &quot;</td>
</tr>
<tr>
<td>Parry's type (Sumatra), ♀</td>
<td>41</td>
<td>6-5</td>
<td>9-0 &quot;</td>
<td>22 &quot;</td>
</tr>
</tbody>
</table>

This species is very rare in collections, and it was only with great difficulty that I
was enabled to bring together the various male forms, which are mostly to be found singly in various museums. The specimens figured on Pl. XCIII. figs. 5, 6, 9, were collected by Mr. H. O. Forbes in Balacud, in the Residency of Palembang, at an elevation of 5300 feet, and I am much indebted to him for the kind permission to figure and describe them. I am only acquainted with two other specimens of the new and interesting form *pectinata*, both from Lahat, in the Museums of Leyden and Amsterdam, the latter of which agrees with fig. 7 in colour.

17. *Odontolabis vollenhoveni*, Parry. (Plate XCIII. figs. 1–3, ♂; fig. 4, ♀.)


*Male.* Very like *O. wollastoni*, but larger; elytra orange-yellow, the black mark still narrower than in *O. ludekingi*, running parallel with the suture, and ending in a point; under-surface and legs entirely black; head with a reddish-brown triangular spot on the vertex; clypeus of the same colour, otherwise as in *O. wollastoni*.

**Mandibles.**

1. *Forma telodonta.*—As in *O. wollastoni* (fig. 1; comp. fig. 5).

2. *Forma pectinata.*—As in *O. wollastoni*, but the basal tooth is much more strongly developed, and the small comb-like teeth above the central tooth are longer and stronger (fig. 2; comp. fig. 6).

3. In an *amphio-mesodont* form the apical teeth are broader than in *O. ludekingi* the mandibles are more strongly curved, the central tooth projects more in front, and there is only one small tooth on the right mandible and one on the left (fig. 3).

4. *Amphiodont* and *priodont* forms unknown.

*Female.* Very like that of *O. ludekingi*, but larger, prothorax broader, elytra dark yellow, with a narrow black lanceolate mark in the middle, the rim black beneath, front tibiae straight, with three spines above the terminal fork. Unique in Herr van Lansberge's collection.

Number of specimens examined: five males and one female, in the collections of Messrs. Parry and van Lansberge.

**Habitat.** Borneo (one telodont form said to be from Java?).

**Measurements.**

<table>
<thead>
<tr>
<th></th>
<th>Total length</th>
<th>Head</th>
<th>Mandibles</th>
<th>Prothorax.</th>
<th>Elytra.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
</tr>
<tr>
<td>Parry's type (telodont; Borneo)</td>
<td>75</td>
<td>14-0 by 24</td>
<td>26</td>
<td>10 by 23</td>
<td>29 by 23</td>
</tr>
<tr>
<td>Lansberge's coll. (W. Java)</td>
<td>72</td>
<td>14-0 „ 23</td>
<td>26</td>
<td>10 „ 23</td>
<td>28 „ 22-5</td>
</tr>
<tr>
<td>Lansberge's coll. (Borneo; pectinata)</td>
<td>78</td>
<td>15-0 „ 25</td>
<td>26</td>
<td>10 „ 25</td>
<td>31 „ 24</td>
</tr>
<tr>
<td>Lansberge's coll. (Borneo; pectinata)</td>
<td>71</td>
<td>12-0 „ 23</td>
<td>23</td>
<td>10 „ 24</td>
<td>29 „ 23</td>
</tr>
<tr>
<td>Lansberge's coll. (mesodont)</td>
<td>65</td>
<td>15-0 „ 22</td>
<td>19</td>
<td>10 „ 22</td>
<td>28 „ 23</td>
</tr>
<tr>
<td>Lansberge's type, 2</td>
<td>40</td>
<td>7-5 „ 13</td>
<td>9 „ 18</td>
<td>23 „ 16-5</td>
<td></td>
</tr>
</tbody>
</table>

3 x 2
This wonderful Bornean species was described by Major Parry from a telodont form, which long remained unique in his collection. From its analogy with *O. wollastoni* I anticipated that parallel forms would occur, and my supposition was at length fully confirmed. I found two specimens of the form *pectinata* in Herr van Lansberge's collection under the name of *O. parryi*, MS., a third specimen (fig. 3) and a single female from Borneo, which the owner kindly allowed me to describe and figure. The narrow black band on the suture was constant in every specimen examined.

18. **Odontolabis ludekingi**, Voll. (Plate XCIIf. figs. 10, 11, ♂; fig. 12, ♀. Plate XCIV. fig. 8, ♂.)


**Odontolabis ludekingii**, Parry, Tr. Ent. Soc. Lond. (3) ii. p. 13, pl. ii. fig. 1.

**Male.** Very like that of *O. wollastoni*, but always recognizable by the difference in the mandibles and the colour of the elytra. Uniform black, elytra excepted; head and prothorax as in *O. wollastoni*; elytra yellow, with a narrow black stripe on the suture; mandibles strongly convex and incurved.

**Mandibles.**

1. **Forma telodonta** (!).—Mandibles longer than the head, slender, with three or four apical teeth, and a flattened, bifid central tooth, directed downwards (Pl. XCIV. fig. 8).

2. **Forma mesodonta.**—a. Mandibles longer than the head, with three or four apical teeth, two central teeth, and a strong obtuse basal tooth, as in fig. 7 (Vollenhoven's type in Leyden Museum); b. Mandibles with a single central dichotomous tooth, and a strong obtuse basal tooth (fig. 10).

3. **Forma amphiodonta.**—Fig. ii. as in *O. wollastoni* (fig. 9).

**Female.** Resembles that of *O. wollastoni* in form and size, but may be distinguished from it by the black mark on the elytra, which is narrower at the shoulders.

Number of specimens examined: eight males and three females in Leyden Museum, and in the collections of Messrs. Parry and van Lansberge.

**Habitat.** Eastern Sumatra (also Java !).

**Measurements.**

<table>
<thead>
<tr>
<th></th>
<th>Total length</th>
<th>Head</th>
<th>Mandibles</th>
<th>Prothorax</th>
<th>Elytra</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
</tr>
<tr>
<td>Type!...</td>
<td>60</td>
<td>12 by 19</td>
<td>15</td>
<td>10 by 21</td>
<td>27.0 by 21</td>
</tr>
<tr>
<td></td>
<td>56</td>
<td>11 &quot; 19</td>
<td>14</td>
<td>10 &quot; 21</td>
<td>26.0 &quot; 21</td>
</tr>
<tr>
<td></td>
<td>55</td>
<td>12 &quot; 19</td>
<td>15</td>
<td>9 &quot; 19</td>
<td>25.5 &quot; 20.5</td>
</tr>
<tr>
<td>♂......</td>
<td>41</td>
<td>7 &quot; 13-5</td>
<td>0</td>
<td>8 &quot; 18</td>
<td>22.0 &quot; 18</td>
</tr>
<tr>
<td>♀......</td>
<td>38</td>
<td>7 &quot; 12-5</td>
<td>6</td>
<td>8 &quot; 17</td>
<td>22.0 &quot; 18</td>
</tr>
</tbody>
</table>

Vollenhoven’s types are in the Museum at Leyden, where Herr Ritsema showed me them. The largest specimen agrees fairly with Vollenhoven’s figure; and the second
and smaller male is in Major Parry's collection (fig. 10). A careful examination has
evolved, and both species occur in Sumatra. The specimen measures 37 millim. in
length, and has a comparatively small head, in which the canthus is almost entirely
undeveloped. The very convex prothorax is also abnormal, and therefore narrower
than the elytra (compare the measurements under O. lacordairii). The middle spines
are curved backwards, and are not so much developed as O. ludekingi (♀). The
prothorax is black, with no trace of orange-yellow marks on the front margin, as in
the small female from Solok in the Leyden Museum. The elytra are yellow, and the
oblique mark on the suture, which is 6 millim. broad, runs irregularly to the tip,
without growing narrower, and terminates on the left elytron in an irregular blotch.
The front tibiae likewise agree with O. lacordairii in form, and the femora are reddish
brown beneath, as in that species. The spot on the sternal plate, which is characteristic
of O. lacordairii, occurs in Vollenhoven's specimen also.

I describe a specimen as the female of O. ludekingi (Pl. XCIII. fig. 12) from Herr
van Lansberge's collection. It was taken in Sumatra with a series of males, and only
differs from O. wollastoni (♀) in the narrower black mark on the elytra. I cannot
decide with certainty whether the specimen with the most highly developed mandibles
really belongs to this species, as Herr van Lansberge thinks, or not, as there is a precisely
similar specimen from Java in the Leyden Museum. The extraordinary resemblance
in the pattern of the elytra, and the correspondence of the various mandible-forms, the
great rarity of the insect, and the great variation in colour in the females of O. lacor-
dairii, lead me to consider it very probable that O. ludekingi is a hybrid between the
two Sumatran species O. wollastoni and O. lacordairii.

19. ODONTOLABIS LACORDAIRII, Voll. (Plate XCIV. figs. 1–5, ♂; figs. 6, 7, ♀.)

Male. Head shining black, with a triangular yellow mark on the front and clypeus,
smooth, except on the sides, where it is very strongly wrinkled; canthus broad, bilobed,
emarginate in the middle, the spine behind the eyes sloping forwards, sometimes strongly
developed (fig. 1), sometimes absent (fig. 4); prothorax broad, uniform black, variable
in width (figs. 1, 2, 5), strongly emarginate in front, the sides oblique, and widened as
far as the middle spine, and then strongly emarginate; hind margin waved; prosternal
process straight, projecting downwards (fig. 2 ♂); elytra long, oval, sulphur-yellow,
the base, the suture, and the overlapping rim black; under-surface black and shining,
with two large round reddish-brown spots on the mesosternum; legs black, femora with
long reddish-brown spots, front tibiae long and straight, with one or two spines above
the terminal fork.
Mandibles.

1. *Forma telodonta.*—Mandibles longer than the head, rounded, moderately curved, with four or five small teeth at the tip, behind which is a simple tooth projecting downwards; a rudimentary tooth on the upper side at the base; head with strongly developed frontal crest (figs. 1, 2).

2. *Forma mesodonta.*—Mandibles as long as the head, and strongly curved, rounded, with five apical teeth; a strong central tooth curving downwards (with tendency to bifurcation); base with a rudimentary obtuse tooth (fig. 3) on the upper side near the basis.

3. *Forma amphio-mesodonta.*—Mandibles as long as the head, broad, sickle-shaped, the apical series of teeth not separated from the central teeth; base with two obtuse teeth (fig. 4).

4. *Forma priodonta (irregularis).*—Mandibles very short, with irregular teeth; head with no spine behind the eye; prothorax resembling that of female (fig. 5), and spotted with yellow on each side, at the front angles, as in the female (fig. 6).

**Female.** Very like that of *O. wollastoni* and *O. ludekingi* in the shape of the head and thorax, but flatter, shining black, with a round orange-red spot on the front angle of the prothorax, both above and below; elytra long, oval, pale straw-coloured, with a broad black sutural stripe rapidly narrowing before the tip; borders and the overlapping rim black; under-surface of the abdomen black, with a large pale brown spot on each side of the mesosternum; legs black, the underside of the femora with a pale brown spot (fig. 6 a, b).

**Female (variety).** There is a small specimen in the Leyden Museum in which the yellow spots on the prothorax are wanting, and the black suture is as narrow as in the male (fig. 7).

Number of specimens examined: ten males and four females in the Leyden Museum and in Herr van Lansberge's collection.

**Habitat.** Eastern Sumatra.

**Measurements.**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>millim.</strong></td>
<td><strong>millim.</strong></td>
<td><strong>millim.</strong></td>
<td><strong>millim.</strong></td>
<td><strong>millim.</strong></td>
</tr>
<tr>
<td><strong>♂. Teledont</strong></td>
<td>81</td>
<td>14 by 24</td>
<td>23</td>
<td>11 by 25</td>
</tr>
<tr>
<td><strong>Type</strong></td>
<td>71</td>
<td>14 „ 20</td>
<td>23</td>
<td>11 „ 22</td>
</tr>
<tr>
<td>67</td>
<td>13 „ 19</td>
<td>24 „ 5</td>
<td>10 „ 21</td>
<td>28-0 „ 22</td>
</tr>
<tr>
<td><strong>Type (♀)</strong>*</td>
<td>45</td>
<td>8 „ 15</td>
<td>7</td>
<td>10 „ 20</td>
</tr>
<tr>
<td>37-5</td>
<td>6 „ 11</td>
<td>6</td>
<td>8 „ 16</td>
<td>23-0 „ 17-5</td>
</tr>
</tbody>
</table>

Vollenhoven described this species from a single male from Sumatra (type in the Leyden Museum), and gave a recognizable figure, which, however, is less accurate than it looks. The head is broadest in front; but Vollenhoven has represented it as broadest behind,
from spine to spine, which entirely alters the appearance of the insect. The yellow mark on the head is by no means so sharply defined as in the figure, which represents it as raised. The prothorax is equally incorrect, being represented as much too broad at the base. It is unfortunate, too, that Vollenhoven had an abnormal male of the telodont form before him, in which the prothorax was strongly narrowed in front, a character which is neither constant nor typical (fig. 2). In normal specimens the prothorax resembles that of *O. ludekingi* and *O. wollastoni.*

This specimen long remained unique; but a short time ago the Leyden Museum received seven males and three females. Herr Ritsema, who described the males and the previously unknown female, was kind enough to show me his MS. All the specimens figured on Pl. XCVI, are from the Leyden Museum. The various forms figured are exceedingly interesting and instructive, for they show us what considerable variations may occur in other parts of the body besides the mandibles. (Compare the head and thorax in figs. 1 & 2.) The front tibiae in figs. 1 & 2 are rounded, while figs. 3 & 4 show a slight inward curvature, and a shallow channel on the upper surface. The proidont male (fig. 5) is like the female both in the form of the thorax and in the reddish-yellow spots on the front angles, which are so characteristic in the large females. The female represented in fig. 7 is equally interesting. The prothorax is black, and the elytra are marked as in the male.

20. **Odontolabis gazella**, Fabr. (Plate XCVI. figs. 10, 10 b, ♂; fig. 11, ♀: compare Plate XCI. fig. 6, ♀, Fabrician type!)


**Male.** Uniform black, with the upper side of the elytra yellowish brown; mandibles sickle-shaped, with strong wrinkled punctuation; head flattened, finely punctured; frontal edge but slightly emarginate; canthus very broad, spine behind the eyes straight, directed slightly backwards, and obliquely truncated behind; prothorax very short and broad, only slightly convex, widened on the sides towards the middle spine, and then strongly emarginate; underside smooth; prosternal process well developed, oblique, directed backwards. Elytra long, oval, strongly convex, yellowish brown, with

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1 This apparently unimportant modification of form throws a light on those retrograde male forms with short mandibles, large heads strongly narrowed behind, a broad prothorax, and curved front tibiae. (Compare *O. gazella*, Fabr., and the other species figured together on Pl. XCVI.)
a narrow black suture, and a narrow black border at the base of the shoulders; front tibiae very long, and incurved and channelled on the upper side; terminal fork slightly developed, and with three or four very slightly developed spines above it.

**Female.** Resembles that of *O. wollastoni*. Uniform black, except the bicolorous elytra. Head strongly convex, and coarsely punctured; canthus broad; mandibles strongly punctured, with three irregular teeth on the inside; mentum with a semicircular excavation, and coarsely punctured. Prothorax broad, the sides running straight and oblique to the middle spine, the latter hardly pointed. Elytra more convex, and broader than in the male, half black and half yellow; the black mark begins at the shoulder, runs straight nearly to the tip, and then suddenly ceases. The black colour frequently extends to the tip, where it unites with the borders. Under-surface of the overlapping rim always black; front tibiae long and narrow, with well-developed terminal fork, and four or five spines on the outer side; the hind tibiae are slightly incurved, and longitudinally furrowed.

Number of specimens examined: eighty-eight males and twenty-five females in various museums. The males vary in size from 45 to 68 millim., and the females from 36 to 44 millim.

**Habitat.** (Nepal?), Siam, Malacca, Sumatra, Borneo.

**Measurements.**

<table>
<thead>
<tr>
<th></th>
<th>Total length</th>
<th>Head</th>
<th>Mandibles</th>
<th>Prothorax</th>
<th>Elytra</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
</tr>
<tr>
<td>Lansb. coll. (mesodont, fig. 10, b)</td>
<td>62</td>
<td>11 by 21</td>
<td>15</td>
<td>10.5 by 26</td>
<td>28 by 23</td>
</tr>
<tr>
<td>Lansb. coll. (amphiodont)</td>
<td>68</td>
<td>14 &quot;</td>
<td>24</td>
<td>12.6 &quot;</td>
<td>26</td>
</tr>
<tr>
<td>Brit. Mus. coll. (priodonta irregulare)</td>
<td>56</td>
<td>12 &quot;</td>
<td>19</td>
<td>14</td>
<td>11.0 &quot;</td>
</tr>
<tr>
<td>Parry's coll. (Borneo, Wallace)</td>
<td>42</td>
<td>8 &quot;</td>
<td>14</td>
<td>6</td>
<td>10.5 &quot;</td>
</tr>
<tr>
<td>Lansb. coll. (Malacca)</td>
<td>44</td>
<td>9 &quot;</td>
<td>15.5</td>
<td>7</td>
<td>10.5 &quot;</td>
</tr>
<tr>
<td>Lansb. coll. (Sumatra)</td>
<td>41</td>
<td>9 &quot;</td>
<td>14</td>
<td>6.5</td>
<td>10.0 &quot;</td>
</tr>
<tr>
<td>Parry's coll. (Borneo, Wallace)</td>
<td>36</td>
<td>6 &quot;</td>
<td>11</td>
<td>4.5</td>
<td>8.0 &quot;</td>
</tr>
</tbody>
</table>

The males and females vary in size, as well as in the form of the prothorax. The specimens from Sumatra and Borneo differ a little, although they indubitably belong to the same species. The mandibles of the males are always irregularly amphio-priodont, and there is a gap between the teeth in larger specimens, which is wanting in small ones. The crippled and irregular form, which resembles the amphiodont form of *O. wollastoni* (Pl. XCVIII. fig. 9) and *O. ludekingi* (fig. 11), led me to suspect that a higher development of the mandibles might occur. But it is extremely rare, and the only specimen which I have seen is in Herr van Lansberge's collection (fig. 10 b). In this specimen the mandibles are longer than the head, rounded, slender, and regularly curved; the two sides are nearly symmetrical; the upper surface finely punctured;
there are three or four irregular apical teeth, and a central rounded tooth rather beyond the middle. Clypeus vertically descending between the mandibles as in *O. wollastoni*. The specimen is much damaged in a manner which could only have happened in a contest with a rival, for the middle tooth of the right mandible is broken off, the same mandible is strongly indented on the underside at the tip, the right canthus is almost entirely broken off, and the left one in front. The front tibiae have only two spines on the outer side.

Fabricius's type of his *Lucanus gazella* (represented on Pl. XCl. fig. 6, for comparison with *O. sinensis* and *O. cuvera*) is preserved in the Banksian collection at the British Museum. It agrees perfectly with the descriptions of Fabricius and Olivier, but not so well with the figure of the latter, in which (in well-coloured copies only) half the elytra are represented as dark brown. In other copies, as, for instance, in the working-copy at the British Museum, the dark colour extends nearly to the borders, as in *O. sinensis*. It is undoubtedly the true female of *O. bicolor*, Oliv. (a male of which is contained in the same collection), an opinion in which Mr. C. O. Waterhouse now concurs. It came from Siam (or Malacca?), and agrees with specimens from Malacca, Sumatra, and Borneo. (Comp. p. 452, anteā.)

21. *Odontolabis inaequalis* (Kaup). (Plate XCVI. figs. 12, 12 b, c.)


**Male.** Only differs from *O. gazella* in the constant dark-brown colour of the elytra, and by the less spinose front tibiae (one or two spines only above the terminal fork).

**Female.** Unknown.

Number of specimens examined: three males (including type) in Major Parry's collection, and two males in the British Museum.

**Habitat.** Nias.

**Measurements.**

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
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</tr>
<tr>
<td>Fig. 12 b .... 52</td>
<td>10 by 18</td>
<td>13</td>
<td>10 by 21</td>
<td>24 by 21</td>
</tr>
<tr>
<td>Fig. 12 ...... 43</td>
<td>9 ,, 14-5</td>
<td>10</td>
<td>9 ,, 19</td>
<td>22 ,, 18-5</td>
</tr>
</tbody>
</table>

This insect is constantly darker than the male of *O. gazella* from the adjoining island of Sumatra. Until the female is discovered, we cannot be certain whether this is a constant dark race, or a distinct species. I do not understand why Dr. Kaup compared this insect with the males of *O. latipennis* and *O. stevensi*, rather than with the closely allied *O. gazella*. 
Section V.

22. Odontolabis castelnaudi, Parry. (Plate XCV. figs. 1-4, $\delta$; fig. 5, $\varphi$.)

$\delta$. Odontolabis castelnaudi, Parry, Trans. Ent. Soc. Lond. (3) ii. p. 14, pl. i. fig. 2; l. c. (1870) p. 74, pl. iii. figs. 4, 5, 6.

Male. Uniform black, the elytra excepted. Head flattened, finely punctured, front margin slightly arched; canthus very narrow, spine behind the eyes very prominent, rounded, obtuse, sloping obliquely towards the neck. Prothorax with the front edge emarginate on each side, the sides straight, rounded off beyond the middle, in the position of the central spine, and then somewhat emarginate. Under-surface smooth, dull. Prosternal process projecting strongly forwards. Elytra uniform orange-yellow, except a narrow black border at the base, and a line on the suture; the outer margin is also very narrowly edged with black. Front tibiae long, slender, and slightly incurved, the terminal fork well developed, and one or two very small spines above it. A shallow channel runs along the whole of the upper side.

Mandibles.

1. Forma telodonta.—Mandibles as long as the head and prothorax together, slender, the tip simple, below which is a strong projection slightly bifurcate at the tip, below which are four or five small irregular teeth on the inside. A small tooth projects forward on the inside near the base. Head with the front margin somewhat swollen; a broad epistoma is present, which is straight in front, and clothed with red hair (fig. 1).

2. Forma mesodonta.—a, var. pectinata. Mandibles as long as the head, much thicker than in no. 1, with four or five very small irregular teeth at the tip, followed on the inside by four small obtuse teeth, and a strongly developed central tooth curving downwards; base with an obtuse tooth (fig. 2). b, var. mesodonta (s. str.). Mandibles as long as the head, strongly curved, with five small apical teeth, and a rounded tooth curving downwards in the middle; base with an obtuse tooth; head with the front margin emarginate (fig. 3).

3. Forma amphiodonta.—Mandibles much shorter than the head, strongly curved, flattened, with five apical teeth, separated by a gap from the two obtuse basal teeth. Head without frontal crest or epistoma (fig. 4).

4. Forma priodonta.—Unknown.

Female. Black, except the yellow elytra. Head long, slightly convex, strongly and coarsely punctured; canthus round, as broad as the eye; mentum strongly shagreened, and semicircularly excavated; mandibles comparatively small. Prothorax much arched, the sides convex, with no central spine, and but slightly emarginate behind. Elytra long, oval, orange-yellow, narrowly black at the base, and with a narrow black stripe on the suture; rim of the elytra black beneath (fig. 5).
Number of specimens examined: eight males and two females from the collections of Van Lansberge (from Castelnau's and Mniszech's collections), Parry, and Bates; two males collected by Ludeking at Solok, Sumatra, are in the Leyden Museum.

_Habitat._ Sumatra, Borneo.

**Measurements.**

<table>
<thead>
<tr>
<th></th>
<th>Total length</th>
<th>Head</th>
<th>Mandibles</th>
<th>Prothorax</th>
<th>Elytra.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
</tr>
<tr>
<td>*♂._ Castelnau's coll. (\text{telodont}) (\ldots) 81</td>
<td>16·0 by 27</td>
<td>25</td>
<td>12·0 by 27</td>
<td>34·0 by 27</td>
<td></td>
</tr>
<tr>
<td>*♂._ Castelnau's coll. (\text{mesodont}) (\ldots) 83</td>
<td>16·5 „, 29</td>
<td>21</td>
<td>13·0 „, 30</td>
<td>36·0 „, 29</td>
<td></td>
</tr>
<tr>
<td>(amphiodont) (\ldots) 79</td>
<td>16·0 „, 29</td>
<td>16</td>
<td>14·0 „, 30</td>
<td>36·0 „, 29</td>
<td></td>
</tr>
<tr>
<td>*♂._ Parry's coll. (Sumatra; mesodont) (\ldots) 67</td>
<td>15·0 „, 24</td>
<td>17</td>
<td>11·5 „, 25</td>
<td>32·0 „, 25</td>
<td></td>
</tr>
<tr>
<td>*♂._ Bates's coll. (Borneo) (\ldots) 64</td>
<td>12·0 „, 21</td>
<td>15·5</td>
<td>10·5 „, 22</td>
<td>29·0 „, 24</td>
<td></td>
</tr>
<tr>
<td>*♂._ Parry's coll. (Borneo) (\ldots) 56</td>
<td>11·0 „, 19</td>
<td>13</td>
<td>10·0 „, 21</td>
<td>27·0 „, 21</td>
<td></td>
</tr>
<tr>
<td>*♀._ Lansberge's coll. (\ldots) 49</td>
<td>9·5 „, 15</td>
<td>6</td>
<td>11·5 „, 22</td>
<td>29·0 „, 23</td>
<td></td>
</tr>
<tr>
<td>*♀._ Lansberge's coll. (\ldots) 45</td>
<td>9·0 „, 14</td>
<td>6</td>
<td>10·5 „, 21</td>
<td>27·5 „, 21</td>
<td></td>
</tr>
</tbody>
</table>

Two specimens from Borneo (one of which, a male from Major Parry's collection, is represented at fig. 3) show considerable differences both in the mandibles and in the form of the prothorax; but two specimens are not enough to enable me to speak positively as to whether they should be referred to a distinct species or not. For the present I prefer to consider them as representing a local race.

23. _Odontolabis sommeri_, Parry. (Plate XCV. figs. 6–8, *♂_; figs. 10–12, *♀_.)

_Odontolabis sommeri_, Parry, Trans. Ent. Soc. Lond. (3) ii. p. 16 (erroneously as from Manilla), pl. vi. fig. 4 (very bad figure, hardly recognisable).


_Male._ Very like _O. castelnaudi_ and _O. brookeanus_, of the size of the second, but more resembling the first in the shape of the mandibles. Upper side brown, elytra paler. Underside, except the metasternum, dark blackish brown. Mandibles polymorphic. Head smooth, flattened, front edge but slightly emarginate; canthus very narrow: spine behind the eyes obtuse, and sloping obliquely backwards; mentum and gula clothed with long red hair. Prothorax very broad, front strongly emarginate at the sides, the sides convex, strongly emarginate behind the middle spine, which is hardly developed. Elytra flattened, uniform pale brown, but the base of the scutellum is deep black. The suture and the borders are very narrowly edged with black. Front tibiae strongly curved, and broad in front; upper side channelled, and the outer side with two spines above the terminal fork.
Mandibles.

1. *Forma telodonta.*—At present unknown.

2. *Forma mesodonta* (fig. 6).—Corresponds to form *a* of *O. castelnaudi* (comp. fig. 2). Mandibles as long as the head, moderately curved, with three or four series of teeth at the tip, followed by two small obtuse teeth, and then by the central tooth. Head with no raised frontal crest; clypeus resembling an epistoma, as in *O. brookeanus*.

3. *Forma amphiodonta* (fig. 7).—Similar to the same form of *O. castelnaudi* (fig. 4) and *O. brookeanus* (fig. 14). Flattened, finely punctured. Mandibles with four or five apical teeth, and two basal ones.

4. *Forma priodonta.*—Flattened, with five or six irregular teeth on the inside (fig. 8).

*Female.* Very like that of *O. brookeanus* in size, shape, and coloration, but the females are not so constant in coloration as the males. The four females from Banka and Sumatra which I have examined are all dissimilar, but the under surface is deep black in all, whereas it is pale brown in every specimen of *O. brookeanus* (♀) which I have seen. In three specimens from Sumatra the prothorax is dark brown, and the triangular spots at the tip of the elytra are paler in two of them, so that there are only two dark spaces left at the base, whereas the single specimen from Banka (fig. 12) nearly agrees with *O. brookeanus* (♀) in the colour of the prothorax.

Number of specimens examined: twenty-one males and four females from both localities, in the collections of Messrs. van Lansberge and Parry (types), and in the Leyden Museum.

*Habitat.* Eastern Sumatra and the adjacent island of Banka, between Sumatra and Borneo.

**Measurements.**

<table>
<thead>
<tr>
<th></th>
<th>Total length</th>
<th>Head</th>
<th>Mandibles</th>
<th>Prothorax</th>
<th>Elytra</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>millim.</td>
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<td>millim.</td>
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<tr>
<td>Mesodont</td>
<td>50</td>
<td>10 by 16</td>
<td>12</td>
<td>9:0 by 19</td>
<td>21 by 19</td>
</tr>
<tr>
<td>Amphiodont</td>
<td>50</td>
<td>11 &quot; 18</td>
<td>11:5</td>
<td>9:5 &quot; 21</td>
<td>23 &quot; 20</td>
</tr>
<tr>
<td>♂ Sumatra</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Priodont</td>
<td>50</td>
<td>11 &quot; 16</td>
<td>10:0</td>
<td>10:0 &quot; 20</td>
<td>22 &quot; 19</td>
</tr>
<tr>
<td></td>
<td>41</td>
<td>7 &quot; 11</td>
<td>7:5</td>
<td>7:5 &quot; 16</td>
<td>19 &quot; 16</td>
</tr>
<tr>
<td>♀ Sumatra</td>
<td>27</td>
<td>5 &quot; 9</td>
<td>4:0</td>
<td>7 &quot; 13</td>
<td>16 &quot; 14</td>
</tr>
</tbody>
</table>

This very interesting species, strange as it may at first seem, is intermediate between the largest form of *O. castelnaudi* and the Bornean *O. brookeanus*, but it is always misnamed in collections. I lately found a very small priodont specimen from Sumatra in Major Parry’s collection, which this author had separated as a new species. Afterwards I met with small male specimens only in the Leyden Museum, and a great number of both sexes in the collection of Herr van Lansberge under the incorrect name of *O. lowei*, Parry. Gestro, who received a specimen from Van Lansberge’s collection, had already recognized it as distinct from *O. lowei*. I myself was also at first inclined
to regard it as an undescribed species; but the mesodont form (fig. 6) reminded me so strongly of the description of O. sommeri, Parry (although this species does not bear that name in any collection), that I carefully investigated the subject, and was finally convinced of the correctness of this identification. The description and rough sketch which Major Parry received from Count Mniszech, and reproduced, agree in size and character with the present species, allowing for the omission of the colour of the elytra in the description, and of the canthus in the sketch. In order to verify the question beyond a doubt, I applied to Herr Bader in Hamburg (who came into possession of Sommer’s collection after the death of the latter) for information respecting Parry’s type; but I received the unwelcome intelligence that the type no longer existed in the collection when it came into his hands. As no collection contained a trace of O. sommeri, it occurred to me that this unique specimen must have been transferred to Count Mniszech’s collection during Sommer’s lifetime, and that the specimen in Van Lansberge’s collection, which agreed so well with Parry’s description and figure, was really the type. This led me to reject the incorrect locality Manilla, and to recognize this species as the doubtful O. sommeri, of which I give a description above, taken from the series in Herr van Lansberge’s collection.

24. Odontolabis brookeanus, Voll. (Plate XCV. figs. 13–15, ♂ ; figs. 16–18, ♀.)

♂. Odontolabis brookeanus, Voll. Tijdschr. Ent. iv. p. 107, pl. vi. fig. 1 (forma amphiodonta; type; good figure).

♀. Odontolabis brookeanus, Parry, Trans. Ent. Soc. Lond. (3) ii. p. 15, pl. vi. fig. 5 (forma telodonta; good figure).

**Male.** Brown, with straw-coloured elytra; head quadrangular, flattened, shining chestnut-brown; canthus broad in front of the eyes, and then narrower; spine behind the eyes rather prominent, behind which the head is narrowed; emarginate in front, never crested; mentum and gula clothed with thick red hair; mandibles trimorphic; prothorax broader than the elytra, straw-coloured, with a black spot in the middle above, as broad as the head, and frequently bisected by a pale line; sides of the prothorax with a middle spine, which is generally pointed, and near the base of which stands a black dot; prosternal process pointed, and projecting forwards. Elytra straw-coloured, shining, the base, suture, and scutellum black; legs black; front tibiae long, curved, slender, with the terminal fork widened. Upper surface channelled, and two or three spines on the outer side.

**Mandibles.**

1. *Forma telodonta.*—Mandibles longer than the head, slender, and strongly sickle-shaped, flattened, with a single apical spine, followed by a fork on the underside; base with a spine projecting forwards. Head with no frontal crest, and a broad epistoma-like clypeus resembling that of the Dorcini. Eight specimens (fig. 13).
2. *Forma amphiodonta.*—Mandibles as long as the head, flattened, semicircularly curved, with five equal-sized apical teeth, and two separated from the others by a gap at the base; epistoma wanting. Four specimens (fig. 14).

3. *Forma priodont.*—Mandibles as long as the head, upper surface flattened, broadly sickle-shaped, with from seven to nine contiguous and crowded teeth on the inner side; under-surface convex, strongly punctured. About twenty-five specimens (fig. 15).

N.B. In one specimen collected by Mr. A. R. Wallace the black basal band at the base of the elytra is continued to the tip as in the female.

*Female.* Uniform brown; head broad, dark blackish brown; canthus broad; prothorax with all the angles acute, frontal margin nearly straight, sides slightly curved outwards, and then strongly emarginate; hind margin waved; upper surface moderately convex, pale brown, with a broad quadrangular black mark, which is irregularly curved behind; elytra long-oval, pale chestnut-brown, with a triangular black mark, which varies in size (figs. 16–18). Legs black, front tibiae long, much widened in front, with three spines on the outer side above the terminal fork. (Fourteen specimens.)

A long series in all the principal collections.

*Habitat.* Borneo (Sarawak).

**Measurements.**

<table>
<thead>
<tr>
<th></th>
<th>Total length</th>
<th>Head</th>
<th>Mandibles</th>
<th>Prothorax</th>
<th>Elytra</th>
</tr>
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<td>millim.</td>
<td>millim.</td>
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<td>millim.</td>
<td>millim.</td>
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<tr>
<td>♂. Lansberge’s coll. (telodont)</td>
<td>52</td>
<td>11.5 by 17.0</td>
<td>14</td>
<td>9.0 by 20</td>
<td>21 by 18</td>
</tr>
<tr>
<td>♂. Parry’s coll. (telodont)</td>
<td>42</td>
<td>9.5 „ 13</td>
<td>12.5</td>
<td>8.0 „ 16</td>
<td>18 „ 15</td>
</tr>
<tr>
<td>♂. Parry’s coll. (amphiodont)</td>
<td>50</td>
<td>10.0 „ 17.5</td>
<td>12</td>
<td>9.0 „ 20.5</td>
<td>22 „ 19</td>
</tr>
<tr>
<td>Lansberge’s coll. (priodont)</td>
<td>53</td>
<td>9.0 „ 17</td>
<td>12</td>
<td>10.0 „ 21.5</td>
<td>23 „ 20</td>
</tr>
<tr>
<td>Lansberge’s coll. (priodont, smallest ♂)</td>
<td>27</td>
<td>5.0 „ 7</td>
<td>5</td>
<td>5.5 „ 11</td>
<td>14 „ 11</td>
</tr>
<tr>
<td>♀</td>
<td>28</td>
<td>5.0 „ 8.5</td>
<td>4</td>
<td>7.0 „ 12.5</td>
<td>16 „ 13.5</td>
</tr>
</tbody>
</table>

A long series of this remarkable species was brought to England by Mr. A. R. Wallace. It exhibits three distinct male forms, two of which have been already described by Parry and Vollenhoven, and the third (priodont) is here added. The colour of the elytra and the pattern on the upper surface of the prothorax vary considerably in both sexes. Male priodont examples occur, though very rarely, with elytra coloured as in the female, and, on the other hand, females occur with male colouring (fig. 18). The transitional forms between figs. 16 & 18 sufficiently indicate that the whole series belongs to one species.

25. *Odontolabis lowii*, Parry. (Plate XCV. fig. 9.)


*Male (forma amphiodonta).* Much larger than the corresponding form of *O. brooke-
Head flattened, longer; canthus not so broad in front of the eyes; mandibles shorter than the head, and not very much curved, rounded, with five apical and two basal teeth; prothorax as in _O. brookeanus_, but with the sides more rounded. Head and mandibles uniform black, with fine granular punctuation; mentum and gula with brown hair; prothorax coloured as in _O. brookeanus_ above; under-surface dark blackish brown, with a reddish-brown spot on each side; elytra straw-coloured, with a black basal band parallel with the base, and broader than in _O. brookeanus_, recurved rim black both above and below. Legs black, under-surface of the femora with a reddish-brown spot as in _O. lacordairii_. Mesosternum and abdomen with reddish-brown spots. Front tibiae as in _O. brookeanus_, long, and slightly incurred, with a double terminal fork (a fork both on the inside and on the outside), above which are two slender spines.

A single male (the type) in Major Parry’s collection. Female unknown.

_Habitat._ Borneo. Discovered by Lowe.

### Measurements.

<table>
<thead>
<tr>
<th></th>
<th>Total length</th>
<th>Head</th>
<th>Mandibles</th>
<th>Prothorax</th>
<th>Elytra</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>millim.</td>
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<td>millim.</td>
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<tr>
<td>♂</td>
<td>60</td>
<td>12.5 by 19</td>
<td>14</td>
<td>10 by 24</td>
<td>27 by 22</td>
</tr>
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</table>

26. _Odontolabis latipennis_, Hope. (Plate XCVI. figs. 1, 3, ♂; figs. 2, 4, ♀.)

♀ _Lucanus latipennis_, Hope, Cat. Luc. Col. p. 17 (type in Oxford) (1845).

♂ _Lucanus dejeani_, Reiche, Rev. & Mag. Zool. (2) iv. p. 23, pl. i. fig. 4 (good figure) (1852).

_Odontolabis dejeanii_, Parry, Trans. Ent. Soc. Lond. (3) ii. p. 76.


_Male._ Black, elytra dark nut-brown. Head flattened, similar to _O. gazella_ and _O. castelnaudii_, broad; canthus broad, spine behind the eyes acute and straight, or sloping slightly forwards, head sloping obliquely behind; front edge slightly emarginate, never crested; clypeus triangular, descending vertically below the closed mandibles; mandibles broad, upper surface flattened, horizontal, as long as the head, strongly curved, with from seven to nine unequal teeth on the inner side; under-surface convex. Head and mandibles with coarse granular punctuation. Prothorax broader than the head, resembling _O. castelnaudii_, the front edge strongly emarginate on each side; sides nearly straight, with all the angles almost rounded off; hinder edge strongly waved, but not emarginate at the sides. Upper side shining, towards the margins dull, with fine granular punctuation, margins beneath smooth. Elytra broadly oval, shining, dark nut-brown, very finely punctured. Legs black, front tibiae long, somewhat curved, dull, with five acute teeth above the terminal fork, middle and hind tibiae thickly clothed with reddish-brown hair on the inner side.
Mandibles.

All the males of this species which I have seen were priodont, except a single specimen in Herr van Lansberge’s collection, which has a small gap between the teeth on each side, and thus becomes an amphiodont form, with six apical teeth and two united obtuse basal teeth. The spine behind the eyes is much broader, and horizontal as in _O. castelnaudi_.

**Female.** Uniform pitchy black. Head slightly convex, resembling _O. castelnaudi_ (♀); clypeus straight; canthus moderately developed, narrower than the eye; prothorax very like that of _O. castelnaudi_ (♀) in form, narrower in front, but as broad as the elytra, flatter, front edge deeply emarginate on the sides; sides slightly curved as far as the central angle, which is not pointed, behind this very slightly emarginate; hind margin slightly waved. Elytra broadly oval, very convex, dark nut-brown, shining, very finely punctured with a broad black suffused central band, ceasing before the tip, resembling _O. gazella_ (♀). Mandibles with three or four teeth on the inside. Under-surface pitchy black. Mentum with coarse granular punctuation, the sides raised. Prosternal process flattened. Front tibiae slightly curved, with five or six spines above the terminal fork; hind tibiae somewhat curved, as in _O. gazella_.

Number of specimens examined: twenty-two males and nine females, in all the principal collections.

**Habitat.** Malacca, Prince of Wales’s Island, Sumatra, Banka, Borneo.

The male and female from Banka in Herr van Lansberge’s collection are smaller than the others (figs. 3 & 4). Male 50–45 millim., female 36 millim.; but there were too few specimens to enable me to ascertain whether this difference in size is constant in specimens from that locality.

**Measurements.**

<table>
<thead>
<tr>
<th></th>
<th>Total length</th>
<th>Head</th>
<th>Mandibles</th>
<th>Prothorax</th>
<th>Elytra</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
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</tr>
<tr>
<td>♂. Lansberge’s coll. (Sumatra)</td>
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<td>12 by 25</td>
<td>16</td>
<td>13-5 by 28</td>
<td>33-0 by 28</td>
</tr>
<tr>
<td>♀</td>
<td>58</td>
<td>10 , 19-5</td>
<td>12</td>
<td>11-0 , 24</td>
<td>29-0 , 24</td>
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<tr>
<td>Banka</td>
<td>40</td>
<td>8 , 14</td>
<td>7</td>
<td>11-0 , 22</td>
<td>27-0 , 23</td>
</tr>
<tr>
<td></td>
<td>36</td>
<td>6 , 10-5</td>
<td>4-5</td>
<td>9-0 , 16</td>
<td>21-5 , 17-5</td>
</tr>
</tbody>
</table>

27. _Odontolabis fratellus_, sp. n. (Plate XCVI. fig. 5, ♂; fig. 6, ♀, inexact.)

Male very like _O. latipennis_, but smaller. Female much more unlike than the male.

**Male.** Mandibles, head, and prothorax flattened, finely punctured, dull, elytra shining. Head as in _O. latipennis_, but broader behind. Prothorax differing from small specimens of the latter; the sides not so prominent, with the front angles acute, then convex to the central spine, then sloping obliquely backwards to the waved hind
margin. Elytra long, oval, upper side less convex, the shoulders straight, shoulder-angles acute, otherwise as in *O. latipennis*.

**Female.** Uniform deep black, head and prothorax dull, elytra shining. Head much broader than in *O. latipennis*; canthus projecting more outwards, and broader; mentum broader; prothorax broader, front edge strongly emarginate on each side; front angles acute, sides nearly straight; prosternal process flattened, finely pointed behind; elytra long, oval, upper side less convex than in *O. latipennis*, but more so than in *O. camelus*; shoulder-angles acute, outer margin strongly curved outwards in the middle; upper surface deep uniform black, in the middle shining, and on the sides dull. Front tibiae longer than in *O. latipennis*, narrow, with five spines above the terminal fork; the hind legs are also longer, and occasionally narrower, and the tarsi much longer in comparison than in *O. latipennis*. All the tibiae are narrower and straighter, and the punctuation is more granular.

**Habitat.** Luzon (Manilla).

<table>
<thead>
<tr>
<th>Measurements.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total length.</td>
</tr>
<tr>
<td>♂</td>
</tr>
<tr>
<td>♀</td>
</tr>
</tbody>
</table>

I found examples of this species mixed with those of *O. alees* from Manilla, not only in Herr Schneider's consignment, but also in Herr van Lansberge's collection. The striking difference in the females led me to treat it as distinct. Although the females are always very like those of *O. latipennis*, they are still more closely allied to those of *O. camelus* from Mindoro. The two figures on the plate are unfortunately not so exact in outline as I could wish.

28. **Odontolabis aeratus**, Hope. (Plate XCVII. figs. 4, 5, ♂; fig. 6, ♀.)


**Male.** Uniform brown, with a coppery green lustre. Head quadrangular, or but slightly expanded behind the eyes, epistoma broad, canthus slender, emarginate before the eyes; mentum thickly clothed with brown hair; prothorax with the front edge strongly emarginate on each side, front angles acute, sides slightly S-shaped, central spine finely pointed; sides behind strongly emarginate, hind margin much waved; elytra flattened, the sides margined, shoulder-angles acute, front tibiae narrow, curved,
somewhat widened in front, and channelled on the upper side, with one or two spines above the terminal fork; tarsi beneath very hairy.

**Mandibles.**

1. *Forma telodonta.*—Mandibles rather longer than the head, strongly curved, the tip forked, behind which stand five or six small teeth, the hindermost most strongly developed (fig. 4).

2. *Forma priodonta.*—Mandibles very short and narrow, with four or five irregular teeth (fig. 5).

**Female.** Uniform dark chestnut-brown, with or without metallic lustre. Head flattened, with an obtuse projection before the eye; prothorax with the sides acute, then slightly curved, and emarginate behind, hinder edge waved; front tibiae rather broad, with two spines above the terminal fork.

Number of specimens examined: about twenty-five males and eight females, in various collections, including the male types of Hope and Westwood, and the female type of Parry.

**Habitat.** Prince of Wales's Island and Southern Malacca (Singapore).

**Measurements.**

<table>
<thead>
<tr>
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<tbody>
<tr>
<td></td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
</tr>
<tr>
<td>♂. Telodont</td>
<td>28-31</td>
<td>6 by 9</td>
<td>—</td>
<td>6 by 11</td>
<td>15 by 11</td>
</tr>
<tr>
<td>♂. Priodont</td>
<td>19-24</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>♀</td>
<td>16-18</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

29. *Odontolabis carinatus,* Linn. (Plate XCVII. figs. 7-9, ♂; fig. 10, ♀; and figs. 11-13, ♂; fig. 14, ♀.)


*Odontolabis cingalesis,* Parry, Trans. Ent. Soc. Lond. (3) ii. p. 16, pl. x. fig. 8.

*Odontolabis bengalensis,* Tennent, Ceylon, i. p. 276.


**Male.** Uniform shining black, head flattened, quadrangular, the sides nearly straight, with no projecting spine behind the eye, canthus before the eye broad, then narrowed; mentum clothed with red hair, and in very rare cases the base of the gula likewise; prothorax broader than the head, strongly emarginate on each side in front, the front and hind margins clothed with silky reddish-brown hair, front angles produced into a point, sides straight, or only slightly curved, then strongly emarginate; hinder margin much waved; prosternal process strongly developed (fig. 12 b); elytra flattened, or

---

1 I have examined a great number of specimens, but have never been able to detect more than two spines, although both Westwood and Burmeister mention five.
Mandibles.

1. *Forma telodonta.*—Mandibles as long as the head and prothorax together, moderately curved, flattened, resembling *O. castelnaudi*, the tip forked, or with three small teeth, followed by a small branch projecting inwards, which is often forked; base without teeth (nineteen examples). *O. cingalensis*, Parry.

2. *Forma mesodonta.*—Mandibles as long as the head, strongly curved, upper side channelled; four or five apical teeth, followed by the middle tooth, which projects strongly downwards; an obtuse basal tooth; head in front narrower, canthus slightly emarginate, spine behind the eyes slightly prominent; prothorax apparently broader, owing to the narrower head; front tibiae straight, or slightly curved (eight specimens).

3. *Forma amphiodonta.*—Mandibles as long as the head, strongly curved, with three or four apical teeth, an obtuse basal tooth; prothorax broader than the head or elytra. *O. carinatus* (type).

4. *Forma priodonta (irregularis).*—Mandibles shorter than the head, the right side more strongly developed than the left, with from five to seven irregular teeth; a small triangular epistoma above the mandibles.

*Female.* Black, upper side dull, underside shining. Head broad, flattened, dull, the front strongly punctured, canthus straight, narrow, mandibles coarsely granulated; prothorax long, broadest in the middle, front edge strongly emarginate on each side and clothed with reddish-brown hair, the sides nearly straight in front, strongly emarginate behind, hind margin nearly straight, with brown hair; elytra flattened, with only the middle shining; front tibiae with two spines above the terminal fork, hind tibiae but slightly curved.

Number of specimens examined: eighty males and twenty-three females.

*Habitat.* Ceylon. The British Museum also possesses specimens from Madras and Calcutta.

**Measurements.**

<table>
<thead>
<tr>
<th></th>
<th>Total length</th>
<th>Head</th>
<th>Prothorax</th>
<th>Elytra</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
</tr>
<tr>
<td>♂. British Museum (telodont)</td>
<td>66</td>
<td>11.0 by 17</td>
<td>22.5</td>
<td>11 by 19</td>
</tr>
<tr>
<td>♂. British Museum (mesodont)</td>
<td>42</td>
<td>8.0 „ 14</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>♂. British Museum (amphiodont)</td>
<td>48</td>
<td>10.0 „ 16</td>
<td>11</td>
<td>10 „ 19</td>
</tr>
<tr>
<td>♂. British Museum (priodont)</td>
<td>39</td>
<td>8.0 „ 11</td>
<td>7</td>
<td>9 „ 15.5</td>
</tr>
<tr>
<td>♀. British Museum</td>
<td>32</td>
<td>6.0 „ 8</td>
<td>5</td>
<td>8 „ 14</td>
</tr>
<tr>
<td>♀. British Museum</td>
<td>32.5</td>
<td>3.5 „ 6</td>
<td>3</td>
<td>6 „ 10</td>
</tr>
</tbody>
</table>

This description may serve as a pattern of exactitude. Thunberg added to it as follows, in his monograph of Lucanidae:—"Magnitudine L. cervi, feminae, ... caput quadrangulare, antico margine excisum, pro oculis complanatum." He gave an indifferent but recognizable figure in his pl. xii. fig. 2. But notwithstanding these descriptions and the figure, the species has been incorrectly identified by all later authors. In all the large museums of Europe which I have visited, O. carinatus is represented either by O. siva from North India, or by O. bellicosus from Java, to neither of which species will the Linnean description at all apply. Thunberg's description clearly pointed to a small male of O. nigrinus, Deyr., or O. cingalensis, Parry; but no one thought it worth the trouble to clear up the matter. Linnaeus's description applies so exactly to a small amphidont form of O. nigrinus, Deyr., in the British Museum, that I found myself compelled (in December 1882) to recognize this species as the true O. carinatus. In order to verify my determination, I sent sketches of O. siva (= O. carinatus, auct.) and O. bellicosus to Prof. Aurivillius, in Stockholm, to be compared with the type in the Museum at Upsala, and had the pleasure of receiving an exact drawing of the Linnean type, which I reproduce on Pl. XCVII. fig. 8. Prof. Aurivillius also sent me the exact measurements, which agreed precisely with the Ceylonese specimen which I had determined as O. carinatus. Deyrolle had actually employed, without suspecting it, the very character ("les mandibules sont fortement carénées supérieurement dans leur moiéité basilaire," &c.) which led Linnaeus to apply the name "carinatus" to this species. About the same time Parry described his O. cingalensis from Ceylon, which, however, also occurs in India. Although O. cingalensis and O. nigrinus look very unlike at first sight, both in the shape of their mandibles and prothorax, and in the lustre of the elytra, it is scarcely possible to separate them as distinct species. On examining a large series Deyrolle found himself obliged to indicate a third species as O. intermedius, the chief character of which consists in the tibiae, which are curved, instead of being straight, as in the other forms. This shows that the characters of these three supposed species are only individual and not specific.

I have carefully examined Deyrolle's type in Herr van Lansberge's collection, and if

1 Parry's description contradicts this, and expressly states:—"tibis anticis curvatis," &c. But Parry describes only the male telodont form, and leaves the other forms and the female unnoticed.
I had only this specimen to guide me, I should have supposed that *O. intermedius*, Deyr., *O. carinatus*, Linn., and the middle-sized specimen of *O. cingalensis*, Parry, were all distinct. But this species varies to such an extent that it is difficult to find two males which are exactly alike.

I have done my best to do justice to my predecessors; but it is difficult even to divide this species into two, as attempted in Pl. XCVII., for we find large and hairy as well as hairless specimens; the front tibiae are sometimes straight, sometimes curved, and the mandibles of the mesodont form vary to any extent. The striking difference in the prothorax of the male (figs. 7–9), which appears much broader in the middle, arises only from the front margin of the prothorax being narrower. The question of specific distinction can only be decided if the Cingalese race shows constant differences when compared with Indian specimens; but we have not a sufficiently large series of the latter for this purpose. In the meantime it may be best, simply as a matter of convenience, to separate two races, both of which are found in Ceylon:—

(a) *O. carinatus*, Linn. (figs. 7–9, ♂; fig. 10, ♀).—Mandibles strongly curved, deeply channelled on the upper surface; prothorax broadest in the middle, and rather narrower in front. Head, prothorax, and elytra shining in the middle, and hairless.

(b) *O. cingalensis*, Parry (figs. 11–13, ♂; fig. 14, ♀).—Much larger than form a, mandibles generally longer and more slender, prothorax as broad in front as in the middle, elytra dull, or clothed with fine brown hair (Calcutta, Madras, Ceylon).

*Species incertae sedis.*

30. **Odontolabis striatus**, Deyr. (Plate XCVII. figs. 1, 2, ♂; fig. 3, ♀.)


**Male.** Entirely clothed with fine brown hair, as in *O. dalmani*. Head flattened, canthus narrow, straight; spine behind the eyes sloping obliquely backwards and downwards; prothorax broader than the elytra, front edge strongly emarginate on each side, the sides moderately curved as far as the central spine, and then deeply emarginate; hind margin waved; elytra flattened, the shoulders angulated, clothed with brown hair, and with four smooth longitudinal stripes on each side, which unite before the tip; front tibiae rather broad, with five or six spines above the terminal fork; mandibles as long as the head and prothorax together, flattened, not much curved at the tip, and bifurcate; base broader, with two teeth on the inner side.

**Female.** Size and appearance of *O. carinatus*, and entirely clothed with brown hair, as in the male. Head flattened, canthus broad, emarginate in front, and then pointed; mentum with a crescent-shaped crest; prothorax with the front edge deeply emarginate on each side; front angles acute, the sides slightly convex, and deeply emarginate behind, hind margin strongly waved; elytra pubescent, with four parallel smooth
stripes on each side, as in the male, shoulder-angles acute; front tibiae long and narrow (like the male), with the terminal fork well developed, and three or four spines above it on the outer side.

_Habitat._ Malacca and Borneo.

<table>
<thead>
<tr>
<th>Measurements</th>
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<tbody>
<tr>
<td><strong>♂. Normal (Borneo)</strong></td>
</tr>
<tr>
<td><strong>Var. cephalotes (Borneo)</strong></td>
</tr>
<tr>
<td><strong>♀. (Malacca)</strong></td>
</tr>
<tr>
<td><strong>♀. (Borneo)</strong></td>
</tr>
</tbody>
</table>

This is so different from other species of _Odontolabis_ that I have been obliged, like Major Parry, to treat it as a separate section. It is distinguished by the striaion of the elytra in both sexes, the broad front tibia of the male (resembling those of the Chinese _O. platynotus_), and the pointed canthus.

Very few specimens of this species are known (only three of each sex), and I examined the types in Herr van Lansberge's collection.

There is a male from Borneo in Parry's collection (smaller than the others) in which the head is very long, and the mandibles are strongly curved downwards, giving the insect a totally different appearance. Prof. Westwood and Mr. C. O. Waterhouse are inclined to consider it a new species; but I have too few specimens to decide. However, I cannot consider the elongation of the head extraordinary in a telodont form. The frontal crest is not raised here, but projects forwards (compare the enormously developed frontal crest in _Homoderus mellyi_, Deyrolle, Ann. Sci. Ent. France (4) iv. p. 313, pl. iv. fig. 2; an extraordinary figure).

The long deflexed mandibles are even more interesting and instructive than the head; they agree in structure with the smaller specimens of typical _O. striatus_, but instead of being flattened and horizontal, their hinder half is curved downwards at an angle of 90°. The teeth at the base and tip are unaltered.

These curved mandibles are remarkably like those of _Chisognathus_, and plainly indicate how these may have originated. Whether this form is distinct from _O. striatus_, or is only a monstrosity, the modification of the mandibles must always be regarded as a remarkable instance of their plasticity, and of the correlation of the structure of the head with that of the mandibles. I propose to call this form var. _cephalotes_.

Other modifications of the male mandibles are at present unknown.
(3) **Heterochthes.**

(erezpos, different; ëçê, elevation.)


**Male.** Head large, broad, quadrangular, sides very slightly swollen behind the eyes; eyes small, entirely enclosed by a narrow canthus; clypeus narrow, quadrate; mentum short, broad; club of the antennae broad, three-jointed, clothed with fine hair; mandibles polymorphic; prothorax shorter than the head, and broader than the elytra, crescent-shaped, hinder angles rounded off, prosternal process rounded, carinated; elytra short, broad, oval; front tibiae elongated, spined on the outer side; the four hind tibiae unarmed.

**Female.** Head comparatively large, broad, quadrangular, scarcely differing from that of the smallest males; emarginate in front; epistoma not distinctly rounded, as in *Odontolabis*; canthus broad, mentum short, very broad; mandibles amphiodont, with four or five apical teeth, separated by a gap from two small basal teeth; prothorax broad, crescent-shaped, entirely rounded off at the sides; elytra broad, oval.

Only two species of this genus are known at present—*H. brachypterus*, Westw., from Cambodia, and *H. andamanensis*, Westw., from the Andaman Islands.

1. **Heterochthes brachypterus**, Westw. (Plate LXXXIV. figs. 5–7, α; fig. 8, ι.)

*Heterochthes brachypterus*, Westw. Trans. Ent. Soc. Lond. (3) ii. p. 18, pl. x. fig. 6, ι (not ι), 7, α, pl. xi. figs. 1–3, α ?.

**Male.** Uniform black, head and mandibles variable, smooth, dull or shining; prothorax very short and broad, scarcely emarginate in front on the sides, front angles acute, sides straight, rounded behind, hind margin straight, or slightly emarginate; elytra convex, scarcely as broad as the prothorax, dull; front tibiae long, with two spines above the terminal fork.

**Mandibles.**

1. **Forma telodonta.**—Mandibles flattened, as long as the head and prothorax, with a single small tooth behind the recurved hook-shaped tip; base projecting inwards, head twice as long as the prothorax, crested in front, and with a small spine rather far back behind the eyes (fig. 5).

2. **Forma amphiodonta.**—a. Mandibles scarcely as long as the head, sickle-shaped, with two apical teeth and a bifid tooth at the base (fig. 6). b (*gynoides*). Mandibles very small, as in the female, with a broad irregular series of apical teeth, separated by a gap from a tooth-like projection at the base. Head scarcely longer than the prothorax, sides behind the eyes punctured; front tibiae rather short and broad, with two spines above the terminal fork (fig. 7).

**Female.** Uniform pitchy black, shining. Head convex, broad, quadrangular, smooth,
with large scattered punctures on the sides behind the eyes; mandibles shorter than the head, coarsely punctured, strongly curved, with a series of four or five apical teeth, separated by a gap from a small bifid tooth at the base; prothorax as long as the head, and broader, crescent-shaped, front edge deeply emarginate on each side, front angles acute, the sides rounded behind; hinder edge emarginate in the middle; elytra oval, strongly convex, smooth and shining; front tibiae broad in front, with two spines above the terminal fork.

**Measurements.**

<table>
<thead>
<tr>
<th>Total length</th>
<th>Head</th>
<th>Mandibles</th>
<th>Prothorax</th>
<th>Elytra</th>
</tr>
</thead>
<tbody>
<tr>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
</tr>
<tr>
<td>♂. Type (telodont)</td>
<td>36</td>
<td>6.5 by 11</td>
<td>12</td>
<td>5.0 by 10</td>
</tr>
<tr>
<td>♂. (amphiodont)</td>
<td>22-5</td>
<td>5.0 &quot; 8</td>
<td>4</td>
<td>4.0 &quot; 8.5</td>
</tr>
<tr>
<td>♂. (gynoide)</td>
<td>20</td>
<td>4.0 &quot; 5.5</td>
<td>3</td>
<td>4.0 &quot; 8</td>
</tr>
<tr>
<td>♀.</td>
<td>21-5</td>
<td>4.5 &quot; 8</td>
<td>4.5</td>
<td>4.5 &quot; 9.5</td>
</tr>
</tbody>
</table>

**Habitat.** Siam (Cambodia), collected by M. Mouhot. Three males and one female (Westwood’s types) in Parry’s collection; one pair, male and female, in the British Museum.

It appears that both Major Parry and Prof. Westwood have mistaken a small male for a female, as is shown by their measurements, and also by their plates (pl. x. fig. 6. pl. xi. fig. 3 a). The mandibles of the type in Major Parry’s collection are differently formed on the left side, and it agrees with the description and figure in the small and inconspicuous quadrate clypeus, which is wanting in the female. If Prof. Westwood had known the real female, he would certainly have mentioned the characteristic form of the female mandibles.

2. **Heterochthes andamanensis**, Westw. (Plate LXXXIV. figs. 9–11, ♂; fig. 12, ♀.)

*Heterochthes andamanensis*, Westw. Trans. Ent. Soc. Lond. 1874, p. 359, pl. iii. fig. 2, ♂ (good figure).

**Male.** Much larger than *H. brachypterus*; head comparatively shorter, and differing in the various forms of the male mandibles; entirely black, or dark nut-brown; mandibles and prothorax dull, elytra shining, head quadrangular, front margin often with two projections in the middle; canthus oblique, narrow; spine behind the eyes generally distinctly visible; strongly punctured above and behind the eyes; prothorax broader than the head and elytra, front edge more emarginate on the sides; the sides rounded; elytra broadly oval, flattened, shining; front tibiae long, with three or four spines above the terminal fork.

**Mandibles.**

1. **Forma telodonta.**—Mandibles as long as the head and prothorax, flattened, with a small rudimentary tooth behind the incurved tip (fig. 9).

2. **Forma mesodonta.**—Mandibles as long as the head, much compressed, with two
small teeth at the tip, and a strong projecting middle tooth on the upper side of the mandibles (fig. 10).

3. **Forma amphiodonta**.—Mandibles as long as the head, with four small teeth at the tip and two at the base on the upper side of the mandibles (fig. 11).

*Female.* Larger than *H. brachypterus*, much broader; head broad, but very short, dull, the sides with large scattered punctures; canthus broader than the eye; mandibles longer than the head, somewhat curved outwards, coarsely shagreened, with five or six teeth at the tip, then with a crescent-shaped emargination (above which is a small obtuse tooth on the upper side), and two small obtuse teeth near the base; prothorax much broader than the head, shaped as in *H. brachypterus*; elytra shining; front tibiae with three or four spines above the terminal fork.

*Habitat.* Andaman Islands.

Thirty-four specimens examined; twenty males and fourteen females. In the collections of Major Parry and of Messrs. Newcombe and Meldola.

**Measurements.**

<table>
<thead>
<tr>
<th></th>
<th>Total length</th>
<th>Head</th>
<th>Mandibles</th>
<th>Prothorax</th>
<th>Elytra</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
<td>millim.</td>
</tr>
<tr>
<td><em>♂</em> (telodont)</td>
<td>46</td>
<td>8·5 by 16</td>
<td>15</td>
<td>8·5 by 18</td>
<td>18 by 17</td>
</tr>
<tr>
<td><em>♂</em> (mesodont)</td>
<td>40</td>
<td>8·0 „, 16</td>
<td>8·5</td>
<td>9·0 „, 18</td>
<td>18 „, 17</td>
</tr>
<tr>
<td><em>♂</em> (amphiodont)</td>
<td>28</td>
<td>4·0 „, 8·5</td>
<td>5·5</td>
<td>5·5 „, 11·5</td>
<td>14 „, 12·5</td>
</tr>
<tr>
<td><em>♀</em></td>
<td>29</td>
<td>4·5 „, 9</td>
<td>5·5</td>
<td>6·0 „, 13</td>
<td>15 „, 12·5</td>
</tr>
</tbody>
</table>

The telodont form of the male only has been previously described; but the kindness of Messrs. Meldola and Newcombe has enabled me to describe the other forms of the male as well as the female. I have already shown (p. 404, no. 9), that the female form of the mandibles is connected with the extreme male form by an unbroken series of transitional forms.

**PART III.**

**Geographical Distribution of the Odontolabini.**

The Lucanidae (exclusive of the Passalidae) form a very natural family of beetles, which is represented in all parts of the world, except the Polar Regions. Each of Scalter’s main Zoo-Geographical Regions possesses its characteristic forms; but in spite of their great morphological differences, their close relationship and common origin cannot be questioned.

The first attempt to investigate the geographical distribution of the Lucanidae was made by Burmeister¹, and was carried further by Wallace² on the basis of Parry’s ‘Catalogue.’ The latter author subsequently called attention to the occurrence of

¹ Burmeister, Handbuch der Entomologie, Band v. p. 316.
Lucanidae in the most isolated islands\(^1\), and made suggestions respecting the sources from whence they may have been derived.

As regards the subfamilies of the Lucanidae, the Lucanini are met with in Europe, Asia, and North America, and the Cladognathini are found in Africa and Asia, and have even some representatives in South America. But the Odontolabini have a more restricted range, being confined to South-eastern Asia, the species mostly inhabiting the Indian or Oriental Region. Nevertheless they extend northwards to about 35\(^°\), and their range is not limited by the Straits of Macassar, for they extend from the Philippines to Celebes and Sangir. They appear, however, to be absent from the smaller islands which lie to the east of Java and Celebes, and which have been well explored by Dutch, English, and German entomological collectors.

The genus Odontolabis is the most widely distributed. Its species are met with in India (five species), from the southern slopes of the Himalayas to Ceylon; in Further India and China as far as the Yellow River (four species); and passing down the long peninsula of Malacca they extend to Sumatra and Java on the one side and on the other to Borneo, Celebes, and the Philippines. No less than twenty-one species (besides several varieties) are met with in the various islands.

Neolucanus preponderates in China\(^2\) and Further India (seven species). It is also represented on the southern slope of the Himalayas (three species) and in Malacca (one species), while there are only four insular species. It is remarkable that the species in Sumatra, Java, and Borneo are very small, and that in two of them (*N. laticollis* and *N. muntjac*, Gestro) the mandibles of the male are so little differentiated that they are not even forked at the tip. The genus is wholly absent from the other islands, as well as from the greater part of India, and Ceylon.

As several forms of Lucanidae are met with in Tertiary deposits\(^3\), it is probable that the present distribution of the Odontolabini may have been influenced by the distribution of land and water during that period.

The development of the mandibles in the male in the species of Neolucanus shows that this genus is lower than Odontolabis, which may have been gradually differentiated from it. This seems to be confirmed by Tertiary geography. The districts of Further India and China, where they are still most numerous, formed part of the mainland in Tertiary times, while the Himalayas and the greater part of Northern India were still under the sea. Their scanty representation in Sumatra, Java, and Borneo is likewise

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1 Wallace, Island Life, p. 305.
2 And Formosa.
3 The following fossil Lucanidae are known to me:
easily accounted for, as these were already islands¹, at least in part, at the same period. Thus these small species, which are far inferior to their continental allies in size, must be regarded as antiquated forms.

In like manner the original home of the species of *Odontolabis* must be sought for in Further India.

*O. carinatus,* which occurs in Ceylon and on the east coast of India, is certainly of Malayan origin. It is difficult to determine whether it has migrated from the south by some previous land-communication or from the north; but Wallace has shown that several of the mammals, birds, and reptiles of Ceylon are likewise of Malayan origin². The species which occur on the other islands show no exceptional distribution; for although many of them are peculiar species, yet they are closely connected with others found either on the continent or on the large adjacent islands. But although the Philippines are nearer to the Chinese coast, their species show a greater affinity to those of the Sunda Islands than to those of Formosa.

Lastly, the two species of the genus *Heterochthes* are confined to Siam and to the Andaman Islands respectively.

As the accompanying Table will show, species occurring in the same locality are generally so dissimilar that their interbreeding is quite impossible, and it is not unlikely that they may arrive at maturity at different seasons, in which case they would be still less likely to interfere with each other.

For example, the following species are met with in the peninsula of Malacca:—


But when closely allied species occur in the same locality, intermediate forms (or hybrids?) are of frequent occurrence, which circumstance renders the species difficult to separate (comp. pp. 412–414).

A comparison of the number of species will give the clearest idea of the important part migration and isolation have played in their differentiation.


² Wallace, Geographical Distribution of Animals, vol. i. p. 327.
Table of the Geographical Distribution of the Odontolabini.

<table>
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<th>Borneo</th>
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2. **Odontolabis (continued)**

- castelnauui, *Parry*  
- sommeri, *Parry*  
- brookeanus, *Parry*  
- lowii, *Parry*  
- carinatus, *Linn.*  
- latipennis, *Hope*  
- fratellus, *Leutha.*  
- cuvera, *Hope*  
- mouhoti, *Parry*  
- delesserti, *Gebrr.*  
- burmeisteri, *Hope*  
- wellasteni, *Parry*  
- ludckiingi, *Voll.*  
- vollhoveni, *Parry*  
- laeordhairii, *Voll.*  
- gazella, *Fabr.*  
- inaqualis, *Kasp.*

3. **Heterechthes, W.**

- brachypterus, *W.*  
- andamanensis, *W.*

Total  

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### Résumé.

Of the 47 species of this subfamily, 16 species are exclusively continental, 24 species are exclusively insular, and 7 species occur both on the continent and on the islands.
IDENTIFICATIONS.

The following identifications must be noted:

— latipennis, *Hope* = — dejenni, Reiche.
Odontolabis alices, *Fabricius* = Odontolabis dux, Westwood.
— gazella, *Fabr., Olivier* ♀ = — bicolor, *Olivier*.

The following species are new:

Neolucanus lansbergii ♀.
— pallescens ♀.
— parryi ♀.

The females of the following species were previously undescribed:

Neolucanus championi, *Parry*.
— saundersi, *Parry*.
Heterochthes brachypterus, *Westw*.
— andamanensis, *Westw*.
Odontolabis siva, *Hope*.
— gracilis, *Kaup*.

INDEX OF GENERA AND SPECIES.

*H.* = *Heterochthes*, *N.* = *Neolucanus*, *O.* = *Odontolabis*.

[Generic names are printed in Capitals, species in Italics, and synonyms in Roman.]

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Explanations of the Tables of Measurements.

All measurements are expressed in millimetres.

The total length is measured from the tip of the mandibles to the tip of the elytra with the compasses. This only gives the actual length of the specimen approximately, and varies from the head being more or less retracted under the prothorax, and also according to the downward curvature of the mandibles.

The length of the mandibles is always measured on the under-surface, from their insertion to the tip.

Head. The length is measured from the tip of the labrum, or epistoma, to the front of the prothorax on the upper side. The breadth is measured in the male from tip to tip of the spines behind the eyes; and in the female the width of the canthus of the eyes is included.

The length of the prothorax is measured on the upper side from the front to the hind margin along the median line; and the breadth is always measured from tip to tip of the central spines.

Elytra. The length is measured from the base of the scutellum to the tip of the elytra. The breadth of both elytra together is always given. It is measured with the compasses at the broadest part, a little behind the shoulders.
DESCRIPTION OF THE PLATES.

All the figures are original, and have been drawn direct on the stone by Mr. E. Wilson under the personal supervision of the author. In order to save time and expense, the forms and varieties have not been fully shaded. Most of the figures have been so arranged as to facilitate a comparison of the different male and female forms of closely allied species. When the figures are enlarged, an adjoining line indicates the natural size.

N.B. Previously unfigured forms are marked thus: X.

PLATE LXXXIV.

Figs. 1–3. Neolucanus laticollis, p. 420: 1 ×, 2 ♂; 3 ♀ X.
Fig. 4. N. lansbergii, p. 421: 4 ♀ X (type).
Figs. 5–8. Heterochthes brachypterus, p. 479: 5 ♂ (telodont), 6 ♂ (amphiodont), 7 ♂ (smallest form, resembling female), 8 ♀ X (all enlarged).
Figs. 9–12. H. andamanensis, p. 480: 9 ♂ (telodont), 10 ♂ X (mesodont), 11 ♂ X (smallest form, resembling female), 12 ♀ X.
Figs. 13, 14. Neolucanus costanopterus, p. 423: 13 ♂, 14 ♀ (a, hairy mentum in male; b, ditto in female).
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Figs. 1, 3. Neolucanus marginatus, p. 426: 1 ♂ X, 3 ♀ X (types).
Fig. 2. N. pallescens, p. 426: 2 ♂ X (type).
Fig. 4. N. parryi, p. 424: 4 ♀ X (type).
Figs. 5, 7. N. sinicus, p. 428: 7 ♂ (telodont: type), 5 ♀.
Figs. 6, 8. N. championi, p. 428: 8 ♂ (telodont: type), 6 ♀ X.
Figs. 13, 15, 16. N. saundersi, p. 431: 13 ♂ (telodont: type), the left elytron exhibits a distinct wound at the tip; 13 b, mentum, figured for comparison with that of N. lama (15 b); 13 c, narrow epistoma-like clypeus; 16 ♂, smallest priodont form; 9 ♀ X, 9 b, mentum, with semicircular crest.
Fig. 10. N. cingulatus, p. 422: 10 ♀ (type).
Figs. 11, 12, 14, 15. N. lama, p. 430: 14 ♂ (telodont: type of N. baladeva, Hope), 14 c, side view, 15 ♂ X (priodont: the difference in the length of the head arises from its having been purposely represented retracted in fig. 14 and elongated in fig. 15), 11 ♀, 12 ♀ (smallest form: var. angulatus, Hope).

N.B. It is to be regretted that the antennæ of all the specimens figured on this Plate are not printed with absolute accuracy.
PLATE LXXXVI.
Figs. 1–7. *Odontolabis siva*, p. 436: 1–6 $\sigma \times$, 7 $\varphi \times$. 1, 2, telodont; 1 with rounded and convex, 2 with flattened mandibles; 1 with long, and 2 with broad elytra. 3, amphiodont (compared with the type at Oxford); 4 (amphiodont); 4, 5, 6 (priodont): a, mentum (telodont); e, mentum (priodont); b, under-surface of prothorax (telodont); d, ditto (priodont); c, head and prothorax of fig. 6, represented twice the natural size.

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Figs. 4–7. O. dalmani, p. 439: 4 $\times$ (amphiodont); 4 b, thorax (profile); m, mentum, $\sigma$; 5, 6 $\sigma$, 7 $\varphi \times$.
G. & D. Under-surface of prothorax in *O. gracilis* and *O. dalmani* ($\sigma$).
G’. & D’. Ditto, ditto ($\varphi$).

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Figs. 9–12. *O. platynotus*, p. 435: 9, 10, 11 $\sigma$; 12 $\varphi \times$. 9, telodont (front tibiae rather too broad); 10, amphiodont; 10 b, prothorax (under surface); 11, priodont, with a retracted head; 9 b, under-surface of head and mentum.

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PLATE XC.
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Fig. 5. *O. mouhotii*, p. 453: 5♀ (type).
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PLATE XCII.
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Figs. 5-9. *O. burmeisteri*, p. 455: 5♀, 6♀, 7♀, 8♀, 9♀. 5, largest known telodont (♀); 5 b, mandibles of a similar form, but more rounded, and with only one basal tooth; 6, mesodont form, with asymmetrical mandibles and narrow prothorax; 7, 8, priodont (7, normal; 8, marked as in female, and with thickly spined front tibiae).

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Figs. 7–13. *O. carinatus*, p. 474: 7 ♂ (=*O. nigritus*, Deyr.); 8 ♂, Linnean type! 9 ♂; 10 ♂, 11, 12 ♂, 13 ♂, large males of a hairy race (*O. cingalensis*, Parry); 13, exhibiting three or four longitudinal stripes on the elytra by abrasion; 14 ♂, large female of var. *cingalensis*; 12 ♂, prosternal process: profile; 12 ♀, mentum and gula, with traces of a hairy covering.
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