Report on the scientific results of the voyage of H.M.S. Challenger during the years 1873-76. Zoology - Vol. 7

Thomson, C Wyville
Murray, John

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REPORT

ON THE

SCIENTIFIC RESULTS

OF THE

VOYAGE OF H.M.S. CHALLENGER

DURING THE YEARS 1873-76

UNDER THE COMMAND OF
CAPTAIN GEORGE S. NARES, R.N., F.R.S.
AND
CAPTAIN FRANK TOURLE THOMSON, R.N.

PREPARED UNDER THE SUPERINTENDENCE OF
THE LATE
Sir C. WYVILLE THOMSON, Knt., F.R.S., &c.
REGIUS PROFESSOR OF NATURAL HISTORY IN THE UNIVERSITY OF EDINBURGH
DIRECTOR OF THE CIVILIAN SCIENTIFIC STAFF ON BOARD
AND NOW OF
JOHN MURRAY, F.R.S.E.
ONE OF THE NATURALISTS OF THE EXPEDITION

ZOOLOGY—VOL. VII.

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(*Received November 15, 1882.*)

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By F. Buchanan White, M.D., F.L.S.

(*Received February 26, 1883.*)

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(*Received January 6, 1883.*)

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By W. B. Carpenter, C.B., M.D., LL.D., F.R.S., F.L.S., F.G.S., Corresp. Memb. Inst. France, &c.

(*Received May 14, 1883.*)

EDITORIAL NOTES.

This volume contains Parts XVIII., XIX., XX., and XXI. of the Zoological Series of Reports on the Scientific Results of the Expedition.

Part XVIII.—During the cruise in the Southern Hemisphere, the Naturalists of the Expedition preserved, in addition to the collection of skins, a large number of young and adult Penguins in salt and spirit. This collection was, on the return of the Expedition, placed in the hands of Dr. Morrison Watson, Professor of Anatomy in the Owens College, Manchester, for examination, and this elaborate Memoir gives the result of a painstaking examination into the anatomy of all the species obtained.

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Part XX.—At the request of the late Sir C. Wyville Thomson, Dr. Allman kindly undertook to prepare a Report on the Hydroida collected by the Expedition.

It is with much pleasure that we publish the first instalment of Dr. Allman's Report, which embraces the Family Plumularidæ. This is an important addition to his previous valuable work upon this group of animals.

Part XXI.—In publishing a paper by Dr. W. B. Carpenter, it may be permitted to recall the prominent part he took in all the preliminary Expeditions and negotiations which led ultimately to the despatch of the Challenger on her circumnavigating cruise. On the return of the Expedition Dr. Carpenter undertook to prepare a Report on the specimens of *Orbitolites*—a genus to which, as is well known, he has given special attention—and the present Monograph embodies the result of his investigations.

The whole work which it is proposed to take up in connection with the Official Reports on the Scientific Results of the Challenger Expedition is now in active progress, and it is estimated that all the Reports will be published by midsummer of the year 1887. The following List shows the present state of the Reports. The type specimens described in the Published Memoirs have been deposited in the British Museum.

John Murray.

Challenger Office,
Edinburgh, 20th *July* 1883.

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ζ. ON THE BIRDS COLLECTED IN THE SANDWICH ISLANDS.
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MEMOIRS IN PROGRESS.

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Report on the Cirripedia (in 1883).
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By Professor A. C. Haddon, M.A., F.Z.S.

Report on the Tunicata. Second Part (in 1884).
By Professor W. A. Herdman, D.Sc., F.R.S.E., F.L.S.

Report on Diatomaceæ (in 1884).
By Conte Abate Francesco Castracane degli Antelminelli.

Report on the Gephyrea.
By Professor E. Ray Lankester, M.A., F.R.S., F.L.S.

Report on the Cumacea and Schizopoda (in 1884).
By Professor G. O. Sars.

Report on Reef Corals (?)
By John J. Quelch.

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Report on the Siphonophora.
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REPORT ON THE ANATOMY OF THE DEEP-SEA MOLLUSCA.
By

REPORT ON VARIOUS SURFACE ORGANISMS.
By

CONCLUDING PART WITH INDEX.
By the EDITOR of the Reports.

ERRATUM.

In the Report on the Spheniscidæ, page 222, line 10, for "*Aptenodyptes*" read "*Aptenodytes*."

THE
VOYAGE OF H.M.S. CHALLENGER.

ZOOLOGY.

REPORT on the ANATOMY OF THE SPHENISCIDÆ collected during the Voyage of H.M.S. Challenger.

By MORRISON WATSON, M.D., F.R.S.E., Professor of Anatomy in the Owens College, Manchester.

INTRODUCTION.

UPON the return of the Challenger to this country at the expiration of the cruise, the late Sir Wyville Thomson placed in my hands the valuable collection of Penguins made during the voyage, with a request that I should draw up a Report on the anatomy of these remarkable birds.

The collection comprised firstly, three or four adult specimens of each of the species obtained, preserved for the most part in brine, but in some instances in spirit; and secondly, a number of immature birds taken from the nest, together with eggs in various stages of development, preserved partly in spirit and partly in bichromate of potash. All were in an excellent state of preservation.

The present Report refers only to the anatomy of the adult birds, that on the young and embryonic specimens being reserved to form the second part of the memoir.

The material, the report on which forms the subject of the present communication, consisted of adult specimens of the following birds:[1]—

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[1] For the synonyms of these different birds, see Sclater's Report on the Birds collected by the Challenger, Zoology, vol. ii. p. 122-132; as also Coue's Monograph of the Spheniscidæ, in Proc. Acad. Nat. Sci., Philad., 1872, p. 170. *Spheniscus mendiculus* is not mentioned in either of these papers. It was first described by Sundevall, in Proc. Zool. Soc., 1871, pp. 126 and 129, and was subsequently figured by Salvin, in the Trans. Zool. Soc., vol. ix. p. 508.

1. *Eudyptes chrysocome*, from Tristan d'Acunha.[1]
2. *chrysocome*, from the Falkland Islands.
3. *chrysocome*, from Kerguelen Island.
4. *chrysolophus*, from Kerguelen Island.
5. *Spheniscus demersus*, from the Cape of Good Hope.
6. *magellanicus*, from the Falkland Islands.
7. *mendiculus*, from the Galapagos Islands.
8. *minor*, from Australia.
9. *Pygosceles tæniatus*, from Kerguelen Island.
10. *Aptenodytes longirostris*, from Kerguelen Island.

besides heads, with the soft parts attached, of nearly every one of these species.

In drawing up this Report two courses were open to me. Either I might confine myself to a simple enumeration of the distinctive anatomical features of the Penguins as compared with those of other birds, or, with the expenditure of considerably more time and labour, I might give an exhaustive account of the anatomy of every member of the group which was placed in my hands. The adoption of the first plan would certainly have led to the production of a more readable memoir, and one adapted to the requirements of those whose object is to arrive at cut and dry conclusions, without the labour of minute investigation.

On the other hand, it appeared, in view of the difficulty of procuring fresh specimens of so many species of Penguin, that it would be well to make the most of the material at my command. To accomplish this, it would be necessary to carry out an exhaustive anatomical examination of every species, and to compare the results obtained from the dissection of one with those obtained from the dissection of all. If this plan were adopted, I might hope to put on record a complete description of the anatomy of every species at my disposal, and thus exhaust the subject so far as these were concerned, leaving it to other anatomists to supplement my observations by the examination of species, examples of which I did not possess.

After due consideration I adopted the latter course, and in following it out have selected *Eudyptes chrysocome* from Tristan d'Acunha as a standard with the anatomy of which to compare that of other species. In every section I have in the first place described the anatomy of that species, and thereafter appended the variations met with in such others as I have had an opportunity of examining. In those cases in which no variations are reported, it will be understood that such did not exist, and that the anatomy of these forms is identical with that of the species selected as a standard. In every instance I dissected the birds systematically, beginning with the bones and ending with the nerves, and in every instance I have been careful to institute a

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[1] Professor Watson had for the purposes of this investigation: one adult specimen of *Spheniscus minor*, presented to the Expedition at Sydney by Dr. George Bennet; two adult specimens of *Spheniscus mendiculus*, presented by Professor Alexander Agassiz, and four or five adult specimens of each of the other species.—J. M.

comparison of the anatomy of the species examined with that of *Eudyptes chrysocome* from Tristan d'Acunha. By this means I trust I have made the most of the material at my disposal, and although, as it turns out, the anatomy of one species, in its leading features, to a large extent represents that of all, yet it must be remembered that this fact could only be elicited by means of a somewhat tiresome and laborious investigation into the anatomy of every member of the group. The satisfaction, moreover, remains that the work undertaken has been accomplished once and for all, and that the time and labour of other anatomists need not be expended in repeating the task.

Among others who have assisted me in various ways, I have to acknowledge my obligations more especially to Mr. P. L. Sclater, F.R.S., for identifying several of the species examined, and for placing at my disposal fresh specimens of various species of Penguins which died from time to time in the menagerie of the Zoological Society. I am also indebted to the kindness of Mr. W. Forbes, prosector to the Zoological Society, for the brain of an *Aptenodytes longirostris*, which he kindly removed for me immediately after the death of the bird.

I.—OSTEOLOGY.

The salient and distinctive osteological features of the Penguins have long been known, and numerous references to them are to be found in the systematic works of Cuvier,[1] Meckel,[2] and Owen.[3] In the article of the last-named author on the anatomy of birds, in "Todd's Cyclopædia of Anatomy"[4] especially, an excellent account is given of the skeleton of the Penguin as compared with that of other birds.

In 1835 Reid[5] published an elaborate account of the anatomy of the Patagonian Penguin, in which, along with a consideration of the anatomy of the soft parts, he directs special attention to the modifications in form of the various parts of the skeleton.

In 1871 Hyatt[6] published a catalogue of the ornithological collection of the Boston Society of Natural History, and communicated therein a number of important observations made by Dr. Elliot Coues on the osteology of the various species of Penguin contained in the collection of that society.

In 1872 Dr. Elliot Coues[7] published a monograph on the Spheniscidæ. In this monograph he directed attention to the varying form of the cranium in the different genera of Penguins, and pointed out the value of these differences in the determination of the various genera. In the plate which accompanies the monograph he figures the skulls of

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[1] Leçons d'anatomie comparée, vol. i.

[2] Traité général d'anatomie comparée, vol. iii.

[3] Anatomy of Vertebrates, vol. ii.

[4] Cyclopædia of Anatomy, vol. i., Art. "Aves."

[5] Proc. Zool. Soc., 1835, p. 132.

[6] Proc. Boston Soc. Nat. Hist., 1871, p. 237.

[7] Proc. Acad. Nat. Sci. Philad., 1872, p. 170.

Spheniscus and of *Eudyptes*, and some of the bones of *Aptenodytes*. This paper is an extremely valuable contribution, and has to some extent anticipated the conclusions at which I have arrived with regard to the subdivision of the Penguins into genera and species.

More recently MM. Gervais and Alix[1] have published a memoir on the osteology and myology of the Spheniscidæ, founded on an anatomical examination of a specimen of *Eudyptes chrysolophus*.

The skeleton, either in whole or in part, of one or other species of Penguin will be found figured in the works of Blumenbach,[2] Brandt,[3] Wagner,[4] Eyton,[5] and Barkow.[6]

In the works of none of the authors above named, however, can I find any approach to a complete comparative description of the osteology of the various species of Penguin, and this deficiency I now endeavour to make good, so far as the material at my disposal will permit.

THE AXIAL SKELETON.

The Skull.

The skulls of all the Penguins which I have had an opportunity of examining being accurately figured (Plates I. to V.), it is unnecessary that I should give a detailed description of each. The following observations, therefore, refer only to the leading and distinctive features of the cranial osteology of each member of the group.

The cranium of every species is completely ossified in the adult, and presents no trace of its original sutures. The form of its exterior closely corresponds with the outline of the contained encephalon, and indicates externally the subdivision of the latter into the cerebral hemispheres and cerebellum. This correspondence is to a certain extent masked by the development of a large transverse ridge, situated on the side of the cranium, to which the squamous, parietal, and occipital bones each contribute a part, as also by the large size of the supra-orbital ledges which accommodate the nasal glands. Apart from these osseous ridges, the correspondence in form between the exterior of the skull and the contained viscus is more striking in the Penguins than in the majority of birds.

The cerebellar prominence of the skull forms a well-marked osseous dome situated immediately above the occipital foramen. In *Eudyptes* the most projecting portion of this dome is rounded, while in *Spheniscus* it is somewhat sharper and more acute. In *Spheniscus minor*, however, as in *Aptenodytes* and in *Pygosceles*, the cerebellar dome presents a form intermediate between that which characterises the other species of

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[1] Journal de Zoologie, tom. vi., 1877.

[2] Handbuch der vergleichenden Anatomie, Tab. 3.

[3] Beiträge zur Kenntniss der Naturgeschichte der Vögel.

[4] Icones Zootomicæ.

[5] Osteologia Avium.

[6] Syndesmologie der Vögel, 1856.

Spheniscus and that of *Eudyptes*, being more rounded than in the former and less so than in the latter.

A large transverse osseous crest is developed to a greater or less extent in the temporal region of every Penguin. This crest is formed by the squamosal, parietal, and occipital bones. In every species it makes its appearance immediately above the external auditory aperture, and extends vertically upwards towards the vertex of the skull. Its relation to the latter, however, varies in different genera. In *Eudyptes* it terminates above, opposite the base of the post-orbital process, by coalescing with the posterior surface of the cerebral prominence of the skull, and consequently falls short of the cranial vertex. In *Spheniscus*, on the other hand, the temporal crest is developed to a greater extent than in *Eudyptes*, and instead of subsiding opposite the base of the post-orbital process ascends to the vertex of the skull, where it meets its fellow of the opposite side. In *Spheniscus*, moreover, unlike *Eudyptes*, the temporal crest lies altogether behind the cerebral prominence, and coalesces above with the upper part of the cerebellar portion of the skull. In *Eudyptes* the temporal crest forms the posterior boundary of a narrow groove, which is limited to the *lower half* of the lateral surface of the cranium, while in *Spheniscus* this groove is much wider and extends from the base to the vertex of the skull. In *Spheniscus mendiculus* and *Spheniscus minor* the temporal crest differs somewhat from that of other species of the genus, and presents a condition intermediate between that which is characteristic of *Spheniscus* and that met with in *Eudyptes*. In *Spheniscus mendiculus* the temporal crest scarcely reaches the vertex of the skull but as in *Spheniscus demersus* terminates superiorly by becoming coincident with the cerebellar prominence. In *Spheniscus minor*, on the other hand, the temporal crest resembles that of *Spheniscus demersus* in reaching the vertex of the cranium, but agrees with *Eudyptes* inasmuch as it becomes coalescent superiorly with the cerebral and not with the cerebellar portion of the skull.

In respect of the temporal crest, *Aptenodytes* and *Pygosceles* closely resemble one another. In both these genera the crest is less prominent than in either *Spheniscus* or *Eudyptes*, and in both the groove in front of it can scarcely be said to exist. In both the crest resembles that of *Eudyptes* rather than of *Spheniscus*, inasmuch as it coalesces above with the cerebral, and not with the cerebellar prominence, and in both it falls short of the vertex and does not extend higher than the level of the base of the post-orbital process.

The supra-orbital grooves for the reception of the nasal glands are strongly pronounced in every species of Penguin. In *Eudyptes* they are broader posteriorly than in other genera, by reason of the presence of a broad, supra-orbital ledge of bone which, projecting outwards from the external margin of the frontal bone posteriorly, contributes to the formation of the groove in question. This ledge in *Eudyptes* extends forwards nearly to the lachrymal bone, whereas in *Spheniscus demersus* and *Spheniscus* anterior narial apertures considerably exceed in relative length even those of *Eudyptes* itself.

The intermaxillary suture is entirely obliterated in every species of *Eudyptes* and *Spheniscus*. In *Pygosceles* and *Aptenodytes* it is clearly visible in the upper two-thirds of its length.

With regard to the relative dimensions of the various portions of the upper jaw, there is a considerable amount of variation in the different genera. In *Eudyptes, Pygosceles,* and *Aptenodytes* the frontal processes of the intermaxillary bones, together with the applied processes of the nasal bones which together form the bridge of the nose are relatively narrow, and form a bony bar which, when the skull is viewed from below, does not completely fill the interval between the lateral portions of the upper jaw. In *Spheniscus,* on the other hand, with the single exception of *Spheniscus minor,* the bridge of the nose is relatively broader, and completely fills up the interval between, and indeed slightly overlaps the lateral bars of the upper jaw. *Spheniscus minor* in this respect, as in several others, seems to hold an intermediate position between *Eudyptes* and *Spheniscus.* In it the bridge of the nose fills up the interval between the lateral bars of the upper jaw, but does not overlap them to the same extent as in other species of *Spheniscus.*

The upper jaw, as a whole, differs in form in *Eudyptes, Spheniscus,* and *Aptenodytes.* In *Eudyptes* it is elongated-oval in form, being broadest at the middle, and narrowing both towards its base and apex. In *Spheniscus, Pygosceles,* and *Aptenodytes* the basal portion of the upper jaw is the broadest part, and from it the beak narrows gradually to a point in front. The very elongated form of the beak in *Pygosceles* and *Aptenodytes* at once distinguishes these from the other genera of Penguins. In *Pygosceles, Aptenodytes,* and *Spheniscus,* moreover, the lateral bar of the upper jaw is relatively narrow, while in *Eudyptes* it is proportionally broader and stronger.

The occipital condyle is sessile in every species of Penguin, and the articular surface is almost globular in form. Immediately in front of the condyle the basi-occipital bone presents a deep circular depression into which the musculi recti capitis antici are inserted.

The basi-sphenoidal rostrum is triangular in form, and narrows in breadth from behind forwards. It is altogether destitute of basi-pterygoid processes in every species of Penguin.

The pterygoid bones are triangular in form and much flattened from above downwards. Their anterior internal angles articulate both with the basi-sphenoidal rostrum and with the posterior extremities of the palate bones. In *Eudyptes* the pterygoid bones are relatively shorter and broader than in either *Spheniscus, Pygosceles,* or *Aptenodytes,* in all of which the posterior extremities of the bones are slender and elongated.

The palate bones are oval in form. They articulate behind with the pterygoid bones and coalesce in front with the intermaxillaries. There is no trace of an intermaxillary suture in the adult of any species of *Eudyptes* or *Spheniscus.* In *Pygosceles* and *Apteno-*

dytes it is visible in the upper part of its course. The posterior border of the palate bone in the genera *Eudyptes* and *Pygosceles* is almost straight, and articulates with the entire breadth of the anterior extremity of the pterygoid bone. In *Spheniscus* and *Aptenodytes* again, the posterior external angle of the palate bone presents an emarginate notch, and consequently in these genera the posterior border of the palate bone is oblique, and articulates only with the anterior internal angle of the pterygoid bone.

The inferior free margin of the vomer is grooved anteriorly in every species of Penguin except *Pygosceles* and *Aptenodytes*.

The maxillo-palatine processes present the configuration usually met with in the schizognathous cranium, being slender plates of bone which curve backwards and outwards without articulating either with one another or with the vomer.

The maxillary bones approach more closely to the outer border of the palate bone in *Eudyptes* than in *Spheniscus*, and hence when the skull is viewed from below, the base opposite the junctions of its cranial and facial portions appears narrower in the former than in the latter genus. In this respect the crania of *Aptenodytes* and of *Pygoscelcs* agree with that of *Eudyptes* rather than with that of *Spheniscus*.

The post-orbital process is well-developed in every species, but differs somewhat in form in different genera. In *Eudyptes* it projects vertically downwards behind the orbit, and is relatively smaller than in *Spheniscus*, in which, moreover, it is directed obliquely downwards and backwards. In *Aptenodytes* and in *Pygoscelcs* the post-orbital process resembles that of *Eudyptes* and differs correspondingly from that of *Spheniscus*.

The orbital process of the quadrate bone is short and stunted in every species of *Eudyptes*. In *Spheniscus* (with the exception of *Spheniscus minor*) and in *Pygoscelcs* it is elongated and pointed. In *Aptenodytes* and *Spheniscus minor* the orbital process presents a form intermediate between that of *Eudyptes* and that of the other species of *Spheniscus*. In every species of Penguin the upper extremity of the quadrate bone is single, rounded, and not bifurcated. A careful examination shows, however, that the articular surface is divided into two distinct facets—an outer and an inner—indicating as it were a tendency to that more complete bifurcation of the upper extremity of the bone which obtains in many birds.

The inter-orbital septum is incomplete in every species of Penguin in consequence of the presence of a large hiatus which is usually almost circular in form.

The lachrymal bone is T-shaped. It articulates above with the frontal and with the nasal bone, below with the jugal.

The lachrymo-nasal fossa is triangular in form and of large size. It is bounded above by the external process of the nasal, behind by the lachrymal, and below by the maxillary bone. In *Spheniscus* it is relatively larger than in *Eudyptes*.

The form of the zygomatic arch forms a distinctive generic feature in the skull of *Eudyptes* as compared with that of *Spheniscus*. In the former the zygomatic arch is strongly curved downwards behind the lachrymo-nasal fossa, while in the latter this curve is much less strongly pronounced in consequence of the jugal and quadrato-jugal elements being prolonged backwards almost in a straight line with the maxillo-jugal element, and without the intervention of a well-defined angle such as exists in *Eudyptes*. In consequence of this arrangement, when viewed from the side, the skull of *Eudyptes* seems to diminish in depth to the base of the upper jaw much more rapidly than does that of *Spheniscus*. In respect of the form and curvature of the zygomatic arch the skulls of *Pygosceles* and of *Aptenodytes* agree with that of *Eudyptes*, and differ from that of *Spheniscus*.

The lower jaw of every species of Penguin is composed of the same number of elements as is that of other birds. In the adult they unite to form a single mass, in which, however, traces remain of the sutures which originally separate the component elements.

In *Eudyptes* each ramus of the lower jaw is rhomboidal in form, the broadest part of the bone, which corresponds to the shorter diagonal of the figure, being placed opposite the middle in length of the ramus, whence the bone tapers to a point anteriorly and posteriorly. Immediately below the middle of the upper border of the ramus is a depression, which in *Eudyptes chrysocome* from the Falklands is perforated to form an open foramen. In the other species of *Eudyptes* it is blind. From this, which may be named the anterior foramen, an indication of the suture which originally separated the dentary from the posterior elements of the ramus, extends with a slight obliquity downwards and backwards. This suture is also clearly indicated on the inner surface of the ramus. Immediately in front of the articular surface of the lower jaw-bone there is a second or posterior foramen which completely perforates the ramus in every species of *Eudyptes*. It is small in size, and of an oval form.

The articular surface of the lower jaw-bone is irregular in form and adapted to the lower end of the quadrate bone. It is bounded internally and posteriorly by a well-developed "angular" process. Of these the internal is shorter and broader than the posterior. A coronoid process does not exist. The lower surface of the internal process is deeply grooved by the pterygoid muscle, and is separated from a second groove on the outer side of the bone by a ridge which forms part of the lower border of the jaw. The latter groove affords insertion to the digastric muscle.

The lower borders of the rami of opposite sides in every species of *Eudyptes* closely approach one another in the middle line inferiorly. This is due to the gradual widening of the bones in front of their articular extremities, and serves at once to distinguish the skull of any species of *Eudyptes* from that of any other genus. In the skulls of other genera the inferior inter-ramal space narrows gradually from the articular to the free extremity of the lower jaw-bone, whereas in *Eudyptes* that space is suddenly contracted opposite the middle in length of the ramus.

In *Spheniscus* the rami of the lower jaw are relatively longer and more slender than in *Eudyptes*, and do not present the rhomboidal form which is characteristic of those of the latter genus. In *Spheniscus* the inferior inter-ramal space narrows gradually from base to apex of the lower jaw-bone, and the depression which represents the anterior of the two foramina in the lower jaw of *Eudyptes*, more pronounced than in that genus, forms a well-marked longitudinal groove, which, however, is not perforated. In *Spheniscus*, moreover, the dentary suture is much more oblique from before backwards than in *Eudyptes*, and the posterior angular process is relatively longer and more prominent in the former than in the latter genus.

Spheniscus minor, however, differs from its congeners inasmuch as the posterior angular process much more closely resembles that of *Eudyptes* than that of any other species of its own genus, being shorter and more stunted than in these.

Pygosceles and *Aptenodytes* agree with one another and with *Eudyptes* in the form of the lower jaw-bone. This resemblance is, however, to some extent masked by the greatly elongated form of the lower jaw of these two genera as compared with that of *Eudyptes*. Still, the form of the jaw as a whole agrees more closely with that of *Eudyptes* than with that of any species of *Spheniscus*. In both *Pygoscèles* and *Aptenodytes* the dentary suture is more oblique than in *Eudyptes* but less so than in *Spheniscus;* in both the anterior ramal foramen presents the form of an elongated slit which completely perforates the ramus, and in both the angular processes resemble those of *Eudyptes* rather than those of *Spheniscus*. In *Pygosceles*, however, the posterior angular process is relatively less prominent than in *Aptenodytes*.

The Hyoid Bone.[1]—The hyoid bone of every species of Penguin much resembles that of the common fowl, and is composed of similar elements.

The glosso-hyal element is entirely cartilaginous in the Penguins. It is triangular in form, and is prolonged posteriorly into two processes which represent the cerato-hyals, and lie on either side of the first basi-branchial bone.

The first or anterior basi-branchial element is completely ossified, and is prolonged anteriorly into a pointed process which articulates with the glosso-hyal element. The posterior extremity of the anterior basi-branchial is immovably connected with the anterior extremity of the second basi-branchial element which in the Penguins presents the form of an elongated, pointed, cartilaginous style, and occupies the interval between the thyro-hyoid muscles of opposite sides. The anterior basi-branchial bone is expanded posteriorly, and is furnished with two lateral facets which articulate with the proximal extremities of the cerato-branchial elements.

The latter are ossified throughout. They are long slender bones, which diminish in thickness from their anterior to their posterior extremities.

The epibranchials in the Penguins are strongly curved to adapt them to the posterior surface of the skull. They diminish in thickness from their anterior to their posterior extremities. They are ossified in the greater part of their extent, but, close to their

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[1] In describing the separate elements of the hyoid bone, I have adopted the terminology used by Professor W. Kitchen Parker in his work on the "Morphology of the Skull."

junction with the cerato-branchial elements, present a cartilaginous portion which is never completely ossified.

THE VERTEBRAL COLUMN.

The vertebral column of the adult *Eudyptes chrysocome* from Tristan d'Acunha, consists of forty-two vertebræ, of which thirteen are cervical, nine dorsal, twelve lumbo-sacral, and eight coccygeal.

Cervical Vertebræ.[1]

The cervical vertebræ, as defined below, are thirteen in number in every species of Penguin which I have examined.

The atlas presents the form characteristic of birds in general, and consists of a simple bony ring which is divided into two segments, a dorsal and a ventral, by means of a transverse bar of bone. In the Penguins the transverse ligament is converted into an osseous bar which intervenes between the neural and articular portions of the bone. The cup-shaped cavity for the reception of the occipital condyle is perforated, the perforation being filled up by the apex of the odontoid process of the axis, which thus enters into the formation of the articulation between the occipital bone and the atlas. The dorsal arch of the atlas is quite complete, and is destitute of a spinous process. Its extremities are prolonged backwards in the form of two small osseous cornua.

The odontoid process of the axis resembles that of birds in general.

The bodies of the other cervical vertebræ in *Eudyptes chrysocome* from Tristan d'Acunha, have the usual form, their extremities being provided with the saddle-shaped articular surfaces met with in other birds. The lower surfaces of the second, third, tenth, eleventh, and twelfth cervical vertebræ are provided with well-developed hypapophyses. These processes are absent in the other cervical vertebræ, with the exception of the thirteenth, in which, however, the hypapophysis is reduced to a mere nodular rudiment. In the case of the second and third vertebræ, the hypapophyses present the form of sharp bony spines, while in the tenth, eleventh, and twelfth they are broad and laterally compressed plates of bone.

The lower (ventral) surfaces of the bodies of the cervical vertebræ are longitudinally grooved for the accommodation of the two carotid arteries. These are not, however, contained in a complete bony canal as in many birds, inasmuch as the bony nodules of opposite sides which arise from the cervical ribs, do not unite with one another across the middle line in the Penguins.

The carotid arteries come into contact with the vertebral column at the ninth, and

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[1] Under the term "cervical" I include those vertebræ, and those only, which, lying pre-axial of the thorax, are destitute of moveable ribs. Adopting Huxley's definition ("Anatomy of Vertebrates," p. 277), the cervical segment of the column includes two additional vertebræ, which, however, I regard as appertaining to the dorsal series along with which they will be described.

diverge from one another opposite the fourth cervical vertebra. The number of cervical vertebræ destitute of hypapophyses, therefore, indicates the extent of the vertebral column with which these arteries are in contact.

The variations in respect of the bodies of the cervical vertebræ in different species are few and unimportant.

In *Eudyptes chrysolophus*, *Spheniscus demersus*, *Spheniscus magellanicus*, *Spheniscus mendiculus*, *Pygosceles tæniatus*, and *Aptenodytes longirostris* the fourth cervical vertebra develops a hypapophysis in addition to those met with in *Eudyptes chrysocome* from Tristan d'Acunha. In *Eudyptes chrysocome* from Kerguelen an additional hypapophysis is developed on the ninth cervical vertebra, while in *Aptenodytes*, on the other hand, the hypapophysis of the tenth cervical vertebra met with in *Eudyptes chrysocome* is wanting. In every species of the genus *Spheniscus* the hypapophyses of the lower cervical vertebræ are relatively larger than in those of any other genus.

The *transverse processes* of the cervical vertebræ consist as usual of two bars, an anterior and a posterior, which unite together to complete the foramen for the vertebral artery. The canal formed by the apposition of the different vertebræ for the reception of that artery extends from the third to the thirteenth cervical vertebra, but is absent at the anterior portion of the neck, where, by reason of both atlas and axis being destitute of any transverse process, and consequently of a vertebrarterial foramen, the canal is deficient. The free extremities of the posterior bars form a series of small, rounded, and but slightly projecting nodules from the fourth to the tenth cervical vertebra. In the eleventh, twelfth, and thirteenth vertebræ, on the other hand, these nodules are largely developed, and assume the appearance characteristic of the transverse processes of the dorsal region. Those of the eleventh and twelfth vertebræ are rather smaller than those of the thirteenth, which indeed are of larger size, and more prominent than the transverse processes of any other vertebræ, not excepting those of the dorsal region. Above the fourth vertebra they are scarcely distinguishable. The anterior bars of the cervical transverse processes (cervical ribs) are provided with elongated spines which afford attachment to the tendons of insertion of the longi colli muscles. These spines are well developed from the third to the eleventh cervical vertebra inclusive. In the first and second, by reason of the absence of a transverse process, they are absent, while in the twelfth and thirteenth, although present, they are thicker, shorter, and less projecting than in the vertebræ higher up.

With respect to the variations in the transverse processes, I find that while in all three specimens of *Eudyptes chrysocome*, the nodular extremities of the posterior bars of the cervical transverse processes are distinctly visible from the fourth to the thirteenth vertebra, in every other species, including *Eudyptes chrysolophus*, they are entirely absent in the upper five cervical vertebræ, and only make their appearance from the sixth to the thirteenth vertebra inclusive.

In every species of *Spheniscus*, with the single exception of *Spheniscus minor*, the bony spines which afford attachment to the tendons of the longi colli muscles in connection with the eleventh, twelfth, and thirteenth vertebræ are developed to a greater extent than in any other species. In *Pygosceles* and *Spheniscus minor*, on the other hand, these spines are entirely wanting in the twelfth and thirteenth cervical vertebræ. In *Pygosceles* I found the foramen in the transverse process of the thirteenth cervical vertebra incomplete on both sides, in consequence of the want of development of the anterior bars of its transverse processes. It is possible, however, that this may have been an individual peculiarity.

The *articular processes* present the usual arrangement. The posterior articular processes of the cervical vertebræ are provided with small bony tubercles which afford attachment to certain of the cervical muscles. These tubercles, in the case of the second, third, fourth, and fifth cervical vertebræ are largely developed, and form well-marked bony spines which diminish in size from before backwards. In the vertebræ behind the fifth they are scarcely recognisable until the tenth is reached, in which, as well as in the eleventh they form mere nodules. The twelfth and thirteenth cervical vertebræ are destitute of any trace of these nodules.

Spinous processes are absent in the case of all the cervical vertebræ, with the exceptions of the second, third, fourth, fifth, twelfth, and thirteenth. The spines of the second, third, and fourth vertebræ are well-marked, pointed processes which diminish in size from the second to the fourth. Those of the fifth and twelfth are mere nodules, while that of the thirteenth vertebra differs from all the others in the cervical region, inasmuch as it presents the form of a well-marked bony plate which is quadrilateral in form and closely resembles the spines of the dorsal vertebræ.

The following variations in respect of the spinous processes of the cervical vertebræ occur in different species. In *Eudyptes chrysocome* from the Falkland Islands the spinous process of the fifth vertebra is of large size. In *Spheniscus demersus*, *Spheniscus magellanicus*, *Spheniscus mendiculus*, and *Pygosceles* the fifth and sixth vertebræ have well-developed spines. In *Spheniscus minor*, *Pygosceles*, and *Aptenodytes* the quadrilateral spinous process of the thirteenth cervical vertebra is, relatively to the corresponding spines in the dorsal region, of smaller size than in *Eudyptes* and in the other species of *Spheniscus*.

Comparative Remarks.—The great peculiarity of the cervical portion of the vertebral column, as a whole, of the Penguins lies in the extraordinary development of its antero-posterior curvatures. These curvatures are two in number. The lower half of the cervical region in the natural condition of the parts describes a curve, the convexity of which is directed forwards, while the upper half forms a curve, the convexity of which is directed backwards. These curvatures are present in all birds, but in none are they developed to the same extent as in the Penguins. So great is the convexity of the lower curve in these birds that the bodies of the cervical vertebræ actually come into contact with, and fill up the angle formed by the two limbs of the clavicle, and consequently both the trachea and œsophagus, instead of passing into the thorax directly in front of the vertebral column, are so to speak pushed away to the right side of the latter at the lower part of the neck, and at their entry into the thorax lie between the right side of the vertebral column and the right limb of the furculum. In every species of Penguin which I have had an opportunity of examining this arrangement holds good, although there seems to be no reason why the tubes in question should not pass into the thorax in contact with the left side of the column. The strongly-developed flexures of the neck in the Penguins are associated with the maintenance by these birds, when on land, of the characteristically erect attitude, and serve to bring the centre of gravity of the head and neck over the base of support formed by the feet. In the genera which include the smaller species (*Eudyptes* and *Spheniscus*) the cervical curves are more strongly developed than in those which include the larger (*Pygosceles* and *Aptenodytes*), but the arrangement is essentially the same in all.

Dorsal Vertebræ.

The dorsal vertebræ, understanding by this term all those which possess moveable ribs, are nine in number in every species which I have examined. The last dorsal vertebra is immovably fused by means of its body, arch, spinous, and transverse processes with the first lumbo-sacral vertebra.

The bodies of the dorsal vertebræ in *Eudyptes chrysocome* from Tristan d'Acunha are much compressed from side to side. The articular surfaces of the bodies of the first and second,[1] and the anterior articular surface of the body of the third dorsal vertebræ are saddle-shaped, and resemble the corresponding surfaces of the cervical vertebræ. The succeeding dorsal vertebræ differ from these inasmuch as they are opisthocœlous, the anterior surfaces of their bodies being rounded and globular, while their posterior surfaces are deeply concave, so that the convexity of any given vertebra is received into the concavity of the body of the vertebra next preceding. In this respect, as pointed out by Owen,[2] and Gervais and Alix,[3] this portion of the vertebral column of the Penguin bears a remarkable resemblance to that of many reptiles. The body of the last dorsal is immovably fused with that of the first lumbo-sacral vertebra. On either side of the body of each dorsal vertebra, close to the anterior extremity, is a facet for the reception of the head of a rib.

The lower surfaces of the bodies of all the dorsal vertebræ, with the exception of the first and ninth, are provided with well-developed hypapophyses. In the first and ninth these processes are absent. Those connected with the second, third, and fourth dorsal vertebræ have bifid extremities which afford additional surface of attachment to the

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[1] According to Gervais and Alix (Ostéologie et Myologie des Manchots, p. 3), the body of the second dorsal vertebra differs from those of the cervical vertebræ in being opisthocœlous. Such is not the case in any of my specimens. Owen (Cyclopæd. of Anatomy, Art. "Aves," vol. i. p. 270) correctly remarks that the opisthocœlous character of the vertebræ shows itself for the first time in the third dorsal vertebra.

[2] Cyclopædia of Anatomy, Art. "Aves," vol. i. p. 270.

[3] *Loc. cit.*, p. 3.

longi colli muscles, while in the succeeding vertebræ they form large, laterally compressed plates of bone of larger size, which present no trace of bifidity. These processes in *Eudyptes chrysocome* have their bases attached to the whole length of the vertebræ to which they belong. They diminish slightly in size from the fourth to the eighth dorsal vertebra.

The following variations with respect to the bodies of the dorsal vertebræ occur in different species.

In *Aptenodytes*, *Pygosceles*, and *Eudyptes chrysolophus* the body of the first dorsal vertebra is destitute of the articular surfaces for the reception of the heads of the first pair of ribs, these bones in the species named articulating only with the transverse processes of the first dorsal vertebra.

The hypapophyses in all three varieties of *Eudyptes chrysocome*, as also in *Aptenodytes* are attached by their bases to the whole length of the bodies of the vertebræ to which they belong, while in *Pygosceles*, *Eudyptes chrysolophus*, and every species of *Spheniscus* the bases of the hypapophysial spines are attached only to the anterior half of their respective vertebræ. In *Pygosceles* and *Eudyptes* these processes are relatively larger than in other species. In *Spheniscus demersus*, *Spheniscus magellanicus*, *Spheniscus minor*, and *Aptenodytes* the hypapophysis of the fifth dorsal vertebra differs from the corresponding process of other species in being bifid. In *Spheniscus minor* the last dorsal vertebra possesses a small hypapophysial spine.

The *transverse processes* are long, pointed, and flattened in the dorsal region. With the exception of those belonging to the first dorsal vertebra they are all directed slightly backwards. The transverse processes of the first dorsal vertebra differ from those of the others, inasmuch as they more nearly resemble those of the last cervical than those of the other dorsal vertebræ. They are, moreover, inclined slightly forwards instead of backwards. The articular surfaces for the tubercles of the ribs are situated on the free extremities of the transverse processes, except in the case of the first dorsal vertebra, in which they are situated midway between the base and apex of its transverse process. The apex of the transverse process of the last dorsal fuses with that of the first lumbo-sacral vertebra. With this exception all the transverse processes are quite distinct and in no way connected with one another.

The *articular processes* present the usual arrangement; the posterior articular processes are destitute of the bony spines which characterise certain of them in the cervical region.

The *spines* of the dorsal vertebræ are broad, flattened, quadrilateral plates of bone, and thus differ much in form from those of the cervical region, with the exception of the last, the spinous process of which closely resembles that of a dorsal vertebra. The spine of the last dorsal vertebra like the transverse process is anchylosed with that of the first lumbo-sacral, and forms a portion of the bony ridge formed by the fusion of the spines of another, and secondly, the the lumbo-sacral vertebræ.

Comparative Remarks.—The peculiarities of the dorsal portion of the vertebral column in the Penguins, as compared with that of other birds, are referrible to two points. Firstly, the freely moveable character of the articulation of these with one another, and secondly, the opisthocœlous character of certain of the vertebræ.

In the majority of birds the dorsal vertebræ are more or less firmly anchylosed with one another by means of their bodies, spines, and transverse processes, whereas in the Penguins, as first pointed out by Meckel,[1] these structures are freely moveable upon one another, and consequently the dorsal segment of the vertebral column is devoid of that rigidity which characterises it in other birds. This arrangement is perhaps explicable, as pointed out by Owen, by the fact that, the Penguins being incapable of flight, there is no necessity for that extreme rigidity of the dorsal region which is met with in those birds in which the powers of flight are largely developed, and in which, therefore, the dorsal region "has almost exclusively to sustain the shock of the violent contractions of the principal muscles of the wings." It should, however, be remembered that as the wings are the principal agents used by the Penguin in propelling itself through the much denser medium of water, there may possibly be need of some further explanation of the arrangement referred to.

The opisthocœlous character of the vertebræ among birds is, so far as I can ascertain, confined to the Auks and Penguins.[2] It was first demonstrated by Owen[3] in *Aptenodytes*, and has since been recognised in other genera of Penguins. So far as my own observations extend, it obtains in every species of Penguin.

Lumbo-Sacral Vertebræ

Under the name of lumbo-sacral, I include all the vertebræ which are interposed between the last dorsal vertebra (characterised by articulation with the last pair of vertebral ribs), and the first moveable coccygeal vertebra. Thus defined the lumbo-sacral vertebræ are twelve in number. The bodies of all these vertebræ in the adult are anchylosed with one another as well as with that of the last dorsal vertebra, to form a single osseous mass, the composition of which is only rendered evident by the presence of the intervertebral foramina. The bodies of these vertebræ, seen from below, form a single osseous lozenge-shaped mass, the widest portion of which is situated immediately in front of the acetabulum, from which point the bodies of the vertebræ diminish in breadth both forwards and backwards. In front of the widest part the bodies form a sharp osseous keel, while behind that point the vertebræ diminish in breadth to that of the bodies of the proximal coccygeal vertebræ. The bodies of the lumbo-sacral vertebræ are altogether devoid of hypapophyses.

The apices of the *transverse processes* of all the vertebræ of this region, with the ex-

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[1] Traité général d'anatomie comparée, vol. iii., partie 1, p. 38.

[2] Cyclopædia of Anatomy, Art. "Aves," vol. i. p. 271.

[3] Owen, Anatomy of Vertebrates, vol. ii. p. 16.

[4] Cyclopædia of Anatomy, Art. "Aves," vol. i. p. 270.

ception of those of the eleventh and twelfth, are fused with one another, as well as with those of the last dorsal vertebra, to form an osseous margin for articulation with the innominate bone. The intervertebral foramina, with the exception of those between the eleventh and twelfth vertebræ, are completed by the vertebræ themselves. Those between the eleventh and twelfth lumbo-sacral vertebræ are of larger size than the others, and are completed externally by the pelvic bone. The renal fossæ are deep and oval in form. They are separated from one another by the median ridge formed by the fusion of the vertebral bodies.

The articular processes, spinous processes and arches of the lumbo-sacral vertebræ, together with those of the last dorsal vertebra, unite to form a single osseous mass. The spinous processes form a single continuous osseous ridge, on either side of which lies the portion of bone formed by the union of the arches of the lumbo-sacral vertebræ. This portion is oval in form, its widest part being situated immediately in front of the acetabulum. It is perforated at regular intervals by small foramina, by means of which the dorsal branches of the lumbo-sacral nerves escape from the vertebral canal.

The distinction between the lumbo-sacral and coccygeal vertebræ is by no means well-defined. In several specimens of different species I found that the first coccygeal was immovably anchylosed with the last lumbo-sacral vertebra, and that the apices of its transverse processes came into contact with the pelvic bone. In every specimen, however, there was a distinct want of anchylosis between the arches and spinous processes of the last lumbo-sacral and those of the first coccygeal vertebra, and this, coupled with the fact that in the majority there was also a certain degree of mobility between the bodies of these vertebræ, while those of the other lumbo-sacral vertebræ were immovably fused together, and that the total number of lumbo-sacral and coccygeal vertebræ together was the same in every species, seems to me to justify the separation of the two segments on the grounds above mentioned.

The only variation in respect of the lumbo-sacral vertebræ from the arrangement above described in *Eudyptes chrysocome*, appears in *Pygosceles tæniatus*. In every other species the spinous processes of the anchylosed vertebræ form a sharp prominent keel, which extends along the whole length of the lumbo-sacral region. In *Pygosceles*, on the other hand, this keel presents a flattened appearance, as if the spinous processes had been compressed from above downwards, and appears as a flattened and but slightly prominent surface of bone of an elliptical form, which presents its greatest breadth opposite the sixth lumbo-sacral vertebra, and narrows to a point at either end.

Comparative Remarks.—The lumbo-sacral portion of the vertebral column in the Penguins differs, as is well known, from that of other birds, inasmuch as it never becomes completely anchylosed with the pelvic bones. Even in the adult the original separation is indicated by the presence of a well-defined suture.

present description in the lumbo-sacral series. I have before adverted to the difficulty in determining to which series that vertebra really belongs.

The caudal vertebræ do not differ much in different species. In *Spheniscus demersus*, *Spheniscus magellanicus* and *Spheniscus mendiculus* there are nine caudal vertebræ, while in every other species examined there are only eight. In *Pygosceles* the transverse processes of the caudal vertebræ are relatively longer than in other species. In *Pygosceles*, *Spheniscus demersus*, and *Spheniscus magellanicus* hypapophyses are not developed in connection with the first, second, third, or fourth caudal vertebræ. The transverse processes of the first caudal vertebra of *Pygosceles* differ from those of other species, inasmuch as they do not abut against the pelvic bones.

The table shows the number of vertebræ possessed by every species of Penguin examined, with the exception of *Spheniscus demersus*, *Spheniscus magellanicus* and *Spheniscus mendiculus*, all of which possess an additional caudal vertebra. In these, therefore, the total number of vertebræ is forty-three.

Cervical.	Dorsal.	Lumbo-sacral.	Caudal.	Total.
13	9	12	8	42

LENGTH OF VERTEBRAL COLUMN FROM ATLAS TO EXTREMITY OF PYGOSTYLE, IN INCHES.

Eudyptes chrysocome, from Tristan,	15½
Eudyptes chrysocome, from the Falklands,	16½
Eudyptes chrysocome, from Kerguelen,	15½
Eudyptes chrysolophus,	18
Spheniscus demersus,	20
Spheniscus magellanicus,	19¼
Spheniscus mendiculus,	15
Spheniscus minor,	12½
Pygosceles tæniatus,	21
Aptenodytes longirostris,	26½

THE RIBS.

The vertebral segments of the ribs are ten in number in every species of Penguin, and increase in length from the first to the ninth. Gervais and Alix[1] figure only nine in *Eudyptes chrysocome*, and Reid[2] found the same number of ribs in the Patagonian Penguin. The diversity of statement between these authors and myself is explicable by the fact that the tenth vertebral rib is extremely slender in every species, and that its proximal extremity does not articulate with the vertebral column. In consequence of its small size and its want of attachment to the vertebral column this rib is apt to be

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[1] Ostéologie des Manchots, pl. xvi. figs. 4 and 5.

[2] Proc. Zool. Soc., 1835, p. 134.

lost sight of, and, lying as it does in the substance of the abdominal muscles, unless specially looked for, is apt to be omitted in the enumeration of the ribs.

The first vertebral rib in *Eudyptes chrysocome* measures only one inch in length. It is, however, provided with a well-developed head, neck and tubercle, by means of which it articulates with the body and transverse process of the first dorsal vertebra. Its inferior extremity terminates in a sharp point, which lies embedded in the substance of the scalene muscle. This rib has no connection with the sternum, being destitute of any sternal segment. It is also destitute of an uncinate process.

The second vertebral rib is also destitute of a sternal segment, and consequently does not articulate with the sternum. It is about three times as long as the first rib, from which it differs, inasmuch as it develops an uncinate process.

The following ribs as far as the seventh are much flattened, and each bears a large uncinate process. The eighth and ninth ribs, again, more nearly resemble the first and second, inasmuch as they lose the flattened form, become almost cylindrical, and are much more slender than those which precede them. The eighth is provided with an uncinate process, which is wanting in the case of the ninth rib. The tenth rib, as already observed, is rudimental, and does not articulate with the vertebral column as do all the others, its proximal extremity being attached by ligament to the middle in length of the posterior border of the ninth vertebral rib. The tenth rib is, moreover, devoid of an uncinate process. All the vertebral ribs, with the exception of the first and second, possess sternal segments. The tubercles of the eighth and ninth vertebral ribs come into relation with the lower surface of the iliac bone, close to its anterior margin or crest.

The uncinate processes are of exceptionally large size, and much flattened. They are elongated-quadrilateral in form, and project backwards and upwards. They are met with in every vertebral rib, with the exception of the first and the last two. In the case of the anterior ribs they are attached to the junction of the middle and lower thirds of the bone, but occupy a higher position with reference to the posterior ribs, being attached in these to about the middle of their length or even opposite the junction of the upper and middle thirds of their vertebral segments. They are of largest size about the middle of the costal series. As is well known, in all the Penguins the uncinate processes are connected with the ribs by means of distinct synovial articulations, and never become anchylosed with them as in the majority of birds.

The sternal ribs are eight in number on each side, and belong to the vertebral segments posterior to the second. They increase in length from the first to the sixth, all of which articulate with special facets on the lateral margin of the sternum. The seventh sternal rib (belonging to the ninth vertebral segment), is much more slender than those which precede. It differs from these inasmuch as it does not reach the border of the sternum, but falling short of that bone is attached by ligament to the sternal segment next in front, about a quarter of an inch from the margin of the sternum. The eighth sternal rib, like the vertebral segment to which it belongs (the tenth), is rudimental and easily lost sight of. It articulates by one extremity with the tenth vertebral rib, and by the other it is attached to the preceding sternal rib, about one inch from the margin of the breast bone. Hence, like the seventh sternal segment, it does not reach the sternum.

I have observed the following variations in respect of the ribs from the arrangement in *Eudyptes chrysocome* above described.

In *Aptenodytes*, *Pygosceles*, and *Eudyptes chrysolophus* the first vertebral rib is destitute of the head and neck, and hence in these species, unlike the others, the first vertebral rib articulates only with the transverse process of the first dorsal vertebra, and not at all with the body of that bone. In *Pygosceles*, moreover, the seventh sternal rib articulates with the lateral margin of the sternum, and in this respect differs from every other species which I have examined, in all of which that rib falls short of the margin of the breast bone. With these exceptions, the arrangement of the ribs is the same in every species.

According to Reid,[1] in the Patagonian Penguin there are only seven sternal ribs. It seems probable that the eighth, like the vertebral segment to which it belongs, had been lost in preparing the skeleton.

THE STERNUM.

The sternum of *Eudyptes chrysocome* from Tristan d'Acunha (Pl. VI. figs. 1 and 2), is quadrilateral in form. Its length is twice as great as its breadth. The body of the bone, as distinguished from the keel, is nearly uniformly convex on its lower surface, except towards its lateral margins, where there is a deep longitudinal groove, bounded on the outer side by an oblique ridge, which, commencing at the lateral border of the bone passes obliquely backwards and inwards, and separates the groove in question from the external xiphoid process. This process nearly equals in length the undivided portion of the bone, from the median portion of which it is separated by the posterior sternal notch, and is prolonged backwards in the recent state by a curved cartilaginous bar, the extremity of which nearly touches its fellow of the opposite side. The posterior sternal notches are two in number, and extend forwards from the posterior border of the bone to midway between the latter and the anterior border of the sternum. They are bounded externally by the external xiphoid processes, and in the recent state are filled up by fibrous membrane. The posterior border of the middle xiphoid process, lying between the sternal notches, is somewhat excavated by a slightly-marked V-shaped notch.

The anterior border of the body of the sternum is prolonged externally into two well-developed "costal processes." These are quadrilateral in form, flattened from above downwards, and project obliquely outwards and forwards. Their lower surfaces are rough

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[1] Proc. Zool. Soc., 1835, p. 134.

and convex, and close to their junction with the body of the bone present a well-defined circular depression, in which is lodged the external basal angle of the coracoid bone. Their upper or thoracic surfaces are concave, smooth, and continuous with the hollowed surface of the body of the bone. Their lateral margins are devoid of any articular surfaces for the sternal ribs, the most anterior of which is placed on the lateral margin of the sternum, immediately behind the base of the costal process. The grooves for the reception of the coracoid bones are deep, and correspond in breadth with the base of the costal process. Their inner extremities approach within half an inch of each other.

The thoracic surface of the bone is smooth and uniformly concave.

The anterior third of the lateral margin of the sternum is provided with six articular surfaces, for the reception of the extremities of as many of the sternal ribs. The most posterior of these depressions is of smaller size than the others, in accordance with the diminutive size of the sixth sternal rib. The posterior two-thirds of this margin is formed chiefly by the external xiphoid process. It is thin, sharp and slightly convex.

The keel of the sternum is triangular in form, and extends along the whole length of the bone. Its greatest depth is in front, from whence it slopes gradually backwards to the posterior border of the bone. The anterior border of the keel is straight and obliquely placed, being inclined slightly forwards from the line of attachment of the keel to the body of the bone.

The anterior border of the sternum is prolonged forwards beyond the anterior margin of the keel, in the form of a small laterally compressed spine of bone or episternum, measuring one-fourth of an inch in length, and rather less in breadth.

Although the sternum presents the same general form in every species of Penguin, differences occur in the configuration of separate portions of that bone in different species. These differences may be included in three groups, according as they relate to the body of the bone, to the keel, or to the costal processes.

Firstly.—With regard to the body of the bone, I find that while in every species of the four genera which I have examined, with the exception of *Aptenodytes longirostris* and *Eudyptes chrysocome* from the Falkland Isles, the body of the sternum is of the same breadth from end to end, in the two species mentioned the sternum is distinctly narrower opposite the articulation of the last sternal rib. Hence at this spot the lateral border of the bone presents a distinct concavity, which although indicated in the sterna of other species, is only fully developed in that of *Eudyptes chrysocome* from the Falklands, and to a greater extent in that of *Aptenodytes longirostris*.

In *Eudyptes chrysocome* from the Falkland Isles (Pl. VI. fig. 11), the sternal notches are wider and the external xiphoid processes broader and stronger than in the varieties of the same species from Tristan d'Acunha or Kerguelen Island.

The articular depressions for the reception of the sternal ribs are six in number on either side in every species, with the single exception of *Pygosceles tæniatus*, in which, in accordance with the fact that seven sternal ribs articulate with the breast bone, there are seven distinct depressions on the lateral margin of the sternum.

In *Pygosceles*, moreover, the relative lengths of the middle and external xiphoid processes, as compared with those of every other species, are reversed. In the latter the external xiphoid processes exceed the middle process in length, while in *Pygosceles* (Pl. VI. fig. 12) the central xiphoid process equals or even exceeds that of the external processes.

The central xiphoid process is relatively narrower in *Eudyptes* than in *Spheniscus*.

Secondly.—In accordance with the form of the sternal keel, the Penguins may be divided into two groups. In the first of these the anterior border of the sternal keel forms nearly a right angle with the plane of the body of the bone, and consequently the anterior-inferior, or furcular angle of the keel projects but little beyond the anterior border of the bone. This form is most strongly pronounced in *Pygosceles* (Pl. VI. fig. 5). In the second group the anterior border of the sternal keel forms an obtuse angle with the plane of the body of the sternum, and consequently the furcular angle of the keel is acute, and projects to a greater extent beyond the anterior border of the bone. This form is best seen in *Aptenodytes* (Pl. VI. fig. 6).

Of the other two genera, *Spheniscus* (Pl. VI. fig. 4) most closely resembles *Aptenodytes* in the form of the furcular angle of the carina sterni, while *Eudyptes* (Pl. VI. figs. 1, 2, 3) occupies an intermediate position between *Aptenodytes* and *Pygosceles*, the furcular angle of the keel being less acute than in the former, and more so than in the latter genus.

In *Eudyptes chrysocome* the anterior margin of the sternal keel is concave, while in both other varieties of the same species it is straight.

In *Pygosceles* the keel as a whole is less prominent than in any other genus.

In the same manner, taking into consideration the size and form of the episternum, the Penguins may be divided into two groups, which coincide with those founded on the form of the sternal keel.

In *Aptenodytes* (Pl. VI. fig. 6) the episternum is entirely absent, while in *Pygosceles* (Pl. VI. fig. 5) it forms a broad laterally compressed plate of bone with irregular edges. Both *Spheniscus* (Pl. VI. fig. 4) and *Eudyptes* (Pl. VI. figs. 2 and 3) present an intermediate condition. An episternum is present in every species of both these genera, and presents the form of a slender, laterally compressed spicule of bone, of smaller size than in *Pygosceles*, but larger than in *Aptenodytes*.

Thirdly.—The modifications in the form and direction of the costal processes agree with the peculiarities already pointed out in the configuration of the body and keel of the sternum.

In *Aptenodytes longirostris* (Pl. VI. fig. 10) the costal processes are of large size, and project obliquely forwards and outwards from the anterior margin of the sternum, so that their inner border forms an obtuse angle with the latter. In *Pygosceles* (Pl. VI. fig. 9), on the other hand, the costal processes are relatively of much smaller size, and are directed more horizontally outwards, so that their inner borders form nearly a right line with the anterior sternal border.

In both *Eudyptes* (Pl. VI. figs. 1, 2, 7) and *Spheniscus* (Pl. VI. fig. 8) the costal processes present an intermediate form. They are relatively of the same size as in *Aptenodytes*, but are directed less obliquely outwards than in *Pygosceles*.

Apart from size, I could distinguish in the sternum no features characteristic of the species of the different genera, except in *Spheniscus demersus*, in which the costal processes are completely perforated by a foramen, which in other species is only represented by a depression on the lower surfaces of these processes.

The accompanying table shows the chief dimensions of the sternum of different species in inches.

Species.	Length of keel.	Greatest depth of keel.	Breadth of anterior border of sternum between first sternal ribs.	Shortest breadth between keel and lateral margin.	Depth of sternal notch from extremity of middle xiphoid process.
Eudyptes chrysocome, from Tristan, . .	4¾	1⅜	2½	1⅛	1⅝
Eudyptes chrysocome, from the Falklands, .	5	1⅜	2¾	1⅛	1½
Eudyptes chrysocome, from Kerguelen, . .	4¾	1¼	2½	1⅛	1⅝
Eudyptes chrysolophus, ...	6	1⅜	3	1¼	2
Spheniscus demersus, ...	5¼	1¾	3	1¼	1⅝
Spheniscus magellanicus, ...	5¾	1¾	3¼	1¼	1¾
Spheniscus mendiculus, ...	4¼	1¼	2¼	¾	1⅜
Spheniscus minor, ...	3⅜	1½	1¾	¾	1
Pygosceles tæniatus, ...	6½	1¼	4½	1⅜	3
Aptenodytes longirostris, ...	8½	2⅛	4½	1¾	3

APPENDICULAR SKELETON.

The Anterior Extremity.

The Scapula.

The scapula in every species of Penguin is, relatively to the other parts of the skeleton, of larger size than in any other group of birds, and is correlated with the great development of the scapular muscles. The relatively large size of the bone is due to increase in breadth rather than in length, the latter remaining much the same as in other birds.

In *Eudyptes chrysocome* from Tristan d'Acunha (Pl. VII. fig. 1), the bone is scimitar-shaped, and increases in breadth from the narrowest point or neck, which is situated immediately behind its articular extremity, nearly to the posterior extremity of the bone. The bone is much flattened, and presents two surfaces—an external and an internal, both of which are rough and uneven, for the attachment of muscles. Immediately in front of its narrowest point, the scapula expands in breadth, and develops its articular facets. These are arranged in the manner common to birds. The inner of the two articular surfaces articulates with the extremity of the clavicle, while the outer, which is separated from the inner by a shallow notch, is divided by means of a vertical ridge into two parts. Of these the internal articulates with the shaft of the coracoid bone, while the external contributes to the formation of the glenoid fossa for the reception of the head of the humerus. The posterior angle of the scapula extends in *Eudyptes chrysocome* as far back as the sixth vertebral rib, which it slightly overlaps.

The form of the scapula varies considerably in different Penguins.

In every member of the genus *Eudyptes* (Pl. VII. fig. 1) the scapula agrees in form with that of *Eudyptes chrysocome.* In this genus the bone increases in breadth somewhat abruptly. The posterior border of the bone is obliquely truncated from above downwards and forwards, and the angle between the superior and posterior borders of the blade of the scapula projects farther backwards than any other portion of the bone.

In *Spheniscus* (Pl. VII. fig. 2) a posterior border of the scapula can hardly be said to exist, the superior and inferior borders of the bone meeting together posteriorly to form a rounded angle which forms the posterior extremity of the bone.

In *Aptenodytes* (Pl. VII. fig. 4) the scapula more closely resembles that of *Eudyptes* than of *Spheniscus.* In it the bone expands more gradually from the neck to the blade than in *Eudyptes,* but its posterior border is even more clearly defined than in that genus. In *Aptenodytes,* however, the posterior border of the scapula forms nearly a right angle with both the superior and inferior borders of the bone, and is less obliquely truncated than in *Eudyptes.* In *Spheniscus* the reverse is the case, the posterior border of the scapula in that genus being indistinguishable because of the coalescence of the superior and inferior borders of the bone.

In *Pygosceles* (Pl. VII. fig. 3) the scapula differs from that of the three other genera, inasmuch as it is relatively shorter and broader, the blade of the bone as distinguished from the neck expanding more abruptly from the neck than in the other genera. The angle, moreover, which forms the posterior portion of the bone is the angle between the inferior and posterior borders of the scapula, whereas in *Eudyptes* and *Aptenodytes* it is the angle between the superior and posterior borders of the scapula. Lastly, in *Pygosceles* the superior border of the scapula resembles that of *Spheniscus* inasmuch as it rounds insensibly into the posterior border without the intervention of the well-defined angle which obtains both in *Eudyptes* and in *Aptenodytes*.

In short, with regard to the scapula as to the sternum, there are two extremes, represented by the genera *Aptenodytes* and *Pygoscèles*, and two means, represented by the genera *Eudyptes* and *Spheniscus*.

The following table shows the principal dimensions of the scapula of different species in inches.

SPECIES.	Length of scapula from articulation with clavicle to posterior border of bone.	Greatest breadth of scapula.	Breadth between articulation with clavicle and with coracoid bone.	Shortest breadth of scapula.
Eudyptes chrysocome, from Tristan,	3⅝	1	¾	⅜
Eudyptes chrysocome, from the Falklands,	3⅝	1¼	¾	⅜
Eudyptes chrysocome, from Kerguelen,	3¾	1¼	¾	¼
Eudyptes chrysolophus,	4½	1½	⅞	⅜
Spheniscus demersus,	4¼	1⅛	¾	⅜
Spheniscus magellanicus,	4½	1⅛	¾	⅜
Spheniscus mendiculus,	3¼	⅞	⅝	¼
Spheniscus minor,	2¾	⅞	½	⅜
Pygoscèles tæniatus,	4½	1½	1	½
Aptenodytes longirostris,	7	1¾	1¼	½

The Clavicle.

The clavicles of opposite sides are united together at an acute angle to form the furculum. The furcular angle is devoid of any hypocleidium, and is attached to the sternal keel only by ligament. The curvature of the clavicle is strongly pronounced and forms about one-third of a circle. Flattened from side to side, the broadest part of each clavicle corresponds to the point of articulation with the coracoid bone. From this point the bone diminishes in breadth upwards and downwards. The upper or scapular extremity of the bone is bevelled at the expense of its lower border to articulate with the acromion process of the scapula, while the lower extremity is fused with its fellow of the opposite side. The internal surface of the bone is smooth, and lies in contact with the interclavicular air-sac, while the outer surface presents a broad shallow depression, from which fibres of the pectoralis major muscle take their rise. The coracoidal facet is situated on the outer side of the anterior border of the broadest part of the bone, and articulates directly with the apex of the coracoid bone.

The clavicle presents no distinctive points of importance in the various genera.

In *Pygosceles* the bone narrows more abruptly from its widest part to the angle of union with its fellow than in any other genus.

In *Eudyptes* the coracoidal articular surface is more elevated than in other genera.

The table shows the dimensions of the clavicle in different species in inches.

Species.	Length of chord of circle from furcular angle to coracoidal articulation.	Length of bone between coracoidal and scapular articulation.	Greatest breadth of bone opposite coracoidal articulation.
Eudyptes chrysocome, from Tristan,	2¼	1	⅜
Eudyptes chrysocome, from the Falklands,	2¼	1	½
Eudyptes chrysocome, from Kerguelen,	2¼	1	½
Eudyptes chrysolophus,	2½	1¼	½
Spheniscus demersus,	2¼	1	½
Spheniscus magellanicus,	2½	1	⅝
Spheniscus mendiculus,	1⅞	1	½
Spheniscus minor,	1¾	¾	⅜
Pygosceles tæniatus,	2⅞	1½	⅝
Aptenodytes longirostris,	3¾	1⅛	¾

The Coracoid Bone.

The coracoid bones (Pl. VII. fig. 5) are remarkably strong in every species of Penguin. The shaft of the bone tapers gradually from base to apex. The upper or thoracic surface of the shaft is nearly flat, except close to the base, where it is deeply concave. The lower or external surface of the shaft of the bone is convex, and almost cylindrical in form from end to end. The tapering appearance of the shaft of the bone is somewhat obscured by the presence on its inner side of an osseous lamella, which is attached below to about the middle in length of the inner margin of the shaft of the coracoid while above it is connected by means of a transverse bridge of bone to the point of junction of the shaft with the curved extremity of the coracoid. Owing to the mode of attachment of this lamellar process, a foramen is developed in connection with the coracoid, bounded on the outer side by the shaft of the bone, and on the inner side by the lamella in question, while in front it is completed by the osseous bridge which attaches the lamella to the shaft of the coracoid. Through this foramen passes the nerve of supply to the pectoralis medius muscle. The free border of the osseous bridge which attaches the lamellar process to the coracoid bone is provided with a narrow articular surface which articulates with the upper extremity of the clavicle, and with the acromion process of the scapula.

The base of the coracoid bone is deeply curved to adapt it to the sternal groove, and terminates on the inner side in a well-marked tubercle, which affords attachment to the powerful ligament which binds the base of the coracoid bone to the inner or thoracic surface of the sternum. Surmounting this tubercle is a sharp bony spine which projects forwards, and affords attachment in the recent state to a strong fibrous band, between which and the inner margin of the shaft of the bone the artery of supply to the middle pectoral muscle passes forwards.

The distal extremity of the coracoid is curved obliquely downwards and inwards, and articulates by its apex with the articular surface developed on the anterior border of the clavicle. Opposite the point of junction of the shaft with the curved extremity of the bone, is the articular surface, which, together with a corresponding one on the scapula, completes the glenoid fossa for the reception of the head of the humerus. The inner surface of the curved extremity of the bone is deeply grooved, and serves as a pulley over which the tendon of the pectoralis medius plays after escaping from the foramen triosseum.

The only varieties which I have noticed in the configuration of the coracoid bone occur in the genera *Aptenodytes* and *Pygosceles*. In both of these (Pl. VII. fig. 6) the osseous bar which in the other genera forms the inner boundary of the foramen, through which passes the nerve to the pectoralis medius, is represented only by ligament.

In *Spheniscus* the osseous bar in question is relatively more slender than in *Eudyptes*, and in one species (*Spheniscus minor*) I found the bar so thin that the circumference of the foramen was deficient at one point. This occurred on the left side only, the right coracoid differing in no respect from that of *Eudyptes chrysocome*.

The following table shows the dimensions of the coracoid bone in different species in inches.

Species.	Length of shaft of coracoid bone.	Breadth of shaft of bone at base.	Length of curved apical process.
Eudyptes chrysocome, from Tristan, . . .	2½	⅞	¼
Eudyptes chrysocome, from the Falklands, . .	2½	⅞	¼
Eudyptes chrysocome, from Kerguelen, . .	2½	⅝	¼
Eudyptes chrysolophus, ...	3	1	⅜
Spheniscus demersus, ...	2¾	⅞	⅜
Spheniscus magellanicus, . . .	2¾	1⅛	½
Spheniscus mendiculus, ...	2¼	⅝	¼
Spheniscus minor, ...	1½	½	⅜
Pygosceles tæniatus, ...	3¾	1⅜	½
Aptenodytes longirostris, ...	5	1½	¾

The Humerus.

The humerus, like all the bones of the wing in the Penguins, is much flattened from side to side, and differs much in form from that of any other group of birds. The articular surface of the proximal end of the bone is crescentic in form, the horns of the crescent being directed towards the middle line of the body. This surface is separated from the rest of the bone by a horizontal groove which affords attachment to the capsular ligament of the shoulder joint. Immediately below this groove on the outer surface of the bone is a deep depression, into which as well as into the ridge in front of it is inserted the tendon of the pectoralis medius. On the inner side of the bone, below its articular surface and close to the anterior border, is another linear groove which affords insertion to the tendon of the pectoralis major. Below the posterior horn of the crescentic articular surface, but separated from it by a horizontal groove, is a well-marked eminence into which is inserted the tendon common to the subscapularis and supraspinatus. Immediately below this eminence is a deep circular excavation, which corresponds in position to that of the foramen which in the majority of birds permits the passage of air into the interior of the bone. In the Penguins, however, the bones of which are destitute of air-containing cells, this fossa is blind and merely affords attachment to the third head of origin of the triceps muscle. The "great tuberosity" of the bone is but ill defined, and is represented only by the slightly projecting upper extremity of the shaft. Into it are inserted the pectoralis major and the tensor patagii longus.

The posterior border of the humeral shaft affords attachment to the fourth head of origin of the triceps, while to the anterior margin are attached the tendons of the greater pectoral and tensor patagii muscles. The lower end of the anterior margin presents a shallow excavation, from which arises the brachialis internus muscle. The outer surface of the bone is smooth, while the inner surface, close to its lower end, presents two or three oblique grooves which accommodate the blood-vessels of the arterial *rete mirabile.*

The lower end of the humerus is very obliquely truncated from the anterior to the posterior border, and is provided with four distinct articular surfaces. Of these the two larger are quite continuous with one another, and are adapted to the upper extremities of the radius and ulna. The posterior border of the bone is prolonged inferiorly into a pointed angle, which is marked by two deep parallel grooves. Of these the external is the deeper, and in it glides the external or larger of the two sesamoid bones found in this region. The internal is the shallower of the two, and is adapted to receive the internal or smaller of the ulnar sesamoids. The internal and external surfaces of the lower end of the humerus are rough for the attachment of the powerful lateral ligaments of the elbow joint.

The humerus presents no distinctive features of any importance in any species of Penguin. Even in the different genera special characteristics are looked for in vain.

The table shows the dimensions of the bone in different species in inches.

Species.	Length of anterior border of humerus.	Length of posterior border of humerus.	Greatest breadth of humerus.
Eudyptes chrysocome, from Tristan,	$1\frac{7}{8}$	$2\frac{1}{2}$	$\frac{1}{2}$
Eudyptes chrysocome, from the Falklands,	$1\frac{7}{8}$	$2\frac{1}{2}$	$\frac{1}{2}$
Eudyptes chrysocome, from Kerguelen,	$1\frac{7}{8}$	$2\frac{3}{8}$	$\frac{1}{2}$
Eudyptes chrysolophus,	$2\frac{1}{4}$	$2\frac{7}{8}$	$\frac{5}{8}$
Spheniscus demersus,	$2\frac{1}{4}$	$2\frac{7}{8}$	$\frac{1}{2}$
Spheniscus magellanicus,	$2\frac{1}{4}$	$2\frac{7}{8}$	$\frac{5}{8}$
Spheniscus mendiculus,	$1\frac{3}{4}$	$2\frac{1}{4}$	$\frac{1}{2}$
Spheniscus minor,	$1\frac{3}{8}$	$1\frac{3}{4}$	$\frac{3}{8}$
Pygoscelis tæniatus,	$2\frac{7}{8}$	$3\frac{1}{2}$	1
Aptenodytes longirostris,	$3\frac{1}{2}$	$4\frac{1}{2}$	1

Sesamoid Bones.

In every species of Penguin two sesamoid bones are developed in connection with the tendons of insertion of the triceps muscle and lie behind the elbow joint.

Of these bones the *external* is the larger. It is circular in form, flattened from side to side, and articulates by means of its circumference with the external groove on the posterior inferior extremity of the humerus.

The *internal* ulnar sesamoid bone is pyramidal in form, and glides over the inner groove on the inferior extremity of the humerus. The opposed surfaces of the two sesamoids glide upon one another, and over each a portion of the tendon of the triceps muscle plays.

These bones present a singular resemblance in every species of Penguin, and differ only in size.

According to Owen,[1] a single sesamoid bone is developed in this region in the Puffin, in the Swifts, and in certain of the raptorial birds. In the Penguins alone are there two separate sesamoids.

The Ulna.

The ulna in the Penguins is of the same length as the radius. It is destitute of an olecranon process, and is much flattened from side to side. Its upper extremity is provided with a single articular surface, adapted to the posterior of the two larger

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[1] Cyclopædia of Anatomy, vol. 1., Art. "Aves," p. 286.

this point the anterior border of the bone is almost straight. The posterior border of the bone is slightly concave. Its inner surface is flat and uniformly smooth, while the outer surface presents two well-defined grooves. Of these one extends along the whole length of, and lies close to the anterior margin of the bone. It accommodates the tendon of the extensor metacarpi radialis muscle. The second groove passes from behind obliquely downwards and forwards, and is situated close to the lower end of the bone. It indicates the course of the extensor proprius indicis muscle. The lower extremity of the radius is provided with a surface of irregular form for articulation with the radial carpal bone. The radius articulates with the ulna by means of two small articular facets, one at the upper and the other at the lower end of the bone, in such a manner that it lies directly in front of and parallel with the ulna. The movement permissible between the two bones of the forearm is extremely limited, an arrangement which confers greater rigidity on the wing as a whole, and increases its power as a flexible paddle.

The radius presents precisely the same configuration in every species of Penguin. The table shows the dimensions of the radius of the various species examined, in inches.

Species.	Length of anterior border of radius.	Length of posterior border of radius.	Greatest breadth of radius.
Eudyptes chrysocome, from Tristan,	1½	1¾	½
Eudyptes chrysocome, from the Falklands,	1⅝	1¾	½
Eudyptes chrysocome, from Kerguelen,	1½	1¾	½
Eudyptes chrysolophus,	1⅞	2	½
Spheniscus demersus,	1¾	2	½
Spheniscus magellanicus,	1¾	1⅞	½
Spheniscus mendiculus,	1¼	1½	⅜
Spheniscus minor,	1	1¼	¼
Pygoscelis tæniatus,	2¼	2⅝	⅝
Aptenodytes longirostris,	2⅞	3½	¾

The Carpal Bones.

The carpal bones in the adult Penguin, as in other birds, are two in number. They differ, however, in form and mode of articulation from those of other birds, in accordance with the altered form of the wing and its adaptation as a paddle to the peculiar requirements of the Penguins.

The *radial carpal* bone is the smaller of the two, and consists of a small osseous cube, interposed between the lower end of the radius and the upper extremity of the metacarpus, with both of which bones it articulates. Both the articular surfaces of the bone are concave, that for the reception of the extremity of the radius being deeper than that which articulates with the metacarpus.

The *ulnar carpal* bone (Pl. VI. figs. 13, 14, 15) is of much larger size than the radial. It presents in *Eudyptes chrysocome* the form of an isosceles triangle, the apex of which is directed downwards. The upper and external angle of the figure is somewhat prolonged to form a projecting tubercle provided with two articular surfaces. The upper of these is concave and articulates with the distal end of the ulna, while the lower, irregular in form, articulates with the proximal extremity of the metacarpal bone. The internal surface of the bone is flat, the external slightly hollowed from above downwards. The anterior and posterior borders of the bone are of equal length, and slightly exceed that of the superior border, which is directed upwards.

The radial carpal bone presents the same form in every species of Penguin. The ulnar carpal is similar in form in *Eudyptes*, *Aptenodytes*, and *Spheniscus*. In *Pygosceles* the length of the bone relatively to its breadth is greater than in any of the other genera.

It is impossible to give measurements of the radial carpal bone. Those of the ulnar carpal are subjoined in inches.

Species.	Length of radial border of ulnar carpal bone.	Length of ulnar border of ulnar carpal bone.	Length of upper border of ulnar carpal bone.
Eudyptes chrysocome, from Tristan,	3/8	3/4	1/2
Eudyptes chrysocome, from the Falklands,	3/8	3/4	1/2
Eudyptes chrysocome, from Kerguelen,	3/8	5/8	1/2
Eudyptes chrysolophus,	1/2	3/4	3/8
Spheniscus demersus,	1/2	3/4	5/8
Spheniscus magellanicus,	3/8	3/4	5/8
Spheniscus mendiculus,	1/4	5/8	1/2
Spheniscus minor,	3/8	1/2	3/8
Pygosceles tæniatus,	3/4	1½	3/4
Aptenodytes longirostris,	1/2	7/8	3/4

The Metacarpus.

The metacarpus of the Penguins consists of a single bone, which, however, clearly shows its originally compound character even in the adult. The elements of which it is composed are three in number. The *first* or radial metacarpal bone is of small size and does not exceed half the length of the second, to the upper half of the radial border of which it is anchylosed. Its original separation as a distinct cartilage has been proved by the observations of Gervais and Alix[1] on the wing of *Eudyptes chrysocome*, and indications of its original independence are visible even in the adult, in the presence of an oblique groove, which is more pronounced on the outer than on the inner surface of the metacarpal mass. This groove extends from the upper end of the metacarpus obliquely downwards and forwards to the radial border of the bone which it meets about the middle of its length.

The *second* or middle metacarpal bone increases in breadth from its upper to its lower end. Its radial border is anchylosed to the whole length of the first metacarpal, while its ulnar border is immovably fused at its upper and lower extremities with those of the third metacarpal bone. The shafts of these bones are separated by an elongated fissure. The surfaces of the second metacarpal bone are flat and smooth. Its upper extremity is provided with a convex articular surface, which articulates with the two carpal bones as well as with the distal extremity of the ulna. The lower end possesses a slightly concave articular surface adapted to the upper extremity of the first radial phalanx.

The *third* metacarpal bone is slightly longer than the second, but is much more slender. It is nearly cylindrical in form, and is fused at its extremities with the second metacarpal. Its upper extremity articulates with the ulnar carpal bone, while its lower possesses an oblique facet for articulation with the first ulnar phalanx.

The metacarpus of different species varies only in size. Its dimensions are given below in inches.

Species.	Length of metacarpus.	Breadth of metacarpus.
Eudyptes chrysocome, from Tristan,	1½	½
Eudyptes chrysocome, from the Falklands,	1½	½
Eudyptes chrysocome, from Kerguelen,	1⅜	½
Eudyptes chrysolophus,	1⅛	⅝
Spheniscus demersus,	1⅝	½
Spheniscus magellanicus,	1⅜	½
Spheniscus mendiculus,	1¼	½
Spheniscus minor,	⅞	⅜
Pygoscelis tæniatus,	2	¾
Aptenodytes longirostris,	2½	¾

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[1] Ostéologie et Myologie des Manchots, pl. xvi. fig. 6.

The Phalanges.

The first or radial metacarpal is destitute of any phalanx, the second or middle metacarpal is provided with two phalanges, and the third or ulnar metacarpal with a single phalanx.

The *first phalanx* of the second finger is oblong in form, and is much compressed. Its inner surface is almost flat, while the outer is slightly convex. Its radial and ulnar borders are parallel. Its upper and lower extremities are each provided with a flat articular surface, one of which articulates with the lower extremity of the middle metacarpal bone, the other with the base of the second phalanx of the same finger.

This bone presents the same form in every species of Penguin. Its dimensions are given below in inches.

Species.	Length of first phalanx of middle metacarpal bone.	Breadth of first phalanx of middle metacarpal bone.
Eudyptes chrysocome, from Tristan,	1	⅜
Eudyptes chrysocome, from the Falklands,	1	⅜
Eudyptes chrysocome, from Kerguelen,	1	½
Eudyptes chrysolophus,	1⅛	⅜
Spheniscus demersus,	1⅛	⅜
Spheniscus magellanicus,	1⅛	⅜
Spheniscus mendiculus,	⅞	¼
Spheniscus minor,	⅝	¼
Pygoscelis tæniatus,	1¼	⅜
Aptenodytes longirostris,	1¼	½

The *second* phalanx of the second finger is triangular in form, and narrows gradually from its base to its distal extremity. On the radial border of the bone, close to its base, is a small osseous tubercle, which slightly overlaps the end of the first phalanx. The articular surface of the bone is oval, and articulates with the first phalanx. Its distal extremity is pointed. Like all the other bones of the wing it is much flattened from side to side. Its form is the same in every species of Penguin.

The table shows the dimensions in inches of this bone in different species of Penguin.

Species.	Length of second phalanx of second finger.	Breadth of base of second phalanx of second finger.
Eudyptes chrysocome, from Tristan,	3/4	1/4
Eudyptes chrysocome, from the Falklands,	3/4	1/4
Eudyptes chrysocome, from Kerguelen,	3/4	1/4
Eudyptes chrysolophus,	3/4	1/4
Spheniscus demersus,	5/8	1/4
Spheniscus magellanicus,	7/8	1/4
Spheniscus mendiculus,	5/8	3/16
Spheniscus minor,	1/2	1/8
Pygoscelis taeniatus,	1	1/4
Aptenodytes longirostris,	1 1/4	3/8

The single *phalanx of the third finger* is elongated and pointed, and diminishes in breadth from base to apex. It is slightly longer than the first phalanx of the middle finger, so that its extremity reaches beyond the articulation between the first and second phalanges of that finger. Its base is provided with a single articular surface for articulation with the third metacarpal bone, and a small osseous nodule projects upwards from the ulnar margin of the bone beyond that surface. The lateral surfaces of the bone are smooth and flat.

The dimensions of this bone in different species are given in inches in the table on the following page.

Comparative Remarks.

The skeleton of the Penguin's wing as a whole differs in several particulars from that of other birds. Perhaps its most characteristic feature is to be found in the great amount of compression exhibited by all the bones of the anterior extremity. This flattening of the bones has doubtless arisen in accordance with the altered function of the wing in these birds. In the majority of birds the principal function of the wing is to support the bird in, and to propel its body through the air. In the Penguins, on the other hand, the power of flight is lost, and the wing is converted into a paddle which serves the purpose of propelling the bird through the water. In accordance with this alteration of function, the bones of the wing are so modified in form that that organ may be carried forwards while its sharp anterior margin offers the minimum resistance to the sur-

Species.	Length of phalanx of third finger.	Breadth of base of phalanx of third finger.
Eudyptes chrysocome, from Tristan,	1⅛	⅝
Eudyptes chrysocome, from the Falklands,	1¼	⅜
Eudyptes chrysocome, from Kerguelen,	1	⅜
Eudyptes chrysolophus,	1⅜	⅜
Spheniscus demersus,	1⅜	½
Spheniscus magellanicus,	1¼	⅜
Spheniscus mendiculus,	1	⅜
Spheniscus minor,	¾	¼
Pygoscelis tæniatus,	1¾	⅜
Aptenodytes longirostris,	2	⅜

rounding fluid. In the backward or effective stroke, on the other hand, a broad surface is presented to the water, and instead of the wing being carried backwards, the body of the bird is propelled forwards. In accordance with the requirements of the animal, moreover, the movements permissible between the separate segments of the limbs are much more limited than in other birds—so much so that movements of pure flexion and extension in the joints beyond the shoulder can scarcely be said to be possible. These articulations, however, admit of a very considerable amount of *rotation*, and consequently instead of the limb being converted into an absolutely rigid paddle or oar, the rotation in question converts the wing into a screw-like blade, the curvatures of which are constantly varying in accordance with the amount of rotation which the forms of the different joints permit.

Upon carefully watching a living specimen of *Aptenodytes* which some time since formed a portion of the menagerie of the Zoological Society, I observed that the wing of the Penguin is never used in the manner of a rigid *oar*, which would imply the *simultaneous* movement of both wings in the same direction in order to propel the bird. On the contrary, the wings are often, and indeed I may say usually, brought into use *alternately*, much in the same manner as the pectoral fins of a fish, and in every movement of the wing, screw-like curvatures, which are due to the rotation of the different segments of the limb upon one another, are strongly developed. In fact, a constant screwing and unscrewing of the separate alar segments upon one another takes place simultaneously with the forward or backward movement of the organ as a whole.

A tendency to this flattening of the alar skeleton is met with in the Auks and Guillemots, but in these birds it is never developed to the same extent as in the Penguins.

Lastly, in the Penguins the first or radial metacarpal bone is inseparably anchylosed with the second, and this, combined with the absence of phalanges appertaining to the former, renders the wing of the Penguin destitute of the free "pollex" met with in the majority of birds.

THE POSTERIOR EXTREMITY.

The Pelvic Bones.

The pelvis as a whole (Pl. VII. figs. 7 and 8) is very narrow and much elongated. The pre-acetabular portion of the ilium is flattened from above downwards. Both its surfaces are smooth and almost flat. The anterior border of the iliac bone reaches as far forwards as the tubercle of the eighth vertebral rib. Its pre-acetabular portion narrows gradually from the anterior extremity backwards nearly to the acetabulum, immediately in front of which, however, it is slightly expanded. It articulates with the twelve lumbo-sacral vertebræ already described. The post-acetabular portion of the iliac bone is flattened from side to side. Its upper margin forms a thin sharp crest of bone, from which the biceps femoris arises. The lower border of the post-acetabular portion of the ilium is anchylosed with the ischium, and in part forms the upper boundary of the sciatic foramen. The latter is of large size and oval in form. The acetabulum presents in the macerated bone a wide perforation, which, as usual among birds, is filled up by fibrous membrane. The upper border of the acetabulum is provided with a very prominent "antitrochanter" for articulation with the great trochanter of the femur.

The ischium is broad and flat. Its posterior border presents a sharply-defined V-shaped notch, which forms the posterior border of the pelvic bone.

The pubis is almost straight, and does not converge posteriorly towards its fellow of the opposite side. It is a narrow but stout bone, which, except at its anterior extremity, is of equal thickness throughout. The obturator foramen corresponds to the entire length of the pubic bone, the latter, except where it enters into the formation of the acetabular cavity, not coalescing with the ischium at any point. The anterior portion of the obturator foramen is rounded, and transmits the tendon of the obturator internus muscle. The circumference of the posterior portion of the obturator foramen is formed exclusively by the fibrous membrane which attaches nearly the whole length of the pubic bone to the lower margin of the ischium. It ought, however, to be observed, that although the ischium and pubis are nowhere anchylosed, except in front, they come into very close relation with one another immediately behind the anterior dilated portion of the obturator foramen; but here, as elsewhere, the two bones are united only by fibrous membrane. In consequence of the divergence of the posterior extremities of the two pubic bones, the posterior outlet of the pelvis is very wide, and well adapted to the passage of the eggs, which in the Penguin, as in the majority of water birds, are of large size.

As already observed, the pelvic bone does not anchylose with the lumbo-sacral portion of the vertebral column in any species of Penguin. In them the pelvis is united to the backbone by suture even in the adult bird.

The pelvis presents essentially the same form in every species of Penguin. In *Aptenodytes* and *Pygosceles* it is somewhat longer in comparison with its breadth than in other species.

The following are the dimensions of the pelvic bone of different species in inches:—

Species.	Length of pelvic bone from anterior border of ilium to posterior inferior angle of ischium.	Length of ilium from anterior border to margin of acetabulum.	Greatest breadth of ilium.	Breadth of ischium and pubis together immediately behind acetabulum.
Eudyptes chrysocome, from Tristan,	4	2	½	⅞
Eudyptes chrysocome, from the Falklands,	4⅛	2	¾	⅞
Eudyptes chrysocome, from Kerguelen,	4	2	⅝	⅞
Eudyptes chrysolophus,	4¾	2½	¾	1
Spheniscus demersus,	4¾	2⅜	⅞	1
Spheniscus magellanicus,	4⅜	2⅛	⅞	1⅛
Spheniscus mendiculus,	3¾	1⅞	⅝	⅞
Spheniscus minor,	3¼	1⅝	⅝	⅞
Pygosceles tæniatus,	6	3¼	1	1¼
Aptenodytes longirostris,	7¼	3¾	1	1⅜

The Femur.

The femur in the Penguins differs but little from that of other birds.

The head of the bone is globular in form, its upper surface being somewhat flat. The depression for the attachment of the round ligament is of large size. The neck of the bone is short and stout. As in other birds, its upper surface, as well as that of the great trochanter, is covered with cartilage, to adapt it to the lower surface of the pelvic "antitrochanter." The great trochanter, continuous with the shaft of the bone, is bounded anteriorly and posteriorly by a prominent border. Of these the anterior is the more pronounced, and overhangs a shallow fossa which indicates the upward limit of the extensor cruris muscle. The posterior border of the trochanter is rough, and affords insertion to the obturator internus and gemelli muscles. The outer surface of this eminence is likewise rough, and marked by three depressions, into which are inserted from above downwards the gluteus medius, obturator externus, and gluteus minimus muscles. The shaft of the femur is nearly cylindrical, and presents the longitudinal curve usual in birds. A "linea aspera" can hardly be said to exist, the posterior surface of the shaft being almost smooth. On the anterior surface of the shaft an oblique ridge continuous with the anterior border of the trochanter is traceable as far as the middle in length of the bone. It affords origin to the extensor cruris.

The lower end of the bone is provided with two condyles, of which the internal is the broader. The groove on the outer side of the external condyle for articulation with the head of the fibula is well developed. The intercondyloid surface for the patella is much pronounced. On the posterior surface of the lower end of the femur is a deep recess, which affords insertion to the lower fibres of the adductor magnus, and origin to the outer and inner heads of the gastrocnemius muscle.

I have observed the following peculiarities in the femur of *Aptenodytes*, as compared with that of other species:—*First*, In *Aptenodytes* the femur is relatively stouter and more powerful than in other species. *Second*, In *Aptenodytes* the internal condyle of the femur does not project beyond that of the external to the same extent as in other species. Hence in *Aptenodytes* when the lower end of the femur is placed on a horizontal surface, the shaft of the bone is directed nearly vertically upwards, whereas in other species the shaft of the bone is directed obliquely upwards and outwards. *Third*, In *Aptenodytes* the summit of the trochanter projects above the level of the articular head of the bone to a greater extent than in other species, all of which agree with one another in this as well as in the other points indicated.

The table on the following page shows the length of the femur in different species in inches.

The Patella.

The patella (Pl. VII. figs. 9 and 10) is of exceptionally large size, and presents a somewhat peculiar form in the Penguins. In form it resembles a wedge, the anterior or sharp margin of which is directed forwards, the base backwards towards the femur. The base of the wedge is broad, deeply concave, and adapted to the pulley-like surface of the lower end of the femur. The outer surface of the bone is for the most part smooth, but presents about its middle a deep and narrow groove which, commencing in front at the middle of the anterior border of the bone, passes obliquely backwards, downwards, and outwards across the external surface. This groove accommodates the tendon of the "ambiens" muscle. The inner surface of the bone is smooth. The upper end of the patella is obliquely truncated, and affords insertion to the muscular fibres of the extensor cruris

Species.	Length of femur from summit of trochanter to lowest point of external condyle.	Transverse breadth of upper end of femur from head to trochanter.
Eudyptes chrysocome, from Tristan,	2½	⅜
Eudyptes chrysocome, from the Falklands,	2⅞	⅝
Eudyptes chrysocome, from Kerguelen,	2¾	⅝
Eudyptes chrysolophus,	2⅞	⅝
Spheniscus demersus,	2⅞	½
Spheniscus magellanicus,	3	⅝
Spheniscus mendiculus,	2⅜	½
Spheniscus minor,	2	⅜
Pygoscelis tæniatus,	3¾	¾
Aptenodytes longirostris,	3¾	⅞

muscle, while the lower end, narrower and more irregular in form, is attached by means of very short ligamentous fibres to the anterior border of the upper end of the tibia.

The patella presents essentially the same characters in every species.

The table shows the length of the posterior surface of the patella in the various species in inches.

Eudyptes chrysocome, from Tristan,	⅝
Eudyptes chrysocome, from the Falklands,	¾
Eudyptes chrysocome, from Kerguelen,	⅝
Eudyptes chrysolophus,	⅝
Spheniscus demersus,	⅞
Spheniscus magellanicus,	¾
Spheniscus mendiculus,	⅝
Spheniscus minor,	½
Pygoscelis tæniatus,	¾
Aptenodytes longirostris,	1

The Tibia.

The tibia of the Penguins differs but little from that of the majority of birds. Its upper end is provided with two articular surfaces, which are separated from one another by a slight antero-posterior eminence. Of the two surfaces the internal is much the larger, and articulates through the intervention of the internal semilunar cartilage with the internal condyle of the femur. The external is smaller and bears a similar relation to the external femoral condyle. On the outer side of the latter is situated a concave articular surface for the reception of the head of the fibula.

The two anterior tibial crests present the usual arrangement. The internal, the more extensive, is sharp and extends along the upper fourth of the bone, while the external, confined to the upper end of the tibia, terminates in a blunt tubercle. Both the tibial crests rise above the level of the articular surfaces of the upper end of the tibia, and are united together by a transverse osseous lamella, to the anterior border of which is attached the ligamentum patellae. Between this lamella and the articular surface of the upper end of the bone is a hollowed surface, which in the recent state affords attachment likewise to the patellar ligament.

The tibial crests, together with the upper portion of the shaft of the bone form the boundaries of a deep groove which affords attachment to the extensor longus digitorum muscle. The outer surface of the external anterior tibial crest is likewise deeply hollowed, and allows of the passage downwards of the femoral head of origin of the tibialis anticus muscle.

The shaft of the tibia is prismatic at its upper third, but lower down the angles disappear, and the shaft becomes more nearly cylindrical in form.

Close to the junction of the shaft with the lower end of the tibia is a well-marked osseous bar, which bridges over a groove on the anterior surface of the bone. Through the canal thus formed passes the tendon of the extensor communis digitorum muscle.

The lower extremity of the bone, as usual among birds, is expanded to form two condyles for articulation with the metatarsal bone. Of these the internal is more prominent than the external. The two condyles unite together posteriorly to form a shallow, grooved, pulley-like surface.

The tibia presents the same form in every species of Penguin. The measurements of the bone are given in inches in the table on the following page.

The Fibula.

The fibula of the Penguins agrees with that of the majority of water birds in being relatively longer than in other birds. In the Penguins as a rule it is about four-fifths of the length of the tibia, and tapers gradually from its upper to its lower end. The upper extremity of the bone, as usual among birds, is provided with two articular facets, of which one, on its inner surface, is deeply concave, and articulates with the external condyle of the tibia, while the other, situated on the upper end of the bone, is adapted to the groove on the lower surface of the external femoral condyle. The anterior surface of the upper end of the fibula presents a deep groove, which, passing obliquely downwards and backwards, disappears on the outer surface, half an inch below the upper extremity of the bone. This groove, when the bones of the leg are in position, is continuous with the oblique patellar groove, and lodges the tendon of the

Species.	Greatest length of tibia.	Antero-posterior diameter of upper end of tibia.	Transverse measurement of articular surface of lower end of tibia.
Eudyptes chrysocome, from Tristan,	4¼	⅝	½
Eudyptes chrysocome, from the Falklands,	4⅜	⅝	½
Eudyptes chrysocome, from Kerguelen,	4⅜	⅝	½
Eudyptes chrysolophus,	5	¾	½
Spheniscus demersus,	4½	¾	⅝
Spheniscus magellanicus,	4½	¾	½
Spheniscus mendiculus,	3⅝	⅝	⅜
Spheniscus minor,	3	½	⅜
Pygoscelis tæniatus,	5½	⅞	⅝
Aptenodytes longirostris,	6¾	1	⅞

"ambiens" muscle. Immediately below this groove, on the outer side of the bone, is a well-marked tubercle, to which the tendon of the biceps is attached.

The fibula is closely attached to the tibia by its head and by the upper and lower thirds of its shaft, but is separated from that bone opposite its middle third by an interval through which arterial branches pass from the back to the front of the limb.

In all the Penguins examined the fibula presents the same form, but differs somewhat in length relatively to the tibia in the various genera. In *Pygoscelis* and *Eudyptes* the lower end of the fibula reaches the base of the external condyle of the lower end of the tibia. In *Aptenodytes* it is rather shorter, while in *Spheniscus* the fibula is shorter than in any other genus, its lower end falling considerably short of the external condyle of the tibia (in *Spheniscus demersus* by half an inch).

The table shows the length of the fibula of different species in inches:—

Eudyptes chrysocome, from Tristan,	3¼
Eudyptes chrysocome, from the Falklands,	3⅜
Eudyptes chrysocome, from Kerguelen,	3⅜
Eudyptes chrysolophus,	3¾
Spheniscus demersus,	3¼
Spheniscus magellanicus,	3
Spheniscus mendiculus,	2⅛
Spheniscus minor,	2¼
Pygoscelis tæniatus,	4½
Aptenodytes longirostris,	5¼

The Tarsus.

The tarsal bones, as shown by Gervais and Alix[1] in their observations on the anatomy of the embryonic Penguin, present the same peculiarities as in birds in general—one becoming coalescent with the lower end of the tibia, the other with the upper extremity of the metatarsus.

The Metatarsus.

The metatarsus (Pl. VII. fig. 11) of the adult Penguin differs from that of other birds, inasmuch as it shows clearly its original composition through the union of four distinct metatarsal bones.

The first or innermost metatarsal is very small, and almost rudimental. It is not anchylosed with the others, but articulates by its base with the lower end of the shaft of the second metatarsal bone by means of a moveable joint.

The second, third, and fourth metatarsal bones are anchylosed together to form a single osseous mass, with which, moreover, the lower tarsal element as in other birds is inseparably united. The original composition of the mass by the union of three distinct metatarsal bones is clearly indicated on the anterior surface of the bone by the presence of two well-defined longitudinal grooves. These grooves are deeper at the upper than at the lower end of the bone, and the lower portion of the external is prolonged slightly beyond that of the internal groove. The upper end of each groove, at least in *Eudyptes chrysocome* from Tristan d'Acunha, is perforated by a foramen which appears on the posterior surface of the bone. Through these intermetatarsal foramina, minute blood-vessels pass from the front to the back of the limb. On the posterior surface of the metatarsus, the position of the intermetatarsal grooves is indicated only by these foramina. With regard to the dimensions of the three outer metatarsal bones, the second and fourth are nearly of equal length, the second slightly longer than the fourth, while the third is longer than either. The second metatarsal bone is more slender than either the third or fourth, both of which are of nearly equal thickness. The shaft of the third metatarsal bone is, moreover, provided with a small tubercle situated opposite the junction of the upper and middle thirds of its length for the insertion of the tendon of the tibialis anticus muscle. The lower extremities of the three larger metatarsal bones are quite distinct, being separated by notches which, even more distinctly than the intermetatarsal grooves themselves, indicate the original separation of the component elements of the compound metatarsus. The shafts of the third and fourth metatarsal bones are nearly parallel with one another from end to end, but the second metatarsal bone diverges considerably at the lower end from the third. In consequence of this arrangement, the metatarsus of *Eudyptes* is somewhat broader at its lower than at its upper end—a point in which the members of that genus differ somewhat from those of the others which I have examined. The lower extremities of the metatarsal

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[1] Ostéologie des Manchots, pl. xvi. fig. 8.

bones are provided with pulley-like articular surfaces adapted to the basal extremities of the first row of phalanges.

The upper end of the common metatarsal mass is provided with two articular facets. Of these the inner is oval, the outer quadrilateral in form. They articulate with the condyles of the tibia. The posterior border of the upper extremity of the bone behind these surfaces develops two well-marked calcaneal tubercles between which is a shallow groove in which the tendons of the flexor muscles of the toes are accommodated.

I have observed the following distinctive features in the metatarsus of different genera of Penguins.

In every species of *Eudyptes* the bone agrees with the description just given of that of *Eudyptes chrysocome* from Tristan d'Acunha. In all the members of this genus which I have examined, the proximal ends of the intermetatarsal grooves are perforated above, so that there are two foramina, one between the second and third, and the other between the third and fourth metatarsal bones, both of which appear on the posterior surface of the bone. In all of them there are two calcaneal tubercles, and in all of them the lower end of the second diverges from that of the third metatarsal bone.

In *Aptenodytes* (Pl. VII. fig. 14), as in *Eudyptes*, there are two intermetatarsal foramina, and two calcaneal tubercles, but the lower end of the second does not diverge from that of the third metatarsal bone to the same extent as in *Eudyptes*, these two bones being nearly parallel with one another from end to end. Consequently, in *Aptenodytes* the metatarsus is of nearly the same breadth at the upper and lower ends, whereas in *Eudyptes* the lower exceeds the upper end in breadth.

Pygosceles (Pl. VII. fig. 13) closely resembles *Aptenodytes* in the parallelism of the three metatarsal bones, but differs from that genus as well as from *Eudyptes*, inasmuch as the intermetatarsal grooves are much less pronounced, and the separate elements of the compound metatarsus are more completely anchylosed in it than in these genera. In *Pygosceles* there are two intermetatarsal foramina, and in *Pygosceles tæniatus*, as in every species examined, there are two calcaneal tubercles.

Spheniscus (Pl. VII. fig. 12), on the other hand, differs from all the other genera, inasmuch as in every species of that genus the separate metatarsal bones are less completely fused together. In the members of this the intermetatarsal grooves are much more forcibly pronounced than in those of any other genus, and form deep hollows, which nearly separate the component elements of the metatarsus from one another. In *Spheniscus*, moreover, the separate metatarsal bones are relatively considerably longer and more slender than in any other genus. They are also more nearly parallel with one another from end to end than in *Eudyptes*, but less so than in either *Pygosceles* or *Aptenodytes*. In every species of *Spheniscus* there are two calcaneal tubercles.

In *Spheniscus demersus*, *Spheniscus mendiculus*, and *Spheniscus minor* the external intermetatarsal foramen is alone pervious. In these species the internal foramen is clearly marked on the anterior surface of the bone, but ends blindly and does not appear on the posterior surface of the common metatarsal mass. In *Spheniscus magellanicus*, on the contrary, both foramina are pervious.

Professor Huxley[1] has established the new genus of *Palæeudyptes* for the reception of a Penguin of large size, a portion of the metatarsus of which was obtained from the pliocene strata of New Zealand. This decision was arrived at from the consideration of a number of points in which the metatarsus of the Penguin in question differs from that of the species composing the genera *Aptenodytes*, *Eudyptes*, and *Spheniscus*. From a careful perusal of Professor Huxley's paper, as well as from an examination of the metatarsal bones of recent Penguins, I am inclined, with diffidence however, to dissent from the opinion of that anatomist with regard to the characteristic features of the bird in question being of *generic* value, and to regard them rather as being characteristic of a *species* which might very well have been included along with others in one of the recent genera, probably *Eudyptes*, of existing Spheniscidæ.

The table shows the dimensions of the metatarsus in different species in inches.

Species.	Transverse breadth of upper end of metatarsus.	Transverse breadth of lower end of metatarsus.	Length of second metatarsal bone.	Length of third metatarsal bone.	Length of fourth metatarsal bone.
Eudyptes chrysocome, from Tristan, . .	$\frac{1}{2}$	$\frac{3}{4}$	$\frac{7}{8}$	$1\frac{1}{2}$	$\frac{7}{8}$
Eudyptes chrysocome, from the Falklands, .	$\frac{5}{8}$	$\frac{3}{4}$	1	$1\frac{1}{8}$	$\frac{7}{8}$
Eudyptes chrysocome, from Kerguelen, .	$\frac{1}{2}$	$\frac{5}{8}$	1	$1\frac{1}{8}$	$\frac{7}{8}$
Eudyptes chrysolophus, ...	$\frac{5}{8}$	$\frac{3}{4}$	1	$1\frac{1}{2}$	1
Spheniscus demersus, ...	$\frac{5}{8}$	$\frac{3}{4}$	$1\frac{1}{8}$	$1\frac{3}{8}$	$1\frac{1}{8}$
Spheniscus magellanicus, ...	$\frac{5}{8}$	$\frac{3}{4}$	$1\frac{1}{8}$	$1\frac{1}{2}$	1
Spheniscus mendiculus, ...	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{7}{8}$	1	$\frac{3}{4}$
Spheniscus minor, ...	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{7}{8}$	$\frac{7}{8}$	$\frac{3}{4}$
Pygoscelis tæniatus, ...	$\frac{3}{4}$	1	$1\frac{1}{8}$	$1\frac{1}{2}$	$1\frac{1}{4}$
Aptenodytes longirostris, ...	1	$1\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{3}{4}$	$1\frac{5}{8}$
Palæeudyptes antarcticus, ...	$1\frac{1}{4}$	?	?	$2\frac{1}{4}$	$1\frac{7}{8}$

The Phalanges.

The toes, as in birds in general, are four in number. The first or rudimental toe consists of two, the second of three, the third of four, and the fourth of five

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[1] Quart. Journ. Geol. Soc., vol. xv. p. 670.

phalanges. The third toe is the longest, the fourth is longer than the second, and the first resembles that of the majority of swimming birds in being rudimental. The first phalanx of the first toe is extremely short, but exceeds in length that of its metatarsal bone. In the other toes, the first or basal phalanx and the penultimate phalanx are of equal length. The other phalanges are somewhat shorter. The phalanges diminish in thickness from base to apex of the toe. The basal or proximal end of each presents a double cup-shaped cavity for articulation with the distal extremity of a metatarsal bone or neighbouring phalanx as the case may be. Their distal extremities, on the other hand, present two condyloid eminences separated by a vertical groove. The lower surfaces of the phalanges are flattened, while their dorsal surfaces are almost cylindrical. The terminal phalanx of each toe is laterally compressed and adapted to the basal concavity of the nail.

The following are the measurements of the toes of different species in inches:—

Species.	Length of second toe.	Length of third toe.	Length of fourth toe.
Eudyptes chrysocome, from Tristan,	1¾	2¼	2⅛
Eudyptes chrysocome, from the Falklands,	2	2½	2¼
Eudyptes chrysocome, from Kerguelen,	2	2½	2¼
Eudyptes chrysolophus,	2	2½	2¼
Spheniscus demersus,	1¾	2¾	2½
Spheniscus magellanicus,	1¾	2½	2⅛
Spheniscus mendiculus,	1½	2¼	2
Spheniscus minor,	1¼	1¾	1⅛
Pygoscelis tæniatus,	2	3	2¾
Aptenodytes longirostris,	2½	3¼	3

COMPARATIVE REMARKS.

The bones of the leg in the Penguins differ as a whole but little from those of the birds which most closely resemble them, except in the form of the patella, and in that of the tarso-metatarsus. In respect of form and size the patella resembles to some extent that of the Grebes and Divers, but differs with regard to the great development of the groove for the reception of the tendon of the "ambiens" muscle. It is in the form of the metatarsus that we find the most characteristic feature in the osteology of the limb of the Penguins. The strongly-pronounced separation, even in the adult, of the three greater metatarsal bones is, so far as I am aware, quite peculiar to the group of Spheniscidæ.

According to Gervais and Alix,[1] the component elements of the tarso-metatarsal bone are recognisable as distinct and separate entities, even to the end of fœtal life in the Penguins. These bones therefore unite with one another at a relatively later date in the Spheniscidæ than in the majority of birds. Indications of the original composition of the metatarsal portion of this bone by the union of three elements are distinct enough in the majority of birds by reason of the independence of their lower extremities, but in none, so far as I know, are the *shafts* of the metatarsal bones separated by the well-defined grooves met with in the Penguins. In none, moreover, with perhaps one exception, is the tarso-metatarsus at once so broad and so short as in the Penguins. As shown by Brandt,[2] the tarso-metatarsus of the Frigate Bird resembles that of the Penguins in its shortness, but differs in being relatively narrower, as also in the fact that while in the Penguins the grooves between the second and third, and third and fourth metatarsal bones are well defined, only one, and that the groove between the third and fourth metatarsals, is clearly pronounced in the genus *Fregata*.

II.—ARTHROLOGY.

The ligaments which connect the various bones of the trunk in the Penguins do not differ from those of other birds.

The modifications in form of the bones of the wing, however, and the slight amount of motion permissible between the different segments of that organ in the Penguins, are accompanied by certain modifications in the form and mode of attachment of the ligaments connecting the separate bones which it may be as well to refer to shortly.

LIGAMENTS OF THE WING.

The shoulder joint is surrounded by a capsular ligament similar to that of other birds.

Connected with the elbow joint there are two strong internal, and a single external lateral ligament. The former are attached above to the inner side of the distal end of the humerus, and below to the proximal ends of the radius and ulna. The external lateral ligament is attached above to the humerus, and below to the upper end of the radius. In addition to these ligaments, the various muscles of the forearm arising from the humerus, which in the Penguins are reduced to tendinous bands, serve in these birds to strengthen this articulation. The capsule of the joint is completed posteriorly by the strong ligaments which attach the sesamoid bones to the upper end of the ulna.

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[1] Ostéologie et Myologie des Manchots, p. 9.

[2] Beiträge zur Kenntniss der Naturgeschichte der Vögel, in Mémoires de l'Académie des Sciences, St. Petersburg, 6th series, 1840, p. 150.

The upper ends of the radius and ulna are connected together by means of a strong dorsal as also by a weak palmar ligament, both of which pass transversely between these bones.

The wrist joint is provided with two internal and a single external lateral ligament. The internal ligaments are attached above to the distal ends of the radius and ulna respectively, and below to the inner side of the proximal end of the great metacarpal bone. The external ligament extends from the distal end of the radius above to the proximal extremity of the metacarpal bone below.

The ulnar carpal bone is attached to the distal ends of both the radius and ulna by means of a single stout ligamentous band, and by a broad aponeurotic slip to the whole length of the third metacarpal bone.

The metacarpo-phalangeal articulation is provided with two external and two internal lateral ligaments, which pass from the distal ends of the metacarpal bones to the inner and outer surfaces of the first phalanges of the second and third fingers respectively.

The first and second phalanges of the second finger are connected together by strong internal and external lateral ligaments. The first phalanx of the second is moreover attached to the whole length of that of the third finger by a stout interosseous membrane.

Ligaments of the Leg.

The ligaments connecting the bones of the leg in the Penguin differ less from those of other birds than do those of the wing.

The hip joint is provided with capsular and round ligaments which resemble those of other birds.

In relation to the knee joint there are two very powerful lateral ligaments—an external and an internal. The former passes between the outer condyle of the femur and the head of the fibula, while the latter is attached above to the inner condyle of the femur and below to the inner side of the shaft of the tibia, a short distance below the upper end of that bone. In addition to these, there is an extremely short anterior ligament or ligamentum patellæ which attaches the patella to the anterior border of the upper end of the tibia.

On opening the knee joint the interval between the heads of the tibia and fibula is seen to be occupied by a wedge-shaped mass of cartilage, the broad end of which is directed upwards. This cartilaginous plate is firmly fixed to the head of the fibula, but glides freely on the lateral surface of the head of the tibia, so that a limited amount of rotation is permissible between the heads of these two bones. This piece of cartilage is moreover continuous with the anterior horn of a well-developed semilunar cartilage which intervenes between the inner condyle of the femur and the head of the tibia.

The crucial ligaments of the knee joint are two in number. The anterior is attached below to the anterior horn of the single semilunar cartilage, and above to the intercondyloid depression of the lower end of the femur. The posterior crucial ligament is continuous below with the posterior horn of the semilunar cartilage, and above, it, like the anterior crucial ligament, is inserted into the intercondyloid femoral notch.

The ankle joint is surrounded by a strong capsular ligament, which is attached to the contiguous extremities of the bones which enter into its formation. Posteriorly and laterally this capsule is strengthened by special ligaments. Posteriorly a stout quadrilateral plate of fibro-cartilage is attached below to the posterior border of the upper extremity of the tarso-metarsal bone, while above it presents a free border. This plate is perforated for the transmission of the tendons of the long flexor muscles of the toes. The capsule of the joint is farther strengthened by lateral ligaments, which, however, are not so well defined as are the corresponding structures of the knee joint.

In the interior of the ankle joint there is a single semilunar cartilage which intervenes between the upper extremity of the outer metatarsal bone and the external of the two lower tibial condyles. This cartilage moves freely on both bones, and is continuous in front with the anterior crucial ligament, and behind with the fibro-cartilaginous plate which completes the joint posteriorly.

The crucial ligaments are two in number. Both are attached above to the intercondyloid notch on the lower end of the tibia. The anterior or external is inserted below into the base of the outer metatarsal bone, while the posterior or internal is inserted into the anterior border of the upper end of the tarso-metatarsal bone. Both of these ligaments are drawn tense when the foot is extended upon the tibia.

The metatarso-phalangeal joints are each provided with a capsular ligament, which is strengthened laterally and superiorly by special ligamentous bands. The plantar surface of each is defended by a plate of fibro-cartilage, over which glide the tendons of the long flexor muscles of the toes.

The interphalangeal articulations are similarly arranged, except that superior ligamentous bands are absent.

The metatarsal bone of the hallux is attached to that of the second toe by a few ligamentous fibres. The separate elements of the hallux are connected together by delicate capsular ligaments.

III.—MYOLOGY.

(Plates VIII., IX., X.)

The muscular anatomy of one or other species of the Spheniscidæ has been previously described, either in whole or in part, by Schoepss, Reid, Gervais and Alix, and isolated references to the myology of the group occur in the standard works of such writers upon avian anatomy, as Tiedemann, Cuvier, Meckel, Garrod, and others. Among these various contributions to the subject, that of Schoepss, published in 1829, is remarkable for accuracy of description of the muscles of the wing of *Aptenodytes demersus*, as well as for the excellent figures which illustrate the essay. This essay being exclusively devoted to the consideration of the arrangement and modifications of the muscles of the wing, left much to be done by subsequent workers in the same field before a complete account of the myology of the Penguins could be available to the comparative anatomist intent on working out the affinities of the group, so far as a consideration of muscular modifications might enable him to do so.

In 1835, Reid to some extent supplemented this deficiency by publishing the results of an investigation into the anatomy of a specimen of *Aptenodytes patachonica*, Forst. Reid's description of these muscles is however so defective, and indeed in many points so vague and unsatisfactory, that our knowledge of the anatomy of the group cannot be said to have been materially advanced by his well-meant effort. The identification of the muscles described by him is often impossible owing to the poverty of description, and any attempt to synonymize his designations with those of other authors, is, for the most part, productive only of failure.

In 1877, MM. Gervais and Alix published an instructive and excellent monograph on the osteology and myology of the Spheniscidæ, based upon an examination of the anatomy of *Eudyptes chrysolophus*. This monograph is frequently referred to in the following pages; and although in some parts, more especially in the account of the muscles of the vertebral column, the brevity of description leads to difficulty in the identification of the muscles referred to, yet, as a whole, the essay may be said to contain an accurate and able summary of the principal myological peculiarities of the single species to which it refers.

The collection of Penguins placed in my hands by Sir Wyville Thomson has afforded an opportunity of again examining the muscular anatomy, not only of the species described by the above-mentioned authors, but also of several others.

In drawing up my description, I have omitted no opportunity of directing attention to the observations of previous writers, and of comparing them with those made by myself. By so doing I trust I shall be able to render this monograph more complete than would otherwise be the case, being fortunately in a position not only to check the observations of previous anatomists, but to extend them by the examination of several species which have not hitherto been systematically dissected.

As it happens, the description of the myology of one species may be said (taking into account minor differences) to be that of all. I might therefore, to some extent, have curtailed my essay by adopting the description of MM. Gervais and Alix of the myology of *Eudyptes chrysolophus* as a standard with which to compare that of other species. On the other hand, the difficulty which I have experienced in the identification of several of the muscles described by these authors, and the fact that at the time their monograph appeared I had almost completed my myological observations on all the species in my hands, justify me in adhering to my original plan.

I have therefore chosen as my type *Eudyptes chrysocome* from Tristan d'Acunha, a full account of the muscular anatomy of which appears in the following pages. The designation of each muscle is accompanied by a list of synonyms employed by the various standard writers on avian anatomy. After the description of each muscle, I have added only such "relations" as appear to me to be necessary to enable future workers to identify without difficulty the muscle to which they refer. Under the heading "variations" are given the results of a comparison of the muscle in question of *Eudyptes chrysocome* with that of other species which I have examined. In the case of those muscles in which no "variations" are recorded, the reader will understand that the muscle presented a similar arrangement in every species. Lastly, the "remarks" contain a summary of the observations of other authors who have previously examined one or other species of Penguin.

The subjoined list contains the names and papers of the authors by whom the synonyms appended to each muscle have been employed :—

1. Cuvier, Leçons d'Anatomie Comparée, 1800.
2. Garrod, On certain muscles of the thigh of birds and their value in classification. *Proc. Zool. Soc. Lond.*, 1873, p. 626.
3. Gervais and Alix, Ostéologie et Myologie des Manchots. *Journal de Zoologie*, tom vi., 1877.
4. Herissant, Observations anatomiques sur les mouvements du bec des oiseaux. *Mémoires de l'Academie des Sciences, Paris*, 1748, p. 345.
5. Heusinger, Zootomische Analekten, Ueber einige Besonderheiten des Eulenflügels. *Meckel's Deutsches Archiv für die Physiologie*, vol. vii., 1822.
6. Meckel, J. F., Traité général d'Anatomie Comparée. *Traduit par Reister et Sanson, Paris*, 1828.
7. Merrem, Blasius, Flügelmuskeln des weissköpfigen Adlers. *Vermischte Abhandlungen aus der Thiergeschichte*, 1781.
8. Owen, On the Apteryx Australis. *Proc. Zool. Soc. Lond.*, 1842, p. 22.
9. Reid, Anatomical description of the Patagonian Penguin (*Aptenodytes patachonica*, Forst). *Proc. Zool. Soc. Lond.*, 1835, part 3, p. 132.
10. Rolleston, On the homologies of certain muscles connected with the shoulder joint. *Trans. Linn. Soc.*, vol. xxvi. p. 609.
11. Selenka, Bronn's Classen und Ordnungen des Thierreichs, Bd. vi., "Aves."
12. Schoepss, Beschreibung der Flügelmuskeln der Vögel. *Meckel's Archiv für Anatomie und Physiologie*, 1829.
13. Tiedemann, Anatomie und Naturgeschichte der Vögel. Zoologie, Bd. ii.
14. Vicq d'Azyr, Mémoires pour servir à l'anatomie des Oiseaux. *Histoire de l'Academie royale des Sciences, Paris*, 1772-73-74.
15. Wiedemann, Von den Muskeln des Schwans. *Archiv für Zoologie und Zootomie*, Bd. ii., Stück 2.

MUSCLES OF THE TRUNK.[1]

(a) Cutaneous Muscles.

1. *Dorsal cutaneous muscle.*

Dermo-spinalis, Owen, p. 24.
Panniculus carnosus (second portion) Reid, p. 139.
Tenseur de la membrane axillaire, Gervais and Alix, p. 38.

Attachments.—This muscle is quadrilateral in form. It *arises* from the posterior half of the spinous process of the fourth, from the spinous process of the fifth, and from that of the sixth dorsal vertebra. The fibres pass transversely outwards, and are *inserted* into the subcutaneous fascia of the lateral line of the trunk.

Action.—It pulls the integument of the flank towards the spine.

Relations.—The muscle is subcutaneous, and rests upon the trapezius and latissimus dorsi.

Nerve supply.—Several branches from the posterior divisions of the dorsal spinal nerves.

Variations.—In *Aptenodytes longirostris* the muscle is better developed than in any other species. In it the anterior fibres end in a delicate aponeurosis, which covers the shoulder joint, while the posterior fibres terminate in the subcutaneous fascia covering the knee.

In *Spheniscus magellanicus*, as well as in *Spheniscus minor*, the muscle is relatively smaller than in *Eudyptes chrysocome*, and arises only from *two* dorsal spines.

In both specimens of *Pygosceles tæniatus* which I dissected, this muscle was entirely wanting.

Remarks.—As observed by Gervais and Alix, the costal fasciculus of this muscle, which is present in the majority of birds, is entirely absent in every species of Penguin. According to these authors, in *Eudyptes chrysolophus* the muscle presents the arrangement above described in *Aptenodytes*. In the specimens of *Eudyptes chrysolophus* examined by myself, the muscle was scarcely so well developed as in *Aptenodytes*, and presented the arrangement described above in *Eudyptes chrysocome*.

2. *Constrictor colli.*

Der Hautmuskel des Halses, Tiedemann, vol. i. p. 133.
Panniculus carnosus (part of), Reid, p. 139.
Constrictor colli, Owen, p. 22.
Peaucier du cou (plan superficiel) Gervais and Alix, p. 39.

Attachments.—This, the more superficial of the two cutaneous muscles of the neck, consists of a number of circularly arranged muscular fibres which lie immediately underneath

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[1] In describing the muscles it will be understood that I imagine the trunk of the bird to be horizontal, with the vertebral column directed upwards.

the integument. They extend from the occiput and the posterior extremity of the lower jaw bone, as far backwards as the junction of the posterior and middle thirds of the neck, where they cease to be distinguishable as a separate muscle. Along the middle line of the neck, inferiorly, this muscle is easily separable from the subjacent panniculus, but above, *i.e.*, along the dorsal middle line of the neck, there is no natural separation between this muscle and the panniculus, the fibres of the two muscles blending with one another.

Action.—The muscle wrinkles the skin of the neck, and elevates the feathers of that region.

Relations.—The constrictor colli separates the skin from the subjacent panniculus carnosus.

Nerve supply.—Branches from various cervical spinal nerves.

3. *Panniculus carnosus.*

Sterno-cervicalis, Owen, p. 23.
Panniculus carnosus (first portion), Reid, p. 133.
Peaucier du cou (plan profond), Gervais and Alix, p. 39.

Attachments.—The panniculus is the great cutaneous muscle of the neck. It *arises* from the whole of the anterior border of the clavicle below the articulation of that bone with the coracoid. From this origin the fibres diverge, the anterior fibres passing obliquely forwards and upwards, the posterior backwards and upwards, while the intermediate fibres pass with varying obliquities towards the dorsal middle line of the neck. The anterior fibres pass forwards to the occipital bone, into which, as well as into the post-orbital process of the frontal bone, they are *inserted.* By far the larger number of fibres reach the dorsal middle line of the neck, where they blend with the corresponding fibres of the opposite side, while the posterior fibres, passing obliquely backwards and upwards, blend in a similar manner as far back as the fourth dorsal vertebra. In this way the two muscles of opposite sides form as it were a hood, which covers the cervical as well as the anterior portion of the dorsal region. The lower borders of the two muscles are in contact in front of the clavicle, but as they pass forwards to their insertion into the skull, they diverge so as to leave an angular interval, in which, after removal of the constrictor colli, the trachea and larynx with their muscles are exposed.

Action.—This muscle wrinkles the skin of the neck, and ruffles the feathers of that region.

Relations.—The anterior fibres of this muscle are concealed by the constrictor colli, but the greater portion of the muscle lies immediately underneath the skin. The posterior border of the muscle is free, and extends between the shoulder joints of opposite sides. Its origin is concealed by the anterior fibres of the pectoralis major.

Nerve supply.—Branches from the cervical spinal nerves.

Remarks.—The cutaneous muscular system of the Penguin includes the constrictor colli, the panniculus carnosus, the dorsal cutaneous muscle, and the "muscle des parures." This system is developed to a greater extent in the Penguins than in any other bird, with the exception of the Apteryx, and is probably related to their aquatic habits, and to the necessity of an arrangement whereby the water may be readily expelled from the interstices of their fur-like plumage.

4. *Subcutaneous abdominalis.*

Subcutaneus abdominalis, Wiedemann.
Der Bauchhautmuskel, Tiedemann, vol. i. p. 134.

Attachments.—This muscle, which in reality forms a portion of the "muscle des parures," *arises* from the free cartilaginous extremity of the pubic bone, and passes obliquely forwards and downwards to the posterior border of the sternum. Here a few of the lower fibres terminate in the subcutaneous fascia covering the border of the sternum, but by far the largest portion of the muscle is directly continuous with the "muscle des parures," of which, indeed, it may be considered as constituting the pubic origin.

Action.—The action of this muscle is doubtful.

Relations.—This muscle separates the abdominal origin of the semi-membranosus from the superficial surface of the obliquus externus abdominis.

Nerve supply.—Branches from the last intercostal nerve.

Remarks.—This muscle is present in every species of Penguin which I have examined. It appears to be simply a backward prolongation of the "muscle des parures." At the same time the distinct insertion of the lower fibres into the subcutaneous fascia of the abdomen, and the fact that it is supplied by nerves from a totally different source, sufficiently justify its description as a muscle distinct from, although actually connected with, the "muscle des parures." Strange to say, this muscle seems to have escaped the notice of Gervais and Alix when drawing up their extremely accurate account of the myology of *Eudyptes chrysolophus*.

(*b*) Muscles of the Vertebral Column.

1. *Sacro-lumbalis.*

Costo-cervical, Vicq d'Azyr, 1774, p. 580, No. 2.
Der äussere Rückgrats-Strecker, Tiedemann, p. 289, No. 6.
Der Rückenmuskel, Merrem.

Muscle No. 1. (ventre externe), Meckel, vol. vi. p. 4, No. 1.
Sacro-lumbalis, Owen, p. 25.
Sacro-lumbalis, Selenka, vol. vi. p. 93, No. 1.
Sacro-lombaire, Gervais and Alix, p. 13.

Attachments.—This muscle consists of a flattened band, which measures one inch in breadth at its origin. It *arises* from the anterior as well as from the outer margin of the iliac bone, and passing forwards is attached to each of the vertebral ribs external to their tubercles. The muscle terminates by being *inserted* into the transverse process of the first dorsal vertebra.

Action.—This muscle extends the cervical upon the dorsal portion of the vertebral column.

Relations.—It rests upon the ribs, and lies to the outer side of the longissimus dorsi.

Nerve supply.—Branches from the posterior divisions of the dorsal nerves.

Remarks.—Meckel directs attention to the large size of this muscle in the Penguins, and associates it with the erect position habitual to these birds when on land. Gervais and Alix describe the muscle as consisting of three distinct portions in *Eudyptes chrysolophus*. These I failed to recognise.

2. *Longissimus dorsi.*

Costo-cervical (part of), Vicq d'Azyr, 1774, p. 380, No. 2.
Der innere Rückgrats-Strecker, Tiedemann, p. 289, No. 6.
Muscle No. 1 (ventre interne), Meckel, vol. vi. p. 4.
Longissimus dorsi, Owen, p. 26.
Longissimus dorsi, Selenka, vol. vi. p. 94, No. 2.
Long du dos, Gervais and Alix, p. 13.

Attachments.—The longissimus dorsi occupies the groove between the spinous and transverse processes of the dorsal vertebræ. It consists of a number of short fibres, which *arise* from the anterior margin of the ilium, and from the spinous and transverse processes of the dorsal vertebræ. The fibres pass forwards, and are *inserted* into the neural arches of all the dorsal vertebræ. At the root of the neck they are to some extent continuous with the fibres of the extensor colli magnus.

Action.—This muscle extends the cervical upon the dorsal portion of the vertebral column.

Relations.—The longissimus dorsi fills up the dorsal vertebral groove. It is concealed superficially by the biventer cervicis which rests upon it.

Nerve supply.—Numerous branches from the posterior divisions of the dorsal nerves.

3. *Extensor magnus colli.*

Long extenseur du cou, Vicq d'Azyr, 1773, p. 580, No. 1.
Der grosse Halsstrecker, Tiedemann, p. 287, No. 2.
Vielarmiger Halsmuskel, Merrem.
Grosser Halsstrecker, Wiedemann, p. 76.
Cervical ascendant, Meckel, vol. vi. p. 5, No. 1.
Longus colli posticus (part of), Owen, p. 27.
Longus colli posticus, Selenka, vol. vi. p. 95, No. 4.
Long postérieur du cou (part of), Gervais and Alix, p. 14.

Attachments.—This muscle *arises* by means of a stout flattened tendon from the spinous processes of the last cervical and first three dorsal vertebræ. The muscular fibres pass obliquely forwards and outwards, and are *inserted* by means of separate slips into the tubercles surmounting the posterior articular processes (hyperapophyses of Mivart[1]) of the fourth to the eleventh cervical vertebræ inclusive.

Action.—This muscle is the most powerful of the numerous extensor muscles of the neck.

Relations.—At its origin the extensor magnus is united with the muscle of the opposite side. As it passes forwards it is separated from its fellow by the two lesser extensors of the neck. To its outer side is the cervicalis ascendens.

Nerve supply.—Branches from the posterior divisions of the lower cervical nerves.

Variations.—In *Aptenodytes longirostris* the insertion of this muscle extends from the fifth to the twelfth cervical vertebræ, in *Spheniscus magellanicus* from the sixth to the ninth, and in *Eudyptes chrysolophus* and *Spheniscus demersus* from the third to the ninth cervical vertebræ inclusive.

4. *Splenius colli.*

Der Strecker des Trägers, Wiedemann, p. 76.
Der Strecker des Trägers, Tiedemann, p. 286, No. 1.
Splenius du cou, Meckel, vol. vi. p. 7, No. 3.
Long postérieur du cou (part of), Gervais and Alix, p. 14.

Attachments.—The splenius colli *arises* by means of a number of separate muscular slips from the spinous processes of the third, fourth, and fifth cervical vertebræ, as well as from the arches of the sixth to the ninth cervical vertebræ inclusive. (The latter do not possess spinous processes). The muscular fibres converge as they pass forwards, and are *inserted* into the posterior articular process (hyperapophysis) of the second cervical vertebra.

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[1] Trans. Zool. Soc., vol. viii., pt. 7, 1874.

Action.—This muscle extends the neck, and rotates the vertebræ upon one another, so as to direct the head towards the side on which the muscle acts.

Relations.—The splenius colli at its origin is in contact with its fellow of the opposite side. Its outer side is in contact with the insertion of the extensor magnus colli. A few of the fibres at its insertion are continuous with those of the rectus capitus lateralis.

Nerve supply.—Branches from the posterior divisions of the cervical nerves.

Variations.—In *Spheniscus minor* the origin of this muscle is limited to the arches of the sixth, seventh, eighth, and ninth cervical vertebræ. In *Spheniscus magellanicus* it arises from the fourth to the ninth cervical vertebræ inclusive. In *Spheniscus demersus* the splenius colli arises from the second to the ninth cervical vertebræ inclusive, and is inserted into the hyperapophyses of the second and third cervical vertebræ. In *Spheniscus mendiculus* and *Eudyptes chrysolophus* it is likewise inserted into the second and third cervical vertebræ.

5. *Extensor colli tertius.*

The muscle which I have thus named is present in nearly every species of Penguin, and consists of a delicate slip which lies between and separates the splenius colli and the extensor longus colli. It *arises* from the arches of the seventh and eighth cervical vertebræ, and passing obliquely forwards and outwards, is *inserted* into the posterior articular process of the fifth cervical vertebra.

Action.—It extends the neck.

Variations.—This muscle is absent in *Spheniscus mendiculus* and in *Aptenodytes longirostris.*

6. *Extensor parvus colli.*

Der kleine Halsstrecker, Wiedemann, p. 77.
Der kleine Halsstrecker, Tiedemann, p. 287, No. 3.
Obliquus colli, Owen, p. 26.

Attachments.—This muscle is divisible into two parts, an upper and lower. The *lower* portion arises by means of a number of separate slips from the transverse processes of the five posterior cervical vertebræ. The fibres pass forwards, and are *inserted* into the posterior articular processes of the fifth to the ninth cervical vertebræ inclusive.

The *upper* portion *arises* from the transverse processes of the sixth to the ninth cervical vertebræ inclusive, by means of distinct muscular slips. These slips unite to form a single muscular belly, which is *inserted* into the posterior articular process of the third cervical vertebra.

Action.—This muscle extends the neck, and directs it towards the side on which the muscle acts.

Relations.—The origin of the lower portion of this muscle lies to the outer side, and in contact with the slips of insertion of the extensor magnus colli. That of the upper portion lies to the outer side, and in contact with the outer border of the lower portion of the muscle. The insertion of the former lies between the origins of the splenius capitis and complexus muscles.

Nerve supply.—Branches from the posterior divisions of the cervical nerves.

Variations.—In several specimens of different species the upper portion of the muscle is inserted into the articular processes of the second and fourth cervical vertebræ.

In *Spheniscus minor* and *Spheniscus demersus* there is no trace of the separation above described of the muscle into two distinct portions, the two parts being quite continuous with one another.

7. *Interspinales.*

Inter-épineux, Meckel, vol. vi. p. 8, No. 6.
Die Zwischendornmuskeln, Tiedemann, p. 292, No. 12.
Interspinales, Owen, p. 28.
Interspinales, Selenka, vol. vi. p. 97, No. 9.

Attachments.—The interspinous muscles are confined to the neck and tail. In the neck they consist of a number of small fleshy slips, which pass between the arches and spinous processes of the anterior five or six cervical vertebræ.

Action.—These muscles extend the anterior cervical vertebræ upon one another.

Relations.—They are concealed by the larger extensor muscles, and rest upon the cervical vertebræ.

Nerve supply.—Branches from the posterior divisions of the cervical spinal nerves.

Remarks.—The rectus capitis posticus minor forms, morphologically, one member of this series.

8. *Intertransverse muscles.*

Die Zwischenquermuskeln, Wiedemann, p. 78.
Die vordern und hintern Zwischenquermuskeln, Tiedemann, p. 291, Nos. 10 and 11.
Intertransversaires, Cuvier, vol. i. p. 190.
Intertransversaire du cou, Meckel, vol. vi. p. 7, Nos. 4 and 5.
Obliquus colli, Owen, p. 26.
Transversus colli, Selenka, vol. vi. p. 94, No. 3.
Intertransversaires, Gervais and Alix, p. 14.

Attachments.—The intertransverse muscles consist of a mass of muscular fibres which occupy the intervals between the transverse processes of the different cervical vertebræ. These fibres cannot without artificial dissection be separated into distinct bundles. At the root of the neck the fibres of the intertransverse muscles are to some extent continuous with those of the longissimus dorsi and longus colli externus. Their fibres extend from the anterior dorsal vertebra behind, to the basi-occipital bone in front. As they pass forwards they are *inserted* into the transverse processes of the cervical vertebræ between the origin of the extensor parvus colli above, and the bony spines which afford insertion to the tendons of the longus colli below. The anterior fibres of these muscles are inserted by means of a special tendon into the hollowed surface of the basi-occipital bone, close to the inner side of the tendon of insertion of the rectus capitus lateralis.

Action.—The intertransverse muscles bend the neck towards the side on which they act.

Relations.—These muscles fill up the intervals between the cervical transverse processes lying between the origin of the extensor magnus colli above, and the insertion of the longus colli below. At their insertion into the basi-occipital bone their tendon separates the insertion of the rectus capitis anticus major from that of the rectus capitis lateralis.

Nerve supply.—Numerous branches from the cervical spinal nerves.

Remarks.—In most of the birds dissected, and especially in *Spheniscus minor*, the upper fibres of the intertransverse muscle form an almost distinct slip, which arises from the transverse processes of the upper two or three cervical vertebræ, and is inserted into the base of the skull. This is the "petit oblique de la tête" of Gervais and Alix.

9. *Longus colli.*

Long fléchisseur du cou, Vicq d'Azyr, 1773, p. 582, No. 1.
Der lange Halsbeuger, Wiedemann, p. 77.
Der lange Halsbeuger, Tiedemann, p. 291, No. 9.
Longus colli, Owen, p. 29.
Longus colli, Selenka, vol. vi. p. 100, No. 19.
Long antérieur du cou, Gervais and Alix, p. 15.

Attachments.—The longus colli *arises* from the hypapophyses of the last three cervical and five anterior dorsal vertebræ. The muscular fibres separate into a series of separate muscular slips, each of which is provided with a distinct tendon. These tendons pass forwards, lying parallel to one another, and are *inserted* into well-marked bony spines of the cervical vertebræ, from the second to the eleventh inclusive. The tendons of the external fasciculi are inserted into the posterior, while those which appertain to the internal fasciculi are *inserted* into the anterior of the vertebræ named, the intermediate fasciculi from without inwards being attached to successively higher vertebræ.

A number of muscular fibres, moreover, which form what may be called an accessory to the longus colli, *arise* from the inferior middle line of the various vertebræ to which the tendons of that muscle are attached. They form a continuous longitudinal sheet the fibres of which are directed obliquely forwards and outwards, and are attached to the tendons of insertion of the longus colli.

The anterior fibres of this accessory muscle are in part continuous with the origin of the trachelo-mastoid.

Action.—The longus colli is the principal flexor of the neck.

Relations.—This muscle is separated from that of the opposite side by the two common carotid arteries.

Nerve supply.—Branches from the anterior divisions of the cervical nerves.

10. *Longus colli externus.*

Attachments.—The muscle which I have thus named *arises*, in common with the preceding, from the hypapophyses of the anterior dorsal vertebræ. It is separated by a cellular interval from the longus colli, to the outer side of which it lies. The muscular fibres pass forwards and outwards, and, unlike those of the longus colli, do not terminate on separate tendons, but are *inserted* directly into the transverse processes of the lower four or five cervical vertebræ, where they are inseparably united with the inter-transverse muscles.

Action.—This muscle co-operates with the longus colli in flexing the neck.

Relations.—To its inner side is the origin of the longus colli. The large cords of the brachial plexus pass outwards behind it.

Nerve supply.—Branches from the anterior divisions of the lower cervical nerves.

(c) MUSCLES INSERTED INTO THE SKULL.

1. *Biventer cervicis.*

Dünner Halsmuskel, Merrem.
Der Zweibäuchige Nackenmuskel, Wiedemann, p. 75.
Der Zweibäuchige Nackenmuskel, Tiedemann, p. 232, No. 1.
Digastrique du cou, Cuvier, vol. i. p. 237.
Digastrique du cou, Meckel, vol. vi. p. 9, No. 1.
Longus colli posticus (part of), Owen, p. 27.
Biventer cervicis, Selenka, vol. vi. p. 95, No. 5.
Long postérieur du cou (faisceau occipital), Gervais and Alix, p. 14.

Attachments.—This muscle, as observed by Meckel, is developed to a greater extent in the Penguins than in other birds. It consists of a narrow fleshy band, without any trace of tendinous intersection, which *arises* from the anterior border of the iliac bone as well as from the spinous process of the second last dorsal vertebra, by means of a flattened tendon. It passes forwards to the occipital bone, where it is *inserted* into the upper end of the deep groove which separates the most prominent part of that bone from the transverse occipital crest.

Action.—This muscle is a powerful extensor of the head and neck. Its arrangement is such as absolutely to prevent the entire elimination of the well-marked curve forwards of the lower portion of the cervical vertebral column, without rupture of the fibres which compose the muscle.

Relations.—The muscle in the dorsal region is concealed by the trapezius and rhomboid, and lies in a groove formed by the subjacent vertebral muscles. In the neck it is not in contact with the vertebral column, but forms a chord to the curve of the lower cervical vertebræ.

Nerve supply.—Numerous branches from the posterior divisions of the dorsal and cervical spinal nerves.

Remarks.—The description of this muscle just given applies to every species of Penguin which I have examined. The attachment of the biventer cervicis so low down as the iliac crest, and the remarkable relation above referred to, which the muscle bears to the lower cervical vertebræ, are doubtless related to the upright position which these birds invariably assume when on land.

2. *Complexus.*

Complexus, Vicq d'Azyr, 1773, p. 581, No. 5.
Der Kopfdreher, Merrem.
Grand complexus, Cuvier, vol. i. p. 237.
Der durchflochtene Muskel, Tiedemann, p. 284, No. 3.
Complexus, Owen (Todd's Cyclopædia, vol. i. p. 291).
Muscle No. 2, Meckel, vol. vi. p. 12.
Complexus, Selenka, vol. vi. p. 98, No. 14.
Grand complexus, Gervais and Alix, p. 15.

Attachments.—The complexus *arises* by means of three distinct slips from the tips of the bony spines of the posterior articular processes (hyperapophyses of Mivart[1]) of the third, fourth, and fifth cervical vertebræ. The fibres pass forwards and are attached above the insertion of the biventer cervicis to the upper end of the transverse crest of the occipital bone.

Action.—The muscles of opposite sides acting together extend the skull upon the vertebral column.

Relations.—The complexus is concealed by the cutaneous muscle of the neck, and rests upon the splenius capitis. The tip of the hyoid cornu lies between the outer side of this and the posterior border of the digastric muscle.

Nerve supply.—A branch from the posterior division of the second cervical nerve.

Variations.—In *Spheniscus mendiculus* the origin of the muscle is confined to the fourth and fifth cervical vertebræ.

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[1] Trans. Zool. Soc., vol. viii., pt. 7, 1874.

3. *Splenius capitis.*

Splenius, Vicq d'Azyr, 1773, p. 581, No. 4.
Petit complexus, Cuvier, vol. i. p. 237.
Grosser Halsmuskel, Merrem.
Der bauschähnliche Muskel, Tiedemann, p. 282, No. 2.
Der Bauschmuskel des Kopfes, Wiedemann, p. 75.
Grand droit posterieur, Gervais and Alix, p. 14.

Attachments.—The splenius capitis *arises* from the spinous processes of the second and third, and to a less extent from that of the fourth, cervical vertebræ. Its muscular fibres pass forwards, and are *inserted* into the posterior surface of the transverse occipital crest.

Action.—This muscle extends the skull upon the vertebral column.

Relations.—The splenius lies in contact with its fellow of the opposite side. It is crossed superficially from without inwards by the complexus.

Nerve supply.—A branch from the posterior division of the second cervical nerve.

Variations.—In *Spheniscus demersus* this muscle is divisible into two portions, a superficial and a deep, which are separated by a cellular interval. The latter *arises* from the spine of the third cervical vertebra, and is *inserted* into the occipital bone under cover of the superficial portion.

4. *Rectus capitis lateralis.*

Les droits latéraux, Vicq d'Azyr, 1773, p. 582, No. 6.
Seitenbeuger des Kopfs, Wiedemann, p. 75.
Seitenbeuger des Kopfs, Tiedemann, p. 284, No. 6.
Droit latéral (?), Cuvier, vol. i. p. 237.
Trachelo-mastoid, Meckel, vol. vi. p. 13, No. 1.
Rectus capitis lateralis (?), Owen, p. 30.
Trachelo-mastoid, Selenka, vol. vi. p. 99, No. 15.
Basi-transversaire (?), Gervais and Alix, p. 15.

Attachments.—This muscle *arises* by four fleshy slips from the hyperapophyses of the second, third, fourth, and fifth cervical vertebræ. The fibres converge as they pass forwards, and are *inserted* by means of a stout tendon into the hollowed surface of the basi-occipital bone, in front of the foramen magnum.

Action.—The two muscles acting together flex the skull upon the vertebral column.

Relations.—The muscle arises along with the complexus. As it passes forwards it is crossed superficially by the inferior oblique, and is inserted close to the outer side of the rectus anticus major muscle.

Nerve supply.—Branches from the posterior divisions of the anterior cervical nerves.

5. *Rectus capitis anticus major.*

Le muscle droit et moyen, Vicq d'Azyr, 1773, p. 582, No. 5.
Kopfbieger (part of), Merrem.
Der lange Kopfbeuger, Wiedemann, p. 76.
Droit antérieur (1), Cuvier, vol. i. p. 238.
Der mittlere Kopfbeuger, Tiedemann, p. 285, No. 7.
Grand droit antérieur, Meckel, vol. vi. p. 15, No. 3.
Rectus capitis anticus major, Owen, p. 29.
Rectus capitis anticus major, Selenka, vol. vi. p. 100, No. 20.
Droit antérieur, Gervais and Alix, p. 15.

Attachments.—The rectus anticus major *arises* from the hypapophyses of the first, second, and third, and from the lower surfaces of the bodies of the fourth, fifth, and sixth cervical vertebræ, these origins being continuous along the middle line of the neck. The fibres pass forwards, and are *inserted* by means of a stout tendon into the hollowed triangular surface of the basi-occipital bone, immediately in front of the foramen magnum.

Action.—This muscle flexes the head upon the vertebral column.

Relations.—The rectus major is separated from its fellow of the opposite side by the two common carotid arteries. Its outer surface is in contact with the origin of the trachelo-mastoid, as well as with the insertion of the rectus capitis lateralis.

Nerve supply.—A branch from the anterior division of the second cervical nerve.

Variations.—In *Spheniscus demersus*, *Spheniscus magellanicus*, and *Spheniscus mendiculus*, the origin of the muscle is more extensive than in other species, extending backwards to the lower surface of the body of the seventh cervical vertebra.

6. *Trachelo-mastoid.*

Der lange Kopfbeuger, Tiedemann, p. 285, No. 8.
Muscle No. 2, Meckel, vol. vi. p. 13.
Rectus capitis anticus minor, Owen, p. 29.
Rectus capitis anticus minor, Selenka, vol. vi. p. 100, No. 20.
Occipito-sous-cervical, Gervais and Alix, p. 15.

Attachments.—The trachelo-mastoid is a thin flat muscle, which *arises* from the lower surfaces of the bodies of the second, third, fourth, and fifth cervical vertebræ to the outer side of the origin of the rectus capitis anticus major. The fibres pass obliquely forwards and outwards, and are *inserted* by means of a short tendon into the nipple-shaped process of bone immediately behind the external auditory meatus.

Action.—This muscle flexes the skull upon the vertebral column, and directs the head towards the side on which the muscle acts.

Relations.—Its origin lies in contact with the outer side of that of the rectus anticus major. The belly of the muscle separates the rectus anticus major in front from the rectus lateralis behind.

Nerve supply.—Branches from the anterior divisions of the second and third cervical nerves.

Variations.—In *Aptenodytes longirostris*, as well as in *Spheniscus demersus*, the origin of the muscle is limited to the second, third, and fourth cervical vertebræ.

7. *Rectus capitis posticus minor.*

Kleiner Kopfheber, Merrem.
Der kleine hintere gerade Kopfmuskel, Tiedemann, p. 283, No. 4.
Le petit muscle droit postérieur, Cuvier, vol. i. p. 237.
Troisième postérieur de la tête, Meckel, vol. vi. p. 12.
Rectus capitis posticus minor, Selenka, vol. vi. p. 99, No. 16.
Petit droit, Gervais and Alix, p. 14.

Attachments.—This is a very small muscle, which is inseparably connected with that of the opposite side. It *arises* from the arch of the atlas, and passing forwards is *inserted* into the central projection of the occipital bone close to the foramen magnum.

Action.—This muscle extends the skull upon the atlas.

Relations.—The muscle is concealed by the splenius capitis, and rests upon the posterior occipito-atlantal ligament.

Nerve supply (?)

(*d*) MUSCLES OF THE TAIL.

1. *Levator coccygis.*

Les releveurs du coccyx, Vicq d'Azyr, 1774, p. 496, No. 1.
Der grosse Schwanzheber, Merrem.
Der Steissbeinheber, Wiedemann, p. 82.
Der Heber des Steissbeins, Tiedemann, p. 292, No. 1.
Élévateur et Abducteur de la queue, Meckel, vol. vi. p. 14, No. 1.
Levator caudæ, Owen, p. 30.
Levator coccygis, Selenka, vol. vi. p. 100, No. 21.
Sacro-coccygien supérieur and *Transversaire-épineux*, Gervais and Alix, p. 15.

Attachments.—This muscle has been described by Gervais and Alix as consisting of two distinct portions. The first, anterior, and stronger portion (sacro-coccygien supérieur of Gervais) *arises* from the spines and transverse processes of the last four sacral vertebræ, as well as from the adjacent surface of the ilium and ischium. The muscular belly terminates on several tendons, which, passing obliquely backwards and upwards, are *inserted* into the base of the last caudal vertebra, or ploughshare bone, as well as into the spinous processes of the three preceding vertebræ.

The second or posterior portion of the muscle (transversaire-épineux of Gervais and Alix) consists of shorter fibres, which *arise* from the upper surfaces of the transverse processes of all the caudal vertebræ. They pass obliquely backwards and upwards, and are *inserted* into the bifid spines of the last four caudal vertebræ, including the ploughshare bone. A few of the fibres of this portion of the muscle are, moreover, *inserted* into the fibrous capsule of the uropygium.

The two portions of the levator coccygis are quite continuous with one another, and form, as it seems to me, a single muscle, the distinction between its parts lying rather in the difference in length of the fibres which compose them than in any clearly defined separation of these parts from one another.

Action.—Through the action of the muscle of one side, the tail is abducted. When both muscles contract simultaneously, the tail is elevated.

Relations.—The anterior portion of the muscle lies in contact with the origin of the biceps cruris on its outer side. The posterior portion is to a large extent concealed by the caudal gland which rests upon it.

Nerve supply.—The dorsal branches of the coccygeal nerves give off several twigs to this muscle.

Variations.—In *Eudyptes chrysocome* from Kerguelen, as well as in a specimen from the Falklands, I observed that the slip of this muscle which is inserted into the capsule of the caudal gland is of relatively larger size than in other species.

In *Eudyptes chrysolophus* this slip is given off from the middle in length of the second portion of the muscle. In several species, *e.g.*, *Spheniscus magellanicus* and *Eudyptes chrysocome* from Kerguelen, the transverso-spinal portion is provided with a series of tendons of insertion, one of which is attached to the spinous process of each of the caudal vertebræ. That to the ploughshare bone is stronger than the others, and appears to be formed by the junction of several distinct tendons corresponding to the separate vertebræ which unite to form the ploughshare bone. It would therefore appear that the levator coccygis is composed of a series of distinct transverso-spinal slips, each of which passes between the transverse process of one vertebra and the spine of that succeeding, and that in some birds these remain distinct throughout life, while in others their tendons become more or less fused together, and give rise to the arrangement above described in *Eudyptes chrysocome* from Tristan d'Acunha, in which separate tendons to each of the caudal vertebræ are no longer recognisable.

2. *Interspinales.*

In addition to the levator caudæ above described, there are a number of fleshy slips *inserted* into the base of the last caudal vertebra, or ploughshare bone, as well as into the spinous processes of the three preceding vertebræ.

The second or posterior portion of the muscle (transversaire-épineux of Gervais and Alix) consists of shorter fibres, which *arise* from the upper surfaces of the transverse processes of all the caudal vertebræ. They pass obliquely backwards and upwards, and are *inserted* into the bifid spines of the last four caudal vertebræ, including the ploughshare bone. A few of the fibres of this portion of the muscle are, moreover, *inserted* into the fibrous capsule of the uropygium.

The two portions of the levator coccygis are quite continuous with one another, and form, as it seems to me, a single muscle, the distinction between its parts lying rather in the difference in length of the fibres which compose them than in any clearly defined separation of these parts from one another.

Action.—Through the action of the muscle of one side, the tail is abducted. When both muscles contract simultaneously, the tail is elevated.

Relations.—The anterior portion of the muscle lies in contact with the origin of the biceps cruris on its outer side. The posterior portion is to a large extent concealed by the caudal gland which rests upon it.

Nerve supply.—The dorsal branches of the coccygeal nerves give off several twigs to this muscle.

Variations.—In *Eudyptes chrysocome* from Kerguelen, as well as in a specimen from the Falklands, I observed that the slip of this muscle which is inserted into the capsule of the caudal gland is of relatively larger size than in other species.

In *Eudyptes chrysolophus* this slip is given off from the middle in length of the second portion of the muscle. In several species, *e.g.*, *Spheniscus magellanicus* and *Eudyptes chrysocome* from Kerguelen, the transverso-spinal portion is provided with a series of tendons of insertion, one of which is attached to the spinous process of each of the caudal vertebræ. That to the ploughshare bone is stronger than the others, and appears to be formed by the junction of several distinct tendons corresponding to the separate vertebræ which unite to form the ploughshare bone. It would therefore appear that the levator coccygis is composed of a series of distinct transverso-spinal slips, each of which passes between the transverse process of one vertebra and the spine of that succeeding, and that in some birds these remain distinct throughout life, while in others their tendons become more or less fused together, and give rise to the arrangement above described in *Eudyptes chrysocome* from Tristan d'Acunha, in which separate tendons to each of the caudal vertebræ are no longer recognisable.

2. *Interspinales.*

In addition to the levator caudæ above described, there are a number of fleshy slips

Relations.—The muscle is in part concealed on the outer side by the cruro-coccygeus, which lies parallel with and separates it from the origin of the semi-tendinosus. Its inner surface is in contact with the abdominal viscera.

Nerve supply.—Branches from the anterior divisions of the coccygeal nerves.

Remarks.—I have experienced considerable difficulty with regard to the synonymy of this muscle. This arises from the fact that in the majority of birds there are more than one abductor of the tail, and the descriptions of the various anatomists quoted are not so precise as one could wish. I have attempted to come to a correct decision as to the synonyms, but that I entertain doubts with regard to certain of these is indicated by the insertion of points of interrogation after them.

(*e*) MUSCLES INSERTED INTO THE RIBS.

1. *Diaphragm.*

Attachments.—The diaphragm is a thin fleshy plate, which *arises* by means of six distinct digitations from the inner or thoracic surfaces of the second to the seventh vertebral ribs inclusive, close to the articulations of these with the corresponding sternal segments. The fibres pass upwards, and are *inserted* into the lower or cardiac surface of the lung of the same side.

Action.—This muscle acting upon the lung assists in the expansion of that organ.

Nerve supply (?)

Variations.—In *Spheniscus mendiculus* the origin of the diaphragm is confined to *four* ribs, namely, to the second, third, fourth, and fifth. In *Spheniscus demersus*, on the other hand, the muscle is larger than in other species, and is attached to all the vertebral ribs, with the exception of the first.

2. *Triangularis sterni.*

Der innere oder dreieckige Brustmuskel, Tiedemann, p. 300, No. 4.
Der Erheber der Rippenfortsätze, Merrem.
Triangulaire du sternum, Cuvier, vol. i. p. 219.
Muscle No. 4, Meckel, vol. vi. p. 17.
Triangularis sterni, Selenka, vol. vi. p. 104, No. 29.
Triangulaire du sternum, Gervais and Alix, p. 16.

Attachments.—This muscle *arises* by means of a stout tendon from the thoracic surface of the costal process of the sternum. Its fibres pass horizontally backwards, and are *inserted* by means of distinct muscular slips into the inner surfaces of the first four sternal ribs. The most anterior slip is attached to its rib at some distance from the sternum, while the succeeding slips approach successively nearer to that bone.

Action.—This muscle elevates the sternal ribs, and acts as a muscle of inspiration.

Relations.—Its origin is close to that of the sterno-trachealis, and is in contact with the thoracic viscera.

Nerve supply (?)

Variations.—In *Spheniscus magellanicus* the insertion of the triangularis is limited to the three anterior sternal ribs, while in *Spheniscus demersus* it is attached to five of the latter.

3. *Levatores costarum.*

Les vertébro-costaux, Vicq d'Azyr, 1774, p. 520, No. 3.
Der Erheber der Brust, Merrem.
Levatores costarum, Tiedemann, p. 299, No. 3.
Élévateurs des côtes, Meckel, vol. vi. p. 16, No. 1.
Levatores costarum, Owen, p. 29.
Sur-costaux, Gervais and Alix, p. 12.

Attachments.—The levatores costarum form a series of small muscles, which are with difficulty separable from the external intercostal muscles. They *arise* from the tips of the transverse processes of all the dorsal vertebræ, except the last, as well as from those of the last cervical vertebra. Each levator costæ is *inserted* into the anterior border of the vertebral rib belonging to the succeeding vertebra, the insertion extending from the tubercle to the point of attachment of the uncinate process, where its fibres blend with those of the external intercostal muscle.

The first and second levatores are scarcely separable from the fibres of the scalene muscle, of which they seem to form a part.

Action.—These muscles elevate the ribs, and act as muscles of inspiration.

Relations.—They are concealed by the sacro-lumbalis.

Nerve supply (?)

4. *External intercostal muscles.*

Les muscles intercostaux, Vicq d'Azyr, 1774, p. 520, No. 1.
Die äussern Zwischenrippen-Muskeln, Tiedemann, p. 301, No. 6.
Intercostaux externes, Meckel, vol. vi. p. 16, No. 2.
Intercostaux externes, Cuvier, vol. i. p. 219.
Intercostales externi, Owen, p. 31.
Intercostales externi, Selenka, vol. vi. p. 104, No. 28.
Intercostaux, Gervais and Alix, p. 13.

Attachments.—These muscles are of considerable strength, and occupy the intervals between the vertebral ribs. Their fibres *arise* from the posterior border of one vertebral rib, and pass obliquely downwards and backwards, to be *inserted* into the anterior border of the rib behind. They are very closely related to the accessory intercostal muscles which arise from the uncinate processes.

Relations.—These muscles occupy the whole of the interval between any two vertebral ribs extending from the vertebral column above to the junction of the vertebral with the corresponding sternal ribs below. They do *not* occupy the intervals between the sternal ribs.

Nerve supply.—Branches of the intercostal nerves.

5. *Accessory external intercostal muscles.*

Attachments.—These muscles are superficially placed with reference to the external intercostals, to which they may be regarded as accessories. Each *arises* from the whole length of the posterior border of an uncinate process, and passing obliquely backwards and downwards, is *inserted* into the outer surface of the vertebral rib next behind that to which the uncinate process belongs. These slips correspond in number to the uncinate processes, and are therefore absent in the case of the first and last ribs.

Action.—These muscles elevate the ribs into which they are inserted, and are therefore muscles of inspiration.

Relations.—The accessory muscles rest upon the external intercostal muscles, from the anterior fibres of which they can scarcely be separated.

Nerve supply.—Twigs from the intercostal nerves.

Remarks.—In connection with these muscles, it may be as well to refer to a number of aponeurotic slips which attach the uncinate processes to the corresponding ribs. Each of these consists of a stout aponeurotic plate, triangular in form, which is attached by its apex to the anterior border and free extremity of the uncinate process, while its base is attached to the posterior border of the vertebral rib to which the process belongs. These aponeurotic slips overlap each other from behind forwards, and serve to strengthen the articulation between the rib and its uncinate process. By thus fixing the uncinate process they afford a *point d'appui* from which the accessory intercostal muscles may act in raising the ribs during inspiration.

6. *Internal intercostal muscles.*

Les muscles intercostaux, Vicq d'Azyr, 1774, p. 520, No. 1.
Die innere Zwischenrippen-Muskeln, Tiedemann, p. 301, No. 7.
Intercostaux internes, Meckel, vol. vi. p. 17, No. 3.
Intercostaux internes, Cuvier, vol. i. p. 219.
Intercostales interni, Selenka, vol. vi. p. 104, No. 28.
Muscles intercostaux, Gervais and Alix, p. 13.

Attachments.—These muscles occupy the intervals between the sternal ribs, and extend as far as the uncinate processes. The fibres cross those of the external intercostals, being directed from behind and above, downwards and forwards.

Nerve supply.—Branches of the intercostal nerves.

Remarks.—The anterior fibres which lie between the sternal ribs are the "Musculi interappendiculares costarum" of Tiedemann, the term "Internal Intercostal" being limited by that author to those fibres of the internal intercostals above described which lie between the vertebral ribs.

7. *Scalenus.*

Les muscles qui tiennent la place des scalènes (one of), Vicq d'Azyr, 1774, p. 520, No. 2.
Rippenhalter, Wiedemann, p. 78.
Der erste Rippenhalter, Tiedemann, p. 299, No. 1.
Scalène, Cuvier, vol. i. p. 218.
Scalène, Meckel, vol. vi. p. 216, No. 1.
Scalenus medius, Owen, p. 29.
Scalenus, Selenka, vol. vi. p. 98, No. 12.
Surcostaux (one of), Gervais and Alix, p. 12.

Attachments.—The scalenus muscle *arises* from the transverse processes of the last cervical and first dorsal vertebræ. The fibres pass obliquely backwards and downwards, and are *inserted* into the second rib above the costal process. As the muscle passes backwards it entirely envelops the first or rudimental rib in its fibres.

Action.—This muscle acts as a muscle of respiration, inasmuch as it raises the second rib, and indirectly those succeeding.

Nerve supply (?)

Relations.—The large cords of the brachial plexus pass out in front of this muscle, and separate it from the longus colli externus.

Variations.—In the majority of the birds dissected, I found that the scalenus, as above described, was separable into two distinct portions—an anterior, arising from the last cervical, and a posterior arising from the first dorsal vertebra. In some, however, no trace of this subdivision was recognisable.

(*f*) MUSCLES OF THE ABDOMEN.

1. *Transverso-cloacal.*

Attachments.—The muscle so named by Gervais and Alix (p. 16) *arises* from the transverse processes of the third, fourth, and fifth coccygeal vertebræ. Its fibres pass downwards and forwards, and after crossing the superficial surface of the ischio-pubo-coccygeus, are *inserted* close to the anus. The anterior fibres pass in front of the anus, and become continuous with the corresponding fibres of the muscle of the opposite side. The posterior fibres are inserted into the integument immediately behind the anus, and the intermediate fibres are inserted into the aponeurosis of the abdominal muscles, close to the lateral margin of the anus.

Action.—This muscle, acting in conjunction with its fellow of the opposite side, will diminish the size of the abdominal cavity, by elevating and approximating the abdominal wall to the vertebral column. As remarked by Gervais and Alix, it also acts as a superficial levator ani.

Relations.—This muscle at its origin lies between and separates that of the levator coccygis from that of the semi-tendinosus. As it passes downwards to its insertion it rests against the ischio-pubo-coccygeus.

Nerve supply.—Several twigs from the anterior divisions of the coccygeal nerves.

2. *Obliquus abdominis externus.*

Le grand oblique, Vicq d'Azyr, 1774, p. 490, No. 1.
Aeusserer schräger Bauchmuskel, Merrem.
Der äussere schiefe Bauchmuskel, Wiedemann, p. 79.
Der äussere schräge Bauchmuskel, Tiedemann, p. 296, No. 1.
Grand oblique, Cuvier, vol. i. p. 217.
Muscle oblique externe de l'abdomen, Meckel, vol. vi. p. 18, No. 1.
Obliquus abdominis externus, Selenka, vol. vi. p. 102, No. 25.
Obliquus abdominis externus, Owen, p. 30.
Le grand oblique, Gervais and Alix, p. 17.

Attachments.—The external oblique is a broad flat muscle, which *arises* by means of seven digitations from the outer surfaces of the vertebral segments of the last seven ribs, and by means of a delicate aponeurosis from the whole length of the lower border of the pubic bone. Each costal digitation is attached to the rib immediately below the uncinate process, and to a small extent to that process itself. From this extensive origin the muscular fibres pass obliquely backwards and downwards, and are *inserted* as follows. The anterior or costal fibres of the muscle are inserted into the lateral margin of the sternum from the facet for the reception of the third sternal rib backwards to the posterior extremity of the bone, while the posterior or pubic fibres end on a stout aponeurosis which completes the abdominal wall.

Action.—As observed by Tiedemann, this muscle aids in respiration by approximating the sternum to the vertebral column, and diminishing the capacity of the thoracic and abdominal cavities.

Relations.—The muscle interdigitates with the serrati antici major et minor. Superficially it is in part concealed by the aponeurotic origin of the semi-membranosus, while its deeper surface rests upon and conceals the ribs and intercostal muscles in front, and the rectus abdominis behind.

Nerve supply.—Twigs from the intercostal nerves.

3. *Obliquus abdominis internus.*

Le petit oblique, Vicq d'Azyr, 1774, p. 490, No. 2.
Der innere schräge Bauchmuskel, Merrem.
Der innere schräge Bauchmuskel, Wiedemann, p. 80.
L'oblique interne, Cuvier, vol. i. p. 217.
Der innere schräge Bauchmuskel, Tiedemann, p. 296, No. 2.
Muscle oblique interne de l'abdomen, Meckel, vol. vi. p. 19, No. 2.
Obliquus internus abdominis, Owen, p. 30.
Obliquus internus abdominis, Selenka, vol. vi. p. 103, No. 26.
Le petit oblique de l'abdomen, Gervais and Alix, p. 16.

Attachments.—The internal oblique *arises* from the middle third of the external border of the pelvic bone. The fibres pass obliquely forwards and downwards, and are *inserted* into the lower two-thirds of the posterior border of the last vertebral rib.

Action.—This muscle co-operates with the internal intercostal muscles in depressing the ribs and diminishing the capacity of the abdominal and thoracic cavities.

Relations.—The muscle fills up the interval between the pelvic bone and the last rib. Superficially it is concealed by the obliquus externus. Its deeper surface rests upon a large air sac, which separates it from the subjacent transversalis abdominis.

Nerve supply.—Branches from the last intercostal nerve.

Variations.—In *Aptenodytes* the origin of the muscle is limited to the anterior half of the pubic bone, and its insertion extends to the last two vertebral ribs. In *Pygosceles* the origin is confined to the ilium, and the muscle takes no attachment to the pubis. In *Eudyptes chrysolophus* the muscle is inserted into the vertebral third of the last two ribs, while in *Spheniscus minor* the internal oblique arises from the whole length of the pubic bone, and not at all from the ilium.

Remarks.—I have experienced considerable difficulty in deciding the synonymy of this muscle. The description above given certainly corresponds more closely to that of the quadratus lumborum (No. 9, p. 302) of Tiedemann, than to that of the obliquus internus of that author. If, however, we assume that the internal oblique as above described really corresponds to the quadratus lumborum of Tiedemann, we must conclude that the obliquus internus abdominis is absent in every species of Penguin. This conclusion, in view of the constant occurrence of the internal oblique in other birds, seems so likely to be erroneous, that I prefer to believe that the obliquus internus of the Penguin presents a somewhat unusual disposition rather than that it is entirely wanting.

4. *Transversalis abdominis.*

Le muscle transverse, Vicq d'Azyr, 1774, p. 490, No. 3.
Der Querbauchmuskel, Merrem.
Der Querbauchmuskel, Wiedemann, p. 80.
Der quere Bauchmuskel, Tiedemann, p. 297, No. 3.
Muscle transverse de l'abdomen, Meckel, vol. vi. p. 19, No. 3.
Transversalis abdominis, Owen, p. 31.
Transversus abdominis, Selenka, vol. vi. p. 105, No. 30.
Le transverse, Gervais and Alix, p. 17.

Attachments.—The transversalis abdominis *arises* from the whole length of the pubic bone posterior to the origin of the internal oblique. The greater number of the fibres pass transversely, but the anterior fibres pass downwards and forwards, while the posterior fibres pass downwards and backwards. The fibres are *inserted* into the whole length of the vertebral segment of the last rib, as well as into the abdominal aponeurosis, the latter insertion extending from the sternum in front to within an inch and a half of the anus behind.

Action.—The muscles of opposite sides contracting simultaneously diminish the capacity of the abdominal cavity.

Relations.—The muscle is concealed superficially by the obliquus externus and rectus abdominis.

Nerve supply.—Indirect branches of the lumbar plexus.

Variations.—In one specimen of *Aptenodytes* the costal insertion of this muscle was absent, although in other specimens of the same species it was present. In *Spheniscus mendiculus* also the costal insertion was wanting, the muscle being inserted exclusively into the abdominal aponeurosis. In *Spheniscus minor*, although the specimen which I dissected was in excellent preservation, I failed to recognise the presence of the transversalis abdominis.

5. *Rectus abdominis.*

Gerader Bauchmuskel, Merrem.
Gerader Bauchmuskel, Wiedemann, p. 80.
Der gerade Bauchmuskel, Tiedemann, p. 297, No. 4.
Le muscle droit de l'abdomen, Meckel, vol. vi. p. 20, No. 4.
Droit du bas-ventre, Cuvier, vol. i. p. 217.
Rectus abdominis, Owen, p. 30.
Rectus abdominis, Selenka, vol. vi. p. 103, No. 27.
Grand droit de l'abdomen, Gervais and Alix, p. 17.

Attachments.—The rectus abdominis consists, as pointed out by Gervais and Alix, of two distinct muscular slips.

The internal slip *arises* from the abdominal aponeurosis, midway between the sternum and anus, as well as from the cartilaginous extremity of the pubic bone. The muscle passes forwards, and is *inserted* into the whole length of the inner border of the posterior sternal notch.

The external slip is continuous at its origin with that of the internal portion of the muscle, and is attached by means of a flattened tendon to the posterior half of the free border of the pubic bone, as well as to its cartilaginous extremity. The muscle passes forwards, and is *inserted* by means of distinct digitations into the outer surfaces of the third, fourth, fifth, and sixth sternal ribs, close to the articulations of these with the breast bone.

Action.—The rectus abdominis, in contracting, diminishes the capacity of the abdominal cavity.

Relations.—Both portions of the muscle are concealed by the external oblique, and rest upon a large air sac which intervenes between the rectus and transversalis abdominis. The inner slip towards its insertion overlaps to some extent the inner border of the external portion of the muscle.

Nerve supply.—Branches from the lower intercostal nerves.

Variations.—In *Aptenodytes longirostris* the insertion of the external portion of the muscle extends from the second to the seventh sternal ribs inclusive. In *Pygoscelis tæniatus* and *Eudyptes chrysolophus* it is inserted into the fourth, fifth, sixth, and seventh sternal ribs.

Comparative Remarks.

The most striking peculiarity of the muscular system of the trunk of the Penguin lies in the great development of the extensor muscles of the neck. Associated with this is the peculiar disposition of the biventer cervicis, a disposition which is found elsewhere only in the Ostrich among birds. This muscle arises as far back as the crest of the iliac bone, and passing forwards is inserted into the occiput, without presenting any trace of the tendinous intersection from the presence of which in the majority of birds this muscle has received its name. The great strength of the extensor muscles in question is doubtless correlated with the peculiar flexures of the vertebral column, which in every member of the group Spheniscidæ are more pronounced than in any other birds.

These flexures are developed to such an extent, that, as already pointed out in the description of the vertebral column, the lower cervical vertebræ are actually in contact with the furculum, and thus the trachea and œsophagus, instead of passing along the middle line of the neck, are thereby laterally displaced, and pass into the thorax, lying altogether to the right of the vertebral column. Associated with this anterior cervical curvature, there falls to be noticed the compensatory curves of the vertebral column, both above and below,—curves the movements of which are necessarily controlled by stronger muscles than are possessed by other birds in which these cervical flexures are less pronounced than in the Penguins. To the presence of these cervical curves is attributable the fact that the Penguins, when on *terra firma*, are able to maintain the peculiarly erect position which every member of the group assumes. The absence of power to produce the flexures in question would, it is evident, render the maintenance of the erect attitude impossible.

MUSCLES OF THE WING.

(*a*) MUSCLES INSERTED INTO THE SCAPULA.

1. *Trapezius.*

Trapézoïde, Vicq d'Azyr, 1772, p. 630, No. 1.
Trapèze, Cuvier, vol. i. p. 262.
Aufzieher des Schulterblattes, p. 154, No. 9.
Der Kappenmuskel, Wiedemann, No. 2, p. 84.
Retracteur superficiel, Meckel, vol. vi. p. 22, No. 1.
Cucullaris, Schoepss, p. 90, No. 6.
Cucullaris, Selenka, vol. vi. p. 107, No. 32.
Trapèze, Gervais and Alix, p. 21.

Attachments.—The trapezius *arises* from the spinous processes of the dorsal vertebræ, from the second to the fifth inclusive, by means of a flat aponeurotic tendon. The fibres pass outwards with a slight obliquity forwards, and are *inserted* into the anterior half of the vertebral border of the scapula, as well as into the posterior recurved extremity of the clavicle.

Action.—This muscle approximates the scapula to the vertebral column. In this action it co-operates with the fibres of the rhomboid muscle.

Relations.—The trapezius is concealed by the anterior portion of the latissimus dorsi. Its deeper surface rests upon the rhomboid muscle.

Nerve supply.—A special branch from the first cord of the brachial plexus.

Variations.—In *Eudyptes chrysocome* from Kerguelen, I found the trapezius arising from the spines of the three anterior dorsal vertebræ, as well as from those of the last two cervical vertebræ. In this bird, as well as in *Pygoscelis tæniatus* and *Spheniscus minor*, the insertion of the trapezius is confined to the anterior third of the vertebral border of the scapula.

Remarks.—Gervais and Alix found the trapezius in *Eudyptes chrysolophus* attached to the spines of the last two cervical vertebræ, as well as to those of the dorsal vertebræ above mentioned. They do not mention the insertion of this muscle into the recurved extremity of the clavicle. The observations of Meckel and of Schoepss with regard to this muscle in the Penguin agree with my own.

2. *Rhomboideus.*

Rhomboïde, Vicq d'Azyr, 1772, p. 630, No. 2.
Rhomboïde, Cuvier, vol. i. p. 263.
Rautenmuskel, Wiedemann, p. 82.
Rhomboideus major et minor, Tiedemann, p. 303, Nos. 2 and 3.
Rhomboïde, Meckel, vol. vi. p. 23, No. 2.
Rhomboideus, Schoepss, p. 92, No. 7.
Rhomboideus, Selenka, vol. vi. p. 108, No. 33.
Rhomboïde, Gervais and Alix, p. 21.

Attachments.—The rhomboid muscle *arises* from the spinous processes of the dorsal vertebræ, from the second to the seventh inclusive. The fibres pass outwards and slightly backwards to be *inserted* into the posterior three-fourths of the vertebral border of the scapula.

Action.—The muscle contracting approximates the scapula to the vertebral column. Its action, however, must differ somewhat from that of the trapezius, seeing that the fibres of the latter pass obliquely outwards and forwards, whilst those of the rhomboid muscle pass outwards and backwards.

Relations.—Superficially the anterior and larger portion of this muscle is concealed by the trapezius. Its deeper surface rests against the dorsal spinal muscles.

Nerve supply.—A twig from the nerve which supplies the trapezius, derived through the latter from the first cord of the brachial plexus.

Variations.—In *Spheniscus minor* the origin of the rhomboid muscle is confined to the spinous processes of the same vertebræ that afford attachment to the trapezius.

3. *Serratus anticus major.*

Sous-scapulaire, Vicq d'Azyr, 1772, p. 632, No. 6.
Grand dentelé, Cuvier, vol. i. p. 262.
Rückwärtszieher des Schulterblattes, Merrem, p. 154, No. 10.
Sägemuskel, Wiedemann, p. 87.
Serratus magnus, Tiedemann, p. 304, No. 5.
Grand dentelé antérieur, Meckel, vol. vi. p. 24, No. 6.
Der grosse vordere Sägemuskel, Schoepss, p. 94, No. 8.
Serratus anticus (part of), Selenka, vol. vi. p. 110, No. 35.
Grand dentelé postérieur, Gervais and Alix, p. 20.

Attachments.—This muscle *arises* by means of three distinct digitations from the outer surfaces of the fourth, fifth, and sixth vertebral ribs, close to the junction of these with their sternal segments. The fibres pass almost vertically upwards, and are *inserted* into the external border of the posterior extremity of the scapula.

Action.—The muscle draws the posterior angle of the scapula downwards towards the sternum.

Relations.—The muscle is subcutaneous. It interdigitates with the external oblique of the abdomen, and rests against the ribs.

Nerve supply.—A branch from the great cord of the brachial plexus. This branch comes off from the brachial plexus above the origin of the branch to the pectoralis major, and divides into two twigs. One of these supplies the serratus anticus major, and the other the serratus anticus minor.

Variations.—In *Pygosceles tæniatus* this muscle arises by means of two digitations from the outer surfaces of the fourth and fifth ribs only. In this respect *Pygosceles* differs from every other species which I have examined.

Remarks.—According to Schoepss and Selenka, this muscle in the Penguin arises from four ribs. Such is not the case in any species of Penguin examined by myself.

4. *Serratus anticus minor.*

Costo-scapulaire, Vicq d'Azyr, 1772, p. 629, No. 4.
Costo-scapulaire, Cuvier, vol. i. p. 262.
Der untere Rippenschulterblattmuskel, Wiedemann, p. 87.
Costo-scapularis, Tiedemann, p. 304, No. 6.
Petit pectoral ou petit dentelé antérieur, Meckel, vol. vi. p. 25, No. 7.
Der kleine vordere Sägemuskel, Schoepss, p. 96, No. 9.
Serratus anticus (part of), Selenka, vol. vi. p. 110, No. 35.
Grand dentelé antérieur, Gervais and Alix, p. 20.

Attachments.—This muscle *arises* by means of three digitations from the outer surfaces of the second, third, and fourth vertebral ribs, immediately below their costal processes. The fibres pass obliquely forwards and upwards, and are *inserted* into the anterior third of the outer or axillary border of the scapula.

Action.—The muscle pulls the scapula backwards and downwards, or, taking the scapula as its fixed point, it elevates the ribs from which it arises.

Relations.—The muscle is overlapped superficially by the external border of the infra-spinatus. In contact with its lower border are the axillary vessels and nerves, as they pass from the chest. At its origin it interdigitates with the external oblique of the abdomen. Its insertion separates the origin of the subscapularis from that of the supra-spinatus.

Nerve supply.—A branch from the great cord of the brachial plexus. This branch, after supplying a twig to, and perforating the serratus anticus minor, terminates in the serratus anticus major.

Variations.—In *Eudyptes chrysocome* from the Falkland Islands, as well as in a specimen of the same species from Kerguelen, the origin of the serratus minor was limited to the third and fourth ribs. This was also the case in *Eudyptes chrysolophus*, and in *Spheniscus mendiculus*. In *Spheniscus demersus* the muscle arose by a single digitation from the third rib, while in *Pygosceles tæniatus*, *Spheniscus magellanicus*, and *Spheniscus minor*, the muscle arose by two digitations, one of which was attached to the second, the other to the third and fourth ribs.

Remarks.—Schoepss found this muscle in the Penguin attached to "the outer surfaces of the posterior false ribs, and to the lower portion of the first true rib." According to Gervais and Alix, in *Eudyptes chrysolophus* it arises from the third and fourth ribs as above enumerated.

5. *Levator scapulæ.*

Der Anzieher des Schulterblattes, Merrem, p. 154, No. 11.
Der obere Rippenschulterblattmuskel, Wiedemann, p. 87.
Levator scapulæ, Tiedemann, p. 303, No. 4.
L'élévateur de l'épaule, Meckel, vol. vi. p. 24, No. 3.
Der Schulterheber, Schoepss, p. 97, No. 10.
Levator scapulæ, Selenka, vol. vi. p. 109, No. 34.
L'angulaire, Gervais and Alix, p. 20

Attachments.—The levator scapulæ consists of three distinct plates of muscle, which *arise* from the outer surfaces of the second, third, and fourth ribs. The first or foremost plate is attached to the second rib, close to the extremity of the transverse process, with which it articulates, while the succeeding plates are attached to the respective ribs nearer and nearer to the sternum. The plates pass backwards, lying parallel to one another, and are *inserted* together into the posterior third of the costal surface of the scapula, close to its vertebral border.

Action.—This muscle draws the scapula forwards and upwards towards the vertebral column.

Relations.—The muscle is concealed by the rhomboid muscle and by the scapula. It rests upon the ribs and intercostal muscles.

Nerve supply.—A branch from the nerve which supplies the rhomboid and trapezius muscles.

Variations.—In *Eudyptes chrysocome* from Kerguelen, as well as in *Pygosceles tæniatus*, this muscle consists of four distinct muscular plates, which arise from the second, third, fourth, and fifth ribs. In *Aptenodytes longirostris* the muscle is attached to four ribs by means of three digitations. Of these the first arises from the second rib, the second from the third and fourth ribs, and the third from the fifth rib. In *Spheniscus minor* the muscle arises by means of three digitations which are attached to the first, second, and third ribs. In *Spheniscus demersus* the muscle is inserted into the middle third of the costal surface of the scapula, and not into the posterior third as in the other species examined.

Remarks.—According to Schoepss, this muscle arises from the transverse processes of the first and second dorsal vertebræ, as well as from the posterior border of the second rib. Gervais and Alix found the muscle in *Eudyptes chrysolophus* arising from the transverse process of the last cervical vertebra, as well as from the outer surfaces of the first, second, third, and fourth ribs. According to the last-named authors, the muscle consists of five distinct fascicles. In no species of Penguin have I observed more than four.

(*b*) Muscles inserted into the Humerus.

1. *Pectoralis major.*

Grand pectoral, Vicq d'Azyr, 1772, p. 623, No. 1.
Grand pectoral, Cuvier, 1805, vol. i. p. 277, No. 1.
Described by Merrem, p. 152, No. 1.
Der grosse Brustmuskel, Wiedemann, Bd. ii. p. 82.
Pectoralis major, Tiedemann, p. 305, No. 1.
Pectoralis major, Heusinger, Bd. vii. p. 183, No. 1.
Grand pectoral, Meckel, tom. vi. p. 34, No. 8.
Der grosse Brustmuskel, Schoepss, p. 108, No. 15.
Pectoralis major, Reid, 1835, p. 140.
Pectoralis major, Rolleston, 1868, p. 624.
Pectoralis major et minor, Selenka, Bd. vi. p. 121, Nos. 46 and 47.
Grand pectoral, Gervais and Alix, 1878, p. 24.

Attachments.—The pectoralis major is an extremely powerful muscle. It *arises* from the outer surface of the clavicle below the shoulder joint, from the outer surface of a strong aponeurosis attached to the clavicle, sternum, and coracoid bones, by means of a linear origin from the whole length of the sternal keel, as well as from the fascia which intervenes between the pectoralis major and medius, and by means of a special bundle of fibres from the postero-external, osseo-cartilaginous angle of the breast-bone.

The anterior fibres pass transversely outwards, the posterior outwards and forwards, while the intermediate fibres pass outwards with various obliquities. The anterior clavicular, and neighbouring aponeurotic fibres end on a special tendon, which is attached to the whole length of the anterior or radial margin of the bones forming the wing. This tendon, moreover, expands into an aponeurotic sheath, which covers both surfaces of the wing, and conceals the various tendons, blood-vessels, and nerves met with in the dissection of that organ. The remaining fibres forming the bulk of the muscle terminate on a V-shaped tendon, which is *inserted* into a special linear depression on the inner surface of the humerus, between the anterior margin and the head of that bone.

Action.—The two portions of this muscle have different actions. The anterior fibres when contracting will carry the wing forwards, to a right angle with the trunk, while the posterior fibres by their contraction will carry the wing backwards to produce the effective stroke in swimming through the water. Moreover, by reason of their insertion into the anterior margin of the humerus, they will bring about that rotation of the wing round its long axis which, combined with the backward stroke, gives rise to the screw-like motion of the organ observable when the bird is progressing through the water.

Relations.—The anterior fibres of the great pectoral muscle extend across the clavicle to the middle line of the body, and are only separated from those of the opposite side by a tendinous raphé, to which both are attached. The external border of the muscle is free. Upon its cutaneous surface lies the "muscle des parures."

Nerve-supply.—A special branch from the large cord of the brachial plexus.

Variations.—In *Eudyptes chrysocome* from the Falkland Islands, the attachment of the pectoralis major to the sterno-clavicular membrane is more limited than in *Eudyptes chrysocome* from Tristan d'Acunha. In *Eudyptes chrysocome* from Kerguelen the greater pectoral muscle does not take any attachment to the sterno-clavicular aponeurosis. In *Aptenodytes longirostris* the origin of the muscle from the postero-external angle of the sternum is much more extensive than in *Eudyptes*, and it extends along the outer margin of the sternum for the posterior half of that bone.

Remarks.—Reid describes the muscle in *Aptenodytes* as arising from "the cartilages of the ribs, and from the anterior part of the coracoid bone," in addition to the origins above described. Such was not the case in the specimens examined by myself.

Gervais and Alix describe the pectoralis major in *Eudyptes chrysolophus* as arising from "the aponeurosis of the great oblique, which separates it from the sterno-costal articulations," in addition to the attachments above described. This description is not borne out by my own dissections.

2. *Muscle des parures.*

Der Brusthaut-muskel, Tiedemann, vol. i. p. 134.
Dermo-humeralis, Owen, p. 24.
Panniculus carnosus (second portion), Reid, p. 139.

Attachments.—The muscle so named by Gervais and Alix is flat and riband-like, and has a somewhat peculiar disposition. *Arising* by means of a strong fascia, which covers the external oblique muscle of the abdomen from the free cartilaginous extremity of the pubic bone, it passes forwards and inwards to the posterior margin of the sternum. Here it is reinforced by a number of fibres from the subcutaneous tissue covering the knee-joint, and thereafter diverging from its fellow of the opposite side, passes forwards parallel to the outer border of the pectoralis major, along with the posterior fibres of which muscle it is *inserted* into the anterior margin of the humerus.

Action.—This muscle co-operates with the external fibres of the pectoralis major in depressing the wing. It would appear, moreover, that its posterior fibres, that is, those which form the subcutaneus abdominalis above described (p. 55), will co-operate with the muscles of the abdominal wall in their various actions.

Relations.—The muscle is deeply situated at its origin, lying between the external oblique and the aponeurotic origin of the inner portion of the rectus abdominis. Above the origin of the latter it is subcutaneous, and rests upon the pectoralis major.

Nerve supply.—A twig from the nerve which supplies the pectoralis major.

Remarks.—This muscle is described by Schoepss as forming a portion of the pectoralis major. From Gervais and Alix it has received the name which for want of a better I have adopted.

3. *Pectoralis medius.*

Pectoral moyen, Vicq d'Azyr, 1772, p. 624, No. 2.
Pectoral moyen, Cuvier, 1805, tom. i. p. 277.
Described by Merrem, p. 152, No. 2.
Der kleine Brustmuskel, Wiedemann, p. 83.
Der kleine oder mittlere Brustmuskel, Tiedemann, p. 306, No. 2.
Der kleine Brustmuskel, Heusinger, p. 183, No. 2.
Le second pectoral, Meckel, vol. vi. p. 30, No. 11.
Der grosste Oberarmheber, Schoepss, p. 124, No. 21.
Pectoralis minor, Reid, p. 141.
Subclavius, Rolleston, p. 624.
Subclavius, Selenka, Bd. vi. p. 118, No. 44.
Moyen pectoral, Gervais and Alix, 1878, p. 24.

Attachments.—The pectoralis medius *arises* from the whole of the anterior surface of the sternum, as well as from the entire length of the keel of that bone, with the exception only of those points which afford attachment to the pectoralis major. It moreover takes a considerable attachment to the sterno-clavicular membrane. From these origins the fibres converge to a stout tendon, which, after passing through the *foramen triosseum* as through a pulley, is *inserted* into an oblique ridge situated on the outer surface of the shaft of the humerus close to the head of that bone. The ridge in question separates the head of the bone from the shaft.

Action.—Passing as it does over the pulley formed by the bones of the shoulder girdle, this muscle acts as the great extensor of the wing at the shoulder joint. In other words, it raises the wing, and hence by some authors has been named the *levator humeri*.

Relations.—Superficially the muscle is covered by the pectoralis major. From above its outer border, close to the shoulder joint, the pectoralis minor passes forwards to its insertion.

Nerve supply.—A branch from the nerve which supplies the pectoralis major.

Variations.—In *Aptenodytes longirostris*, in addition to the above, the muscle has an extensive origin from the anterior surface of the proximal half of the coracoid bone.

Remarks.—The pectoralis medius, as was well known to Schoepss and Gervais, shows a distinct indication of a separation into two parts, the anterior half of the muscle, which arises chiefly from the sterno-clavicular membrane, being separated by a cellular interval from the posterior or sternal portion. This separation is more distinct in *Spheniscus demersus* than in any other species. The same arrangement, according to Gervais, obtains in the Gallinaceæ and Tinamidæ. The enormous size of the pectoralis medius in comparison with that of the pectoralis major in the Penguins has been noted by every anatomist who has dissected any member of the group.

4. *Pectoralis minor.*

Le petit pectoral, Vicq d'Azyr, 1772, p. 625, No. 3.
Le petit pectoral, Cuvier, 1805, vol. i. p. 278, No. 3.
Described by Merrem, p. 152, No. 3.
Der kleinste Brustmuskel, Wiedemann, p. 83.
Der kleinste Brustmuskel, Tiedemann, p. 307, No. 3.
Pectoralis minimus, Heusinger, p. 103, No. 3.
Troisième pectoral, Meckel, vol. vi. p. 38, No. 12.
Der dritte Brustmuskel, Schoepss, p. 113, No. 16.
Coraco-brachialis, Reid, p. 141.
Coraco-brachialis longus, Selenka, p. 114, No. 40.
Coraco-brachial, Gervais and Alix, p. 23.

Attachments.—The pectoralis minor *arises* from about half an inch of the lateral margin of the sternum, just posterior to the coraco-sternal articulation, as well as, but to a greater extent, from an aponeurotic septum between the pectoralis medius and minor, which septum is attached to the external margin of the shaft of the coracoid bone. The fibres form an oval belly, from which a tendon passes forwards and upwards, to be *inserted* into the outer margin of the tricipital fossa of the humerus, close to the posterior margin of the tendon of insertion of the pectoralis medius.

Action.—This muscle depresses the wing at the shoulder joint, so as to approximate it to the side of the body. The muscle, therefore, comes into play in producing the effective or propulsive stroke of the wing. Moreover, in consequence of the passage of its tendon upwards below the neck of the humerus, the muscle is enabled to rotate the entire wing around the axis of the humerus in such a manner as to direct the concavity of the wing forwards and downwards. In this respect the pectoralis minor is the antagonist of the pectoralis major, which rotates the wing in the opposite direction. These two muscles are the principal agents in bringing about the screw-like motions of the wing at the shoulder joint, which are observable in the living bird.

Relations.—The muscle is concealed by the pectoralis major, and lies in contact with the outer border of the pectoralis medius. Its upper surface rests against the axillary vessels and nerves as they pass out of the thorax.

Nerve supply.—A twig from the nerve which supplies the pectoralis major.

Remarks.—Selenka is of opinion that this muscle, named by him the coraco-brachialis longus, is identical with muscle No. 17 of Schoepss. This does not appear to me to follow from an accurate reading of Schoeps' description. I am rather inclined, as above noted, to regard Selenka's coraco-brachialis as corresponding to muscle No. 16 of Schoepss' description.

5. *Coraco-brachialis.*

Souclavier interne, Vicq d'Azyr, 1772, p. 628, No. 1.
Der vordere anziehende Armmuskel, Merrem, p. 153, No. 6.
Coraco-brachial, Meckel, tom. vi. p. 39, No. 13.
Der obere Hackenarmmuskel, Schoeps, p. 115, No. 17.
Coraco-brachialis brevis, Selenka, p. 115, No. 41.
L'accessoire coracoïdien du sous scapulaire, Gervais and Alix, p. 23.

Attachments.—The coraco-brachialis muscle *arises* by means of a stout tendon from the anterior border and inner or thoracic surface of the sternum, close to the middle line of the bone. As it passes obliquely forwards and upwards it is further attached to the thoracic surface of the strong sterno-clavicular membrane, as well as to the proximal half of the same surface of the coracoid bone. After passing beyond that bone, the muscle ends on a tendon common to it and to the supra-spinatus, by means of which it is *inserted* into a well-marked bony tubercle, situated upon the inner margin of, and overhanging the tricipital fossa of the humerus.

Action.—This muscle depresses the wing at the shoulder joint, and approximates it to the body. In this respect it co-operates with the pectoralis minor. It acts moreover as an internal rotator of the humerus at the shoulder joint, in which respect it co-operates with the pectoralis major, but opposes the pectoralis minor.

Relations.—The origin of the muscle is deeply situated under cover of the sternum and coracoid bone. In the axilla the muscle lies parallel to and in contact with the inner border of the pectoralis minor. The axillary vessels and nerves are in contact with it posteriorly.

Nerve supply.—A twig from the branch which supplies the pectoralis medius. This twig is given off from the larger nerve just before the latter pierces the coracoid bone.

Remarks.—Cuvier mentions the existence of two muscles in birds, either of which may correspond to the coraco-brachialis.[1] From want of accuracy of description it is impossible to say which. According to Selenka,[2] the coraco-brachialis as above described is included by Tiedemann along with his deltoideus minor and levator humeri. The muscle is not mentioned by Wiedemann.

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[1] Leçons d'Anatomie Comparée, tom i. p. 278.
[2] Bronn, Classen und Ordnungen des Thierreichs, Aves, vol. vi. p. 115.

6. *Subscapularis.*

Sousclavier externe (?), Vicq d'Azyr, 1772, p. 628, No. 2.
Sous-scapulaire, Cuvier, vol. i. p. 271.
Subscapularis, Wiedemann, p. 89.
Sous-scapulaire, Meckel, vol. vi. p. 40.
Unterschulterblattmuskel, Schoepss, p. 128, No. 22.
Subscapularis, Reid, p. 142.
Subscapularis, Selenka, Bd. vi. p. 113.
Sous-scapulaire, Gervais and Alix, 1878, p. 22.

Attachments.—The subscapularis is a very small muscle, which *arises* from about half an inch of the axillary margin of the scapula, immediately behind the articulation of that bone with the coracoid. Its fibres almost at once unite with those of the coraco-brachialis, and are *inserted* by means of a tendon common to the latter and the supra-spinatus into the bony tubercle on the inner margin of the tricipital fossa of the humerus.

Action.—This muscle depresses the wing at the shoulder joint, and approximates it to the trunk. It also co-operates with the coraco-brachialis in rotating the humerus inwards, and in this respect opposes the action of the pectoralis minor.

Relations.—The muscle is separated at its origin from the lower border of the infra-spinatus by the insertion of the serratus anticus minor, both of which lie above it. Below it is the coraco-brachialis.

Nerve supply.—A direct branch of the brachial plexus.

Remarks.—According to Schoepss (*loc. cit.*, p. 130), the tendon of insertion of the subscapularis in the Penguin unites with that of the pectoralis minor. Such is not the case in any species of Penguin dissected by myself.

7. *Supra-spinatus.*

L'huméro-scapulaire, Vicq d'Azyr, 1773, p. 569, No. 6.
Schulterarmmuskel, Wiedemann, p. 86.
Humero-scapularis parvus, Tiedemann, p. 310, No. 9.
Humero-scapularis parvus, Heusinger, p. 184, No. 9.
Sous-épineux, Meckel, vol. vi. p. 30, No. 6.
Supra-spinatus v. Teres minor, Schoepss, p. 107, No. 14.
Teres minor, Reid, p. 142.
Infra-spinatus, Selenka, vol. vi. p. 113, No. 38.
Le petit rond, Gervais and Alix, p. 22.

Attachments.—The supra-spinatus muscle *arises* from the anterior fourth of the dorsal surface of the scapula posterior to the neck of the bone, from which the fibres do not arise. The fibres pass forwards and outwards to end on a tendon common to it, the coraco-brachialis, and the subscapularis. This tendon is *inserted* into the bony tubercle on the inner margin of the tricipital fossa of the humerus.

Action.—The muscle co-operates with the coraco-brachialis in approximating the wing to the side of the body, as well as in rotating that organ inwards at the shoulder joint.

Relations.—The muscle is concealed superficially by the anterior portion of the latissimus dorsi. Its posterior margin is in contact with the infra-spinatus muscle.

Nerve supply.—A twig from the nerve to the latissimus dorsi, which turns round the axillary margin of the scapula, and enters the outer border of the muscle.

Remarks.—Cuvier[1] merely mentions the presence in birds of a supra- and infra-spinatus muscle, but does not describe their exact attachments. Gervais and Alix[2] state that in the Penguin (*Eudyptes chrysolophus*) the supra-spinatus (petit rond) is inserted above the subscapularis. As above stated, I have found that in every species of Penguin, the supra-spinatus and the subscapularis are attached to the humerus by means of a single tendon common to both.

8. *Infra-spinatus.*

Sous-scapulaire, Vicq d'Azyr, 1772, p. 631, No. 3.
Schulterblattmuskel, Merrem, p. 154, No. 13.
Schulterblattmuskel, Wiedemann, p. 87.
Supra-scapularis, Tiedemann, p. 310, No. 8.
Supra-scapularis, Heusinger, p. 184, No. 8.
Sous-épineux, Meckel, vol. vi. p. 29, No. 5.
Infra-spinatus v. Teres major, Schoeps, p. 105, No. 13.
Infra-spinatus, Reid, p. 141.
Teres major, Selenka, vol. vi. p. 113, No. 37.
Le grand rond, Gervais and Alix, p. 22.

Attachments.—The infra-spinatus *arises* from the posterior three-fourths of the dorsal surface of the scapula. The fibres pass forwards and downwards and end on a strong tendon which is *inserted* into the inner margin of the tricipital fossa of the humerus one-eighth of an inch below the bony tubercle which affords attachment to the tendon common to the supra-spinatus, coraco-brachialis, and subscapularis.

Action.—The humerus being raised, this muscle is an important, if not the principal agent in bringing about the backward or effective stroke of the wing. This muscle, moreover, rotates the humerus inwards at the shoulder joint, and thus co-operates with the pectoralis major.

Relations.—Superficially the muscle is covered by the dorsal cutaneous muscle, and by the anterior portion of the latissimus dorsi. Its upper border lies parallel to, and in contact with the posterior border of the supra-spinatus. The lower border projects considerably beyond the axillary border of the scapula, and forms the posterior boundary of the axilla.

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[1] Leçons d'Anatomie Comparée, tom. i. p. 378.

[2] *Loc. cit.*, p. 22.

Nerve supply.—A twig from the nerve to the latissimus dorsi. It turns round the axillary margin of the scapula, and enters the lower border of the muscle.

Remarks.—In *Pygosceles tæniatus* the absence of the dorsal portion of the cutaneous muscle occasions a corresponding difference in the relations of the infra-spinatus muscle.

9. *Latissimus dorsi.*

Grand dorsal, Vicq d'Azyr, 1772, p. 631, No. 4.
Grand dorsal, Cuvier, vol. i. p. 270.
Der hintere anziehende Armmuskel, Merrem, p. 153, Nos. 7 and 8.
Der Rückgratsoberarmmuskel, Wiedemann, pp. 84 and 85.
Latissimus dorsi, Tiedemann, p. 308, No. 4.
Der breite Rückenmuskel, Heusinger, p. 183, No. 4.
Muscle large du dos, Meckel, vol. vi. p. 31, No. 7.
Der breite Rückenmuskel, Schoepss, p. 103, No. 12.
Latissimus dorsi and another, Reid, p. 141.
Latissimus dorsi, Selenka, vol. vi. p. 120, No. 45.
Grand dorsal, Gervais and Alix, p. 21.

Attachments.—The latissimus dorsi consists of two distinct portions, which for the sake of clearness we may distinguish as A. and B.

Portion A. *arises* by means of a broad flattened tendon from the spines of the second, third, fourth, fifth, and sixth dorsal vertebræ. The fibres converge as they pass forwards and outwards, and terminate on a narrow tendon, which, after passing through a fibrous pulley, attached to the axillary margin of the scapula, is *inserted* into the posterior border of the shaft of the humerus, close to the lower margin of the tricipital fossa.

Action.—This muscle carries the wing backwards at the shoulder joint. It is one of the most powerful of the muscles which contribute to the production of the effective or progressive stroke of the wing.

Relations.—The anterior fibres of the muscle are concealed at their origin by the cutaneous muscle of the neck, whilst the posterior are covered by the dorsal cutaneous muscle. It rests upon the trapezius.

Portion B., which is quite distinct, and separated by an interval from the preceding muscle *arises* by means of a delicate fascia covering the last three ribs, from the anterior margin of the iliac bone. The fibres pass forwards towards the shoulder joint, and terminate on a tendon, which, after passing along with that of portion A. through the fibrous pulley above mentioned, is *inserted* into the posterior border of the shaft of the humerus, close to, but slightly higher than the tendon of insertion of portion A.

Action.—The action of this muscle is similar to that of the preceding. In consequence of the greater obliquity of its fibres, however, its action is more powerful than that of portion A.

Relations.—Concealed at its origin by the dorsal cutaneous muscle, as well as by the sartorius, it rests upon the ribs, intercostal, and infra-spinatus muscles.

The fibrous pulley (Pl. X. fig. 4) through which the two tendons of the latissimus dorsi pass, consists of a ligamentous band which measures half an inch in length, and is attached to the axillary margin of the scapula close to the glenoid fossa. The free extremity of the band is perforated by the tendons in question, the aperture being lined by a synovial membrane.

Nerve supply.—A branch from the musculo-spiral nerve, which divides into two twigs—one to each portion of the muscle.

Variations.—In *Eudyptes chrysocome* from Kerguelen, portion A. of the latissimus dorsi arises from the spines of the last two cervical and first three dorsal vertebræ. This is also the case in *Eudyptes chrysolophus.* In *Spheniscus magellanicus* the tendon of insertion of portion A. is double, and this portion of the muscle arises from the spines of all the dorsal vertebræ except the last. In *Spheniscus minor*, *Pygosceles tæniatus* and *Aptenodytes longirostris* the two portions of the latissimus dorsi are not separated by an interval at their origins as in the other species, but form one continuous muscular sheet, the fibres of which, however, end on two distinct tendons which are arranged precisely as in all the other species examined.

According to Meckel and Schoepss, in the Penguin the two portions of the latissimus dorsi are united at their origins, as described above in *Pygosceles.* Meckel, moreover, states that the anterior part of the muscle (portion A. of my description) is provided with two tendons of insertion, as noticed above in *Spheniscus magellanicus.*

10. *Musculus tensor patagii longus.*

Grand extenseur de la membrane de l'aile, Vicq d'Azyr, 1773, p. 568, No. 3.
Der langsehnige Muskel, Merrem, p. 156, No. 1.
Spanner der vorderen Flügelhaut, Tiedemann, vol. ii. p. 317.
Spanner der vorderen Flügelhaut, Heusinger, p. 185, No. 13.
Spanner der vorderen Flügelhaut, Wiedemann, p. 85, No. 2.
Tenseur de la membrane antérieure du vol, Meckel, vol. vi. p. 61.
Langer Muskel der vorderen Flügelfalte, Schoepss, p. 82, No. 2.
Deltoid (?), Reid, p. 141.
Tensor patagii longus, Selenka, vol. vi. p. 122, No. 48.
Tenseur marginal de la membrane antérieure de l'aile, Gervais and Alix, p. 23.

Attachments.—This muscle *arises* from a small part of the dorsally recurved portion of the clavicle, from the hook-like extremity of the coracoid bone, and from the coraco-clavicular ligament. The fibres converge as they pass backwards and outwards over the shoulder joint, and are *inserted* by means of a tendon into the whole length of the anterior or radial margin of the bones of the wing, as far as the extremity of the last phalanx.

Action.—The muscle carries the wing forwards at the shoulder joint, at the same time that it elevates it. In this respect it is the direct antagonist of the latissimus dorsi.

Relations.—The muscle is in part subcutaneous, and rests upon the shoulder joint. Its anterior margin lies in contact with the pectoralis major. Its posterior border is concealed by the long head of the triceps. The tendon of insertion of this muscle contributes, along with that of the pectoralis major, to the formation of the alar aponeurotic sheath described along with the last-named muscle (see page 80).

Nerve supply.—A branch from the trunk of the musculo-spiral. This branch winds round the inner side of the neck of the humerus, and enters the posterior border of the muscle.

Variations.—In *Pygosceles tæniatus*, as well as in *Aptenodytes longirostris*, the tensor patagii longus is divisible into two portions—a superficial and a deep. The superficial part (detoideus postérieur of Gervais and Alix, p. 23) *arises* from the dorsal, recurved extremity of the clavicle, between the articulation of the latter with the coracoid and with the scapula. It is *inserted* into the posterior margin of the humerus, immediately above the insertions of the two tendons of the latissimus dorsi. The deeper portion of the muscle corresponds exactly to the tensor patagii longus as above described, and is *inserted* in a similar manner into the anterior or radial border of the humerus. In *Aptenodytes longirostris*, moreover, there is an accessory slip to the tensor patagii, the presence of which I could not substantiate in any other species of Penguin. It *arises* from the outer surface of the sterno-clavicular aponeurosis, immediately in front of the origin of the pectoralis medius, and passing through the foramen bounded by the three bones forming the shoulder girdle, is *inserted* along with the deeper fibres of the tensor patagii longus into the anterior or radial border of the humerus.

Remarks.—Schoepss figures the tensor patagii longus in the Penguin as consisting of two bellies, an anterior and a posterior. Gervais and Alix also describe in *Eudyptes chrysolophus* a "*deltoïde postérieur*," which evidently corresponds to the superficial portion of the tensor patagii longus above referred to as occurring in *Aptenodytes longirostris* and in *Pygosceles tæniatus*. Meckel describes the tensor longus in the Penguins as consisting of two bellies, one of which can with difficulty be separated from the pectoralis major. One of these evidently corresponds to the superficial, the other to the deeper portion of the tensor patagii longus above noticed as occurring in *Aptenodytes* and in *Pygosceles*. Possibly this is the normal arrangement in all species of Penguin, although I failed to identify it in any excepting *Aptenodytes* and *Pygosceles*. It must be remembered, however, that all the specimens examined had been submitted to the action of preservative fluids, which may have prevented the separation and identification of two portions of this muscle in any but the two species above mentioned.

The accessory slip above described in *Aptenodytes* does not appear to have been observed by any other anatomist who has investigated the anatomy of the Spheniscidæ.

(c) Muscles inserted into the Radius and Ulna.

1. *Triceps extensor cubiti.*

Le grand extenseur du coude, Vicq d'Azyr, 1773, p. 571, No. 1.
Extenseur de l'avant bras, Cuvier, vol. i. p. 296.
Described by Merrem, p. 155, Nos. 1 and 2.
Der lange äussere und innere Ellenbogenmuskel, Wiedemann, pp. 86 and 89.
Anconeus longus et brevis, Tiedemann, p. 314, Nos. 7 and 8, and p. 315, No. 9.
Der lange, kurzere, und kleinste Ellenbogenknorrenmuskel, Heusinger, p. 185, Nos. 16, 17, 18.
L'extenseur de l'avant bras, Meckel, vol. vi. p. 53, No. 9.
Der Strecker des Vorderarmes, Schoepss, p. 130, No. 23.
Triceps extensor cubiti, and anconeus, Reid, p. 142.
Triceps brachii, Selenka, vol. vi. p. 123, No. 53.
La longue portion du triceps brachial, le vaste externe, et le vaste interne, Gervais and Alix, pp. 25 and 26.

Attachments.—This, the great extensor of the forearm, consists of four distinct heads. The first and largest head *arises* from the inner or thoracic surface of the dorsal recurved extremity of the clavicle immediately behind the origin of the tensor patagii longus, to a small extent from the coraco-clavicular ligament, and from the acromion process of the scapula. The muscular fibres composing this head form a triangular belly, which arches downwards and outwards to terminate on the tendon common to this and to the second head. The second head *arises* from the axillary border of the scapula, immediately behind the glenoid fossa, close to the attachment of the fibrous pulley through which pass the tendons of the latissimus dorsi. The third head *arises* from the tricipital fossa of the humerus, while the fourth head is attached to the whole length of the posterior or ulnar border of the humerus. The first and second heads unite together immediately behind the shoulder joint, the common tendon being subsequently joined by the muscular fibres of the third head. Thereafter the tendon of insertion divides into two parts—an inner and an outer. The inner tendon receives the majority of the muscular fibres which form the fourth head of origin, and after passing behind the elbow joint is *inserted* into an angular projection on the upper end of the posterior margin of the ulna. In connection with this tendon, as it passes over the elbow joint, is developed the inner or smaller of the two ulnar sesamoid bones. The outer tendon of insertion of the triceps receives a few of the muscular fibres which form the fourth head of the muscle, and passing behind the elbow joint is *inserted* into the outer side of the upper end of the ulna, midway between the insertion of the inner tendon and the articular surface for the reception of the humerus. In connection with this tendon is developed the outer or larger of the two ulnar sesamoid bones.

Action.—The first and second heads of origin of the triceps co-operate with the latissimus dorsi in effecting the backward or effective stroke of the wing. In conjunction with the third and fourth heads, they are the principal extensors of the forearm at the elbow joint.

Relations.—The first head is to a large extent subcutaneous, and rests upon the shoulder joint. The second head arises from the scapula close to the attachment of the fibrous pulley of the latissimus dorsi. The tendon of insertion of the pectoralis minor, as well as those of the latissimus dorsi, intervenes between the second and third heads.

Nerve supply.—The first and second heads are supplied by nerves derived from the great cord of the brachial plexus. The third and fourth heads are supplied by branches from the musculo-spiral nerve.

Variations.—In *Eudyptes chrysolophus* the second head of the triceps arises not only from the axillary border of the scapula, but also from the fibrous pulley through which the tendons of the latissimus dorsi pass. In this bird, moreover, the third and fourth heads are quite continuous, and are not separated by an interval, as in the other species examined. In *Aptenodytes longirostris* the external tendon of insertion of the triceps is inserted into the ulna by two distinct slips, one of which coalesces with the internal tendon above described.

2. *Brachialis internus.*

Le court fléchisseur de l'avant bras, Vicq d'Azyr, 1773, p. 572, No. 3.
Der Ellenbogenbeuger, Wiedemann, p. 89.
Brachialis internus, Tiedemann, p. 312, No. 2.
Der innere Armmuskel, Heusinger, p. 184, No. 11.
Le deuxième fléchisseur de l'avant bras, Meckel, vol. vi. p. 48, No. 2.
Der kurze Beuger des Vorderarmes, Schoepss, p. 141, No. 28.
Brachialis internus, Selenka, vol. vi. p. 125, No. 52.
Court fléchisseur de l'avant bras, Gervais and Alix, p. 27.

Attachments.—The brachialis internus is a short quadrilateral muscle, which *arises* from a slight depression occupying the lower third of the anterior (radial) margin of the shaft of the humerus. The fibres pass in front of the humero-radial articulation, and are *inserted* into a deep excavation on the anterior border of the radius, immediately below the upper end of that bone.

Action.—This muscle is the principal flexor of the forearm upon the humerus.

Relations.—The brachialis internus rests upon the front of the elbow joint.

Nerve supply.—A twig from the radial nerve, which is given off opposite the elbow joint.

Remarks.—According to Gervais and Alix, this muscle corresponds to the long external supinator of the Crocodile. These authors consider that this muscle, because of its insertion into the radius, cannot be considered as homologous with the brachialis anticus of other birds. Neither does it constitute the representative of the Biceps, seeing that it is not inserted into the interosseous border of the radius.

3. *Flexor profundus antibrachii.*

Le fléchisseur profond de l'avant bras, Vicq d'Azyr, 1773, p. 573, No. 8.
Le profond fléchisseur, Cuvier, vol. i. p. 293.
(?) Described by Merrem.
Der kurze Ellenbogenstrecker, Wiedemann, p. 91.
Kurze Beuger des Ellenbogenbeins, Tiedemann, p. 313, No. 6.
Der kurze Beuger des Ellenbogenbeins, Heusinger, p. 185, No. 15.
Muscle No. 6, Meckel, vol. vi. p. 50.
Der tief. Beuger des Vorderarmes, Schoepss, p. 142, No. 29.

Attachments.—Schoepss found this muscle present in *Spheniscus demersus*, and describes it as a slender muscle which *arises* from the lower part of the anterior border of the humerus. From this point it descends, lying parallel to the deeper fibres of the brachialis internus, and after crossing the humero-radial articulation is *inserted* into the radial border of the ulna, close to the ligamentous capsule of the elbow joint.

Remarks.—I failed to recognise the presence of this muscle in any species of Penguin which I dissected. In this respect my observations agree with those of Meckel, who asserts the absence of this muscle in the Penguin. Gervais and Alix, moreover, omit all reference to it in their description of the myology of *Eudyptes chrysolophus*.

4. *Anconeus.*

Attachments.—The muscle so named is said by Reid to be present in *Aptenodytes longirostris*, where it *arises* from the lower end of the humerus, and is *inserted* into the sesamoid bones of the elbow.

According to Gervais and Alix, it is represented in *Eudyptes chrysolophus* by the tendon which attaches the external sesamoid bone of the elbow to the upper extremity of the ulna.

Remarks.—I failed to recognise this muscle in any species of Penguin. The ligament which, according to Gervais and Alix, replaces it, is present in every species of Penguin, but appears to me to be simply that portion of the tendon of insertion of the triceps which attaches the external sesamoid bone to the upper end of the ulna.

5. *Pronator quadratus.*

Attachments.—Reid describes this muscle in *Aptenodytes* as "arising as is usual in this class."

It was absent in every species which I examined. Gervais and Alix, moreover, observe that it is entirely wanting in *Eudyptes chrysolophus*.

6. *Supinator brevis.*

Le court supinateur, Vicq d'Azyr, 1773, p. 573, No. 7.
Le court supinateur, Cuvier, vol. i. p. 299.
Der Anleger des Vorderarmes, Merrem, p. 155, No. 4 (?).
Der äussere Speichenbeuger, Wiedemann, p. 90.
Supinator, Tiedemann, p. 313, No 5.
Supinator brevis (?) Heusinger, p. 185, No. 14.
Le court supinateur, Meckel, vol. vi. p. 51, No. 8.
Der Rückwärtswender, Schoepss, p. 140, No. 27.
Supinator brevis, Selenka, vol. vi. p. 129, No. 57.
Le court supinateur, Gervais and Alix, p. 26.

Attachments.—This muscle *arises* by means of a delicate flattened tendon from the outer surface of the lower end of the humerus, close to the external lateral ligament of the elbow joint. The muscular fibres pass obliquely downwards and forwards, and are *inserted* into the upper third of the groove on the outer surface of the radius, which accommodates the tendon of the extensor carpi radialis longior.

Action.—The supinator brevis flexes the elbow joint.

Relations.—It rests upon the outer surface of the upper end of the radius, and is concealed by the alar aponeurosis, as well as in part by the upper portion of the long radial extensor.

Nerve supply (?)

Variations.—I found this muscle better developed in *Aptenodytes longirostris* and in *Spheniscus demersus* than in any other species.

(*d*) Muscles inserted into the Carpal Bones.

1. *Flexor carpi ulnaris.*

Le cubital interne, Vicq d'Azyr, 1773, p. 573, No. 6.
Le cubital interne, Cuvier, vol. i. p. 319.
Der Ausdehner des Armes, Merrem, p. 155, No. 6 (?).
Der lange Ellenbogenbeuger, Wiedemann, p. 92.
Flexor carpi ulnaris, Tiedemann, p. 320, No. 5.
Ellenbogen-Handwurzelbeuger, Heusinger, p. 189, No. 26.
Fléchisseur cubital, Meckel, vol. vi. p. 59, No. 8.
Langer Beuger des Handwurzels, Schoepss, p. 154, No. 35.
Flexor carpi ulnaris, Selenka, vol. vi. p. 133, No. 64.
Cubital antérieur, Gervais and Alix, p. 29.

Attachments.—This muscle is entirely replaced by tendon. It *arises* from the inner side of the lower end of the humerus, immediately behind the origin of the tendon which represents the flexor sublimis digitorum. It passes along the inner side of the ulna, close to the posterior border of that bone, and is *inserted* into the inner side of the base of the ulnar carpal bone.

Relations.—Covered by the alar aponeurosis this tendon rests against the inner side of the ulna. It lies behind and parallel with the flexor sublimis digitorum.

(e) Muscles inserted into the Metacarpal Bones.

1. *Extensor metacarpi radialis longus.*

Le long radial, Vicq d'Azyr, 1773, p. 575, No. 1.
Der hintere äussere Handspanner, Merrem, p. 156, No. 2.
Der Mittelhandstrecker, Wiedemann, p. 90.
Extensor metacarpi radialis longus, Tiedemann, p. 317, No. 1.
Extensor metacarpi radialis longus, Heusinger, p. 187, No. 22.
Long extenseur radial, Meckel, vol. vi. p. 55, No. 1.
Extensor metacarpi radialis longus, Schoepss, p. 145, No. 31.
Described but not named by Reid, p. 142.
Extensor metacarpi radialis longus, Selenka, vol. vi. p. 130, No. 59.
Le long supinateur, Gervais and Alix, p. 26.

Attachments.—The long radial extensor *arises* from the anterior or radial border of the humerus, immediately above and to the outer side of the origin of the brachialis internus. The muscular fibres are short, and end on a tendon which, after passing along a shallow groove on the outer surface of the radius close to the anterior free border of that bone, is *inserted* into the upper end of the radial or anterior border of the radial metacarpal bone.

Action.—This muscle flexes the elbow and extends the wrist joint.

Relations.—The belly of the muscle rests against the outer side of the brachialis internus.

Remarks.—According to Schoepss, this muscle arises from the humerus in the Penguin by two distinct heads. This arrangement I have failed to find in any species which I have dissected. Meckel found the tendon of insertion of the extensor radialis longus coalescent with that of the tensor patagii. Such was not the case in any of my specimens. According to Gervais and Alix, the tendon of insertion of this muscle is united with that of the short radial extensor as they pass together over the radial carpal bone. In all of the specimens which I have dissected these two tendons are distinct from end to end.

2. *Extensor metacarpi radialis brevis.*

Le radial grêle, Vicq d'Azyr, 1773, p. 574, No. 2.
Der vordere Handaufleger, Merrem, p. 157, No. 4.
Der Hülfsmuskel des Mittelhandstreckers, Wiedemann, p. 92.
Extensor metacarpi radialis brevis, Tiedemann, p. 318, No. 2.
Extensor metacarpi radialis brevis, Heusinger, p. 187, No. 23.
Le court extenseur radial, Meckel, vol. vi. p. 56, No. 2.
Extensor metacarpi radialis brevis, Schoepss, p. 148, No. 32.
Extensor pollicis longus, Selenka, vol. vi. p. 133, No. 63.
Abducteur du pouce, Gervais and Alix, p. 27.

Attachments.—This muscle *arises* from the upper third of the contiguous borders of the radius and ulna, as well as from the middle third of the outer surface of the former. The muscle ends on a tendon which lies at first in an oblique groove on the outer surface of the lower end of the radius, and after crossing the wrist joint is *inserted* into the radial margin of the upper end of the radial metacarpal bone, close to the insertion of the extensor radialis longus.

Action.—The muscle extends the hand at the wrist joint.

Relations.—It rests upon the outer surface of the radius, and is concealed by the alar aponeurosis.

Variations.—In two out of three specimens of *Aptenodytes longirostris* which I dissected, this muscle was absent. In the third it agreed with the description above given.

3. *Extensor carpi ulnaris.*

Le long fléchisseur du métacarpe, Vicq d'Azyr, 1773, p. 575, No. 5.
Cubital externe, Cuvier, vol. i. p. 520.
Der hintere innere Handspanner, Merrem, p. 156, No. 3.
Der obere oder lange Mittelhandbeuger, Wiedemann, p. 91.
Flexor metacarpi radialis, Tiedemann, p. 319, No. 4.
Der Speichen-Mittelhandbeuger, Heusinger, p. 188, No. 25.
L'extenseur cubital de la main, Meckel, vol. vi. p. 57, No. 3.
Abductor metacarpi, Schoepss, p. 150, No. 33.
Extensor carpi ulnaris, Selenka, vol. vi. p. 131, No. 60.
Le cubital postérieur, Gervais and Alix, p. 27.

Attachments.—The extensor carpi ulnaris in the various species of Penguin is entirely tendinous. It *arises* above, from the outer side of the lower end of the humerus immediately behind the attachment to that bone of the external lateral ligament of the elbow joint. It extends along the interval between the radius and ulna, and, after crossing the outer side of the wrist joint, is *inserted* into the middle in length of the ulnar margin of the radial metacarpal bone.

Action.—The muscle being represented throughout by tendon is functionally useless.

Relations.—This tendon is concealed by the alar aponeurosis, and lies partly under cover of the tendon which, in the Spheniscidæ, represents the extensor communis digitorum. It is in part continuous with the external lateral ligament of the elbow joint.

Variations.—In *Eudyptes chrysocome* from Kerguelen I found this tendon inserted into the middle in length of the radial border of the ulnar metacarpal bone. The same arrangement obtains in *Aptenodytes longirostris.*

Remarks.—Schoepss found this tendon inserted into both radial and ulnar metacarpal bones. In figure 1 plate v. attached to Schoepss' paper, the numbers 23 (which in accordance with the text ought to be 33) and 37, indicating the extensor carpi ulnaris and extensor communis digitorum respectively, ought to be reversed.

4. *Flexor metacarpi brevis.*

Le court fléchisseur de l'os du métacarpe, Vicq d'Azyr, 1773, p. 577, No. 3.
Flexor brevis metacarpi, Tiedemann, p. 320, No. 6.
Der kurze Beuger des Mittelhandknochens, Heusinger, p. 196, No. 27.
Muscle No. 4, Meckel, vol. vi. p. 58, No. 4.
Kurze Beuger der Mittelhand, Schoepss, p. 156, No. 36.
Flexor carpi radialis, Selenka, vol. vi. p. 134, No. 65.
Le court adducteur de la main, Gervais and Alix, p. 28.

Attachments.—This muscle *arises* by means of a narrow tendon from the lower end of the posterior border of the ulna, immediately above the wrist joint. The fibres pass downwards, and are *inserted* without the intervention of tendon into the upper half of the ulnar metacarpal bone.

Action.—This muscle flexes the wrist joint.

Relations.—It is covered by the alar aponeurosis, and rests against the outer surface of the ulnar carpal bone.

Nerve supply (?)

Variations.—In *Eudyptes chrysocome* from Kerguelen this muscle is inserted into the whole length of the ulnar metacarpal bone. This is also the case in *Spheniscus demersus.*

Remarks.—According to Gervais and Alix, this muscle in *Eudyptes chrysolophus* is inserted into the whole length of the ulnar metacarpal bone.

5. *Adductor metacarpi.*

Der kleine Mittelhandstrecker, Wiedemann, p. 93.
Ellenbogenstrecker der Mittelhand, Tiedemann, p. 319, No. 3.
Der Ellenbogenbein-Mittelhandstrecker, Heusinger, p. 188, No. 24.

Attachments.—According to Schoepss, this muscle in *Spheniscus demersus* is represented by a slender tendon, which *arises* from the lower part of the inner surface of the ulna, and after coursing along the inner side of the radial metacarpal bone, is *inserted* into the inner side of the base of the first radial phalanx.

Remarks.—I failed to find any trace of a tendon answering to this description in *Spheniscus demersus*, or in any other species which I examined; neither is it referred to by Gervais and Alix in their account of the myology of *Eudyptes chrysolophus.*

(*f*) MUSCLES INSERTED INTO THE PHALANGES.

1. *Extensor indicis proprius.*

L'extenseur externe du doigt (!), Vicq d'Azyr, 1773, p. 574, No. 3.
Der Strecker des ersten und zweiten Gliedes des zweiten Fingers, Tiedemann, p. 322, No. 5.
Der äussere oder hintere Strecker des ersten und zweiten Gliedes des zweiten Fingers, Heusinger, p. 193, No. 35.
L'extenseur propre du deuxième doigt, Meckel, vol. vi. p. 69, No. 2.
Extensor indicis proprius longus, Schoepss, p. 159, No. 35.
Extensor digiti indicis proprius longus et brevis, Selenka, vol. vi. p. 132, No. 62.
Extenseur de la deuxième phalange du doigt médian, Gervais and Alix, p. 28.

Attachments.—This is a very slender muscle. It *arises* from the contiguous borders of the radius and ulna, below the origin of the extensor metacarpi radialis brevis, and terminates on a delicate tendon, which, after passing over the wrist joint and along the outer surface of the radial metacarpal bone, is inserted into the outer side of the second or terminal radial phalanx.

Action.—It extends the hand at the wrist joint.

Relations.—The muscle is deeply situated between the lower ends of the radius and ulna, and is concealed by the tendon of the extensor communis digitorum.

Nerve supply.—A twig from the interosseous branch of the musculo-spiral nerve.

Variations.—In one specimen of *Aptenodytes longirostris* this muscle was absent, and its insertion replaced by a supernumerary tendinous slip derived from the extensor communis digitorum.

Remarks.—According to Meckel, this muscle in the Penguin is represented entirely by tendon. Schoepss found that its origin was confined to the lower end of the radius. The muscle is apparently described by Reid, but his description is unsatisfactory.

2. *Extensor communis digitorum.*

Le fléchisseur de l'appendix, Vicq d'Azyr, 1773, p. 574, No. 4.
L'abducteur commun, Cuvier, vol. i. p. 526.
Der grosse Daumenanzieher, Merrem, p. 157, No 10.

Der zweischwänzige Daumenbeuger, Wiedemann, p. 91.
Flexor communis pollicis et digiti secundi, Tiedemann, p. 323, No. 6.
Der gemeinschaftliche Beuger des Daumens und des zweiten Fingers, Heusinger, p. 196, No. 37.
Muscle No. 1, Meckel, vol. vi. p. 68.
Der lange gemeinschaftliche Fingerstrecker, Schoepss, p. 157, No. 37.
Extensor communis digitorum (?), Reid, p. 142.
Extensor digitorum communis longus, Selenka, vol. vi. p. 131, No. 61.
L'extenseur du pouce et de la première phalange du deuxième doigt, Gervais and Alix, p. 28.

Attachments.—This muscle is entirely replaced by tendon. It *arises* from the outer side of the lower end of the humerus, where it is in contact with the radial border of the extensor carpi ulnaris. The tendon is in part continuous with the external lateral ligament of the elbow joint. It passes along the outer side of the forearm in the interval between the radius and ulna, and, after crossing the wrist joint is *inserted* into the outer side of the radial metacarpal bone, as well as into the outer side of the base of the first radial phalanx.

Relations.—This tendon is concealed by the alar aponeurosis, and rests in the greater part of its course on the tendon which represents the extensor carpi ulnaris.

Variations.—In one specimen of *Eudyptes chrysocome* from Kerguelen, this tendon was composed of two distinct portions, precisely as figured by Schoepss in *Spheniscus demersus*. This arrangement I failed to meet with in any other species of Penguin. In *Eudyptes chrysocome* from Kerguelen, this tendon was traced as far as the base of the last radial phalanx into which it was inserted, having previously given a slip to the first radial phalanx.

3. *Flexor digitorum profundus.*

Muscle No. 4, Vicq d'Azyr, 1773, p. 572.
L'adducteur interne de la deuxième phalange, Cuvier, vol. i. p. 325.
Der Strecker des zweiten Fingergliedes, Wiedemann, p. 92.
Der Strecker des zweiten und dritten Gliedes des zweiten Fingers, Tiedemann, p. 322, No. 3.
Der vordere Strecker des Daumens und zweiten Gliedes des zweiten Fingers, Heusinger, p. 192. No. 33.
Le fléchisseur profond, Meckel, vol. vi. p. 72, No. 4.
Der tiefe lange Fingerbeuger, Schoepss, p. 163, No. 40.
Flexor communis (?), Reid, p. 142.
Flexor digitorum profundus, Selenka, vol. vi. p. 136, No. 67.
Fléchisseur de la dernière phalange du deuxième doigt, Gervais and Alix, p. 29.

Attachments.—This muscle is represented by a single tendon, which *arises* from the inner surface of the lower end of the humerus, close to, and in some measure continuous with the internal humero-ulnar ligament. As it extends along the forearm it takes an additional attachment to the contiguous borders of the radius and ulna. After crossing the inner side of the wrist joint, it passes to be *inserted* into the inner side of the base of the last radial phalanx.

Relations.—It is concealed by the alar aponeurosis and rests against the bones of the forearm.

4. *Flexor digitorum sublimis.*

L'extenseur grêle de la partie qui tient lieu de doigt, Vicq d'Azyr, 1773, p. 572, No. 5.
L'abducteur de la première phalange, Cuvier, vol. i. p. 325.
Der Fingerspanner, Merrem, p. 157.
Der obere oder lange Mittelhandbeuger, Wiedemann, p. 91.
Der vordere Strecker des ersten und zweiten Gliedes des zweiten Fingers, Heusinger, p. 191, No. 32.
Le long fléchisseur superficiel, Meckel, vol. vi. p. 71, No. 3.
Der oberflächliche lange Fingerbeuger, Schoepss, p. 161, No. 39.
Flexor sublimis digitorum, Selenka, vol. vi. p. 135, No. 66.
Le petit palmaire and *fléchisseur de la première phalange du second doigt*, Gervais and Alix, p. 29.

Attachments.—This muscle is entirely represented by tendon. It *arises* from the inner side of the lower end of the humerus, close to the posterior border of that bone, and behind the internal humero-ulnar ligament. It passes along the inner side of the forearm, and immediately above the wrist joint divides into two slips. Of these one (petit palmaire of Gervais) is *inserted* into the inner side of the ulnar carpal bone, while the other (fléchisseur de la première phalange of Gervais) passes onwards, to be *inserted* into the inner side of the base of the first radial phalanx.

Relations.—It is concealed by the alar aponeurosis, and rests against the inner side of the ulna.

Variations.—In *Aptenodytes longirostris* the second portion of this tendon unites with that of the preceding muscle, and both are inserted into the base of the terminal radial phalanx. A similar arrangement was met with in a specimen of *Eudyptes chrysocome* from Kerguelen.

Remarks.—According to Schoepss, this tendon in the Penguin is inserted into the terminal radial phalanx. He does not describe its insertion into the ulnar carpal bone. Meckel found the flexor sublimis and flexor profundus in the Penguins represented by a single tendon. This is not the case in any specimen which I have examined.

5. *Flexor minimi digiti.*

Le court fléchisseur du doigt, Vicq d'Azyr, 1773, p. 577, No. 4.
Der Anzieher des Fingers, Merrem, p. 157, No. 7.
Der Beugemuskel des dritten Fingers, Tiedemann, p. 324, No. 7.
Der Beuger des kleinen Fingers, Heusinger, p. 196, No. 38.
Abducteur du petit doigt, Meckel, vol. vi. p. 77, No. 9.
Der Beuger des kleinen Fingers, Schoepss, p. 175, No. 48.
Adductor manus, Selenka, vol. vi. p. 136, No. 68.
L'abducteur du doigt interne, Gervais and Alix, p. 29.

Attachments.—The muscle *arises* from the inner border of the upper half of the ulnar metacarpal bone. It passes obliquely downwards and inwards, to be *inserted* into the base of the ulnar phalanx.

Action.—It flexes (adducts) the ulnar phalanx upon the corresponding metacarpal bone.

Relations.—The outer side of the muscle rests against the flexor brevis metacarpi. The dorsal interosseous muscle lies parallel to its radial border.

Nerve supply (?)

6. *Abductor digiti secundi.*

Der Strecker des ersten Fingergliedes, Wiedemann, p. 94.
Strecker des ersten Gliedes des zweiten Fingers, Tiedemann, p. 322, No. 4.
Strecker des ersten Gliedes des zweiten Fingers, Heusinger, p. 193, No. 34.
L'adducteur du deuxième doigt, Meckel, vol. vi. p. 77, No. 8.
Der Anzieher des Zeigefingers, Schoepss, p. 170, No. 45.
Vierter interosseus, Selenka, vol. vi. p. 137, No. 70.
L'abducteur du deuxième doigt, Gervais and Alix, p. 29.

Attachments.—This muscle is represented by a tendon which *arises* from the upper half of a slight groove, situated on the inner surface and close to the anterior margin of the radial metacarpal bone. It passes downwards, and is *inserted* into the inner side of the base of the first radial phalanx.

Relations.—It lies in the groove of the radial metacarpal bone, from which it arises.

Variations.—In *Aptenodytes longirostris*, *Pygosceles tæniatus*, as well as in an example of *Eudyptes chrysocome* from Tristan d'Acunha, this tendon was provided with a distinct but weak muscular belly. In *Pygosceles* this muscle is traceable as far as the base of the second radial phalanx. In all the other species examined the muscle was entirely replaced by tendon.

Remarks.—According to Schoepss and Meckel, this muscle is entirely wanting in the Penguin. In *Eudyptes chrysocome*, Gervais and Alix, like myself, found it represented by tendon.

7. *Interosseus dorsalis.*

L'interosseux antérieur, Vicq d'Azyr, 1773, p. 577, No. 5.
Der äussere Mittelhandmuskel, Tiedemann, p. 325, No. 10.
Der äussere Mittelhandmuskel, Heusinger, p. 197, No. 39.
L'extenseur et abducteur interne du deuxième doigt, Meckel, vol. vi. p. 77, No. 6.
Abzieher des Zeigefingers, Schoepss, p. 172, No. 46.
Interosseus, Selenka, vol. vi. p. 137, No. 69.
Interosseux dorsal, Gervais and Alix, p. 30.

Attachments.—The dorsal interosseous muscle is slender. It *arises* from the whole length of the contiguous borders of the radial and ulnar metacarpal bones. The muscular fibres end on a delicate tendon, which, after passing between the first radial and ulnar phalanges, is *inserted* into the base of the last radial phalanx.

Action.—This muscle extends the first and second radial phalanges upon the metacarpal bone, and upon one another.

Relations.—It rests on the dorsal surface of the metacarpal bones, and is covered by the alar aponeurosis.

Nerve supply (?)

Variations.—In one specimen of *Aptenodytes longirostris*, as well as in *Spheniscus minor*, this muscle was entirely absent; while in a specimen of *Eudyptes chrysocome* from Kerguelen, as also in one of *Pygosceles tæniatus*, the muscle was represented by a tendon without muscular belly. In other specimens of both these species the muscle was arranged as above described.

Remarks.—According to Schoepss, this muscle is entirely absent in *Spheniscus demersus*. Gervais and Alix found it in *Eudyptes chrysolophus*, in which bird it presented the disposition above described. The observations of these authors with regard to its presence in *Eudyptes chrysolophus* agree with my own.

8. *Interosseus palmaris.*

Der innere Mittelhandmuskel, Tiedemann, p. 825, No. 11.
Der innere Mittelhandmuskel, Heusinger, p. 197, No. 40.
L'extenseur et abducteur externe, Meckel, vol. vi. p. 77, No. 7.
Der Beuger des Zeigefingers, Schoepss, p. 173, No. 47.
Interosseus, Selenka, vol. vi. p. 137, No. 69.
Interosseux palmaire, Gervais and Alix, p. 30.

Attachments.—The interosseous palmar muscle like the dorsal is very slender. It *arises* from the contiguous borders of the radial and ulnar metacarpal bones. Its tendon passes along the palmar surface of the wing lying between the first radial and ulnar phalanges, and is *inserted* into the inner side of the base of the last radial phalanx.

Action.—This muscle flexes the first and second radial phalanges upon the metacarpal bone, and upon one another.

Relations.—It rests on the palmar surface of the metacarpal bones, and is concealed by the long flexor tendons of the fingers, as well as by the alar aponeurosis.

Nerve supply (?)

Variations.—In one specimen of *Pygosceles tæniatus*, as well as in *Spheniscus minor*, this muscle was absent.

Remarks.—The description of Gervais and Alix of this muscle in *Eudyptes chrysolophus* agrees with the above. According to Schoepss, in *Spheniscus demersus* the muscle is inserted not into the base but into the distal extremity of the second radial phalanx.

COMPARATIVE REMARKS.

Having now described the muscles of the wing, and the varieties which these present in different members of the group of Spheniscidæ, it may be useful to summarise the distinctive characters of that group, so far as these muscles are concerned, by a brief enumeration of the peculiarities which the muscles present in the Spheniscidæ, as compared with other birds. This, I feel, I cannot do more effectively or tersely than by quoting the following paragraph from the oft-referred to monograph on the Osteology and Myology of the Spheniscidæ of MM. Gervais and Alix.

In translating this paragraph I have, for the convenience of future workers in the same field, inserted within brackets the synonymes used in the foregoing pages to designate the muscles referred to by MM. Gervais and Alix.

The peculiarities of the muscular anatomy of the wing in the Spheniscidæ may be summed up as follows :—

"The absence of the brachial biceps, brachialis anticus, pronator teres, pronator quadratus, short muscles of the thumb, and of the costal portion of the tensor membranæ axillaris (dorsal cutaneous) ; the atrophy of the infra-spinatus, and the coincident absence of a humero-scapular bone ; the atrophy of the extensors and flexors of the hand ; the feeble development of the cubitalis anterior (flexor carpi ulnaris) the proximal extremity of which does not pass round the epitrochlea and is not provided with a sesamoid ; the insertion of the angularis (levator anguli scapulæ) into the deeper surface of the scapula ; the great development of the trapezoid fascicle (portion A.) of the latissimus dorsi, its termination by means of a separate tendon, and the presence of a fibrous ring through which that tendon passes along with that of the latissimus dorsi proper (portion B.); the presence of an external fascicle (first head of triceps) belonging to the long portion of the triceps arising from the clavicle, and the great strength of that fascicle ; the presence of two large sesamoid bones behind the elbow joint, of which one receives the tendon of the vastus internus (third head of triceps), and the other those of the vastus externus (fourth head of triceps) and of the long head (second head of triceps) ; the disposition of the short flexor of the forearm (brachialis internus) ; the great strength of the accessory subscapular muscle (coraco-brachialis) ; the adhesion to the middle pectoral (pectoralis medius) of the coraco-brachialis (pectoralis minor) which in other birds does not reach the sternum ; the large size and thickness of the great pectoral (pectoralis major), composed of very oblique as well as of transverse fibres ; its insertion into the inner surface of the humerus, and the strength of its accessory cutaneous muscle (muscle des parures); the enormous strength of the middle pectoral (pectoralis medius), and its division into two parts as in the Gallinaceæ and Tinamidæ, a character which distinguishes the Spheniscidæ from all Palmipedes, at the same time that it is common to the Grebes, Rails, and wading birds in general.

"It is necessary to observe, on the other hand, the development of the great abductor of the thumb (extensor metacarpi radialis brevis), as well as of the adductor of the hand (flexor brevis metacarpi), characters which approximate the Spheniscidæ to the Ostriches."

MUSCLES OF THE LEG.

(*a*) Muscles inserted into the Femur.

1. *Gluteus medius.*

Moyen fessier, Vicq d'Azyr, 1774, p. 495, No. 4.
Moyen fessier, Cuvier, vol. i. p. 355, No. 6.
Der grosse Hüftmuskel, Merrem, fig. 3, 1.
Der grosse Gesässmuskel, Wiedemann, p. 95.
Der grosse Gesässmuskel, Tiedemann, p. 326, No. 1.
Moyen fessier, Meckel, vol. vi. p. 79, No. 1.
Gluteus minimus (?), Reid, p. 143.
Gluteus medius, Owen, p. 34.
Gluteus medius, Selenka, vol. vi. p. 139, No. 76.
Moyen fessier, Gervais and Alix, p. 31.

Attachments.—The gluteus medius *arises* from the whole of the external surface of the iliac bone as far back as the posterior border of the acetabulum, as well as from the adjoining hollowed surface formed by the fifth, sixth, and seventh lumbo-sacral vertebræ. The fibres pass nearly horizontally backwards and are *inserted* by means of a stout tendon into a depression on the outer surface of the great trochanter of the femur.

Action.—The principal action of this muscle is to rotate the femur at the hip joint in such a manner as to carry the foot outwards from the trunk. The posterior fibres of the muscle, moreover, act as direct abductors of the thigh bone.

Relations.—Superficially it is concealed by the sartorius and tensor fasciæ femoris. In contact with its lower border is the gluteus minimus. Its insertion is close to, and rather higher than that of the obturator externus.

Nerve supply.—A branch of the anterior crural, which is given off immediately after the latter escapes from the pelvis.

Remarks.—As observed by Gervais and Alix in *Eudyptes chrysolophus*, the "pyramidalis," which in the majority of birds is quite distinct from the gluteus medius, is fused with the posterior border of the latter in every species of Penguin which I have examined. The direction of the fibres as distinguished from those of the gluteus medius alone indicates its presence.

2. *Gluteus minimus.*

Petit fessier, Vicq d'Azyr, 1774, p. 495, No. 6.
Petit fessier, Cuvier, vol. i. p. 357.
Der kleine Hüftmuskel, Merrem.
Der vordere Darmbeinmuskel, Wiedemann, p. 95.
Der kleine Gesässmuskel, Tiedemann, p. 327, No. 3.
Muscle No. 2, Meckel, vol. vi. p. 80, No. 2.

Gluteus medius (?), Reid, p. 143.
Gluteus minimus, Owen, p. 34.
Gluteus minimus et quartus, Selenka, vol. vi. p. 140, No. 77.
Petit fessier, Gervais and Alix, p. 31.

Attachments.—The gluteus minimus *arises* from the posterior two-thirds of the external border of the iliac bone in front of the acetabulum, as well as from an aponeurotic septum which separates the gluteus medius from the gluteus minimus. The fibres pass obliquely backwards and outwards, and are *inserted* by means of a narrow tendon into a depression on the outer surface of the great trochanter of the femur, at the junction of the latter with the shaft of the bone.

Action.—It flexes the hip joint powerfully, and co-operates with the gluteus medius in rotating the foot outwards.

Relations.—This muscle is in great part concealed by the gluteus medius. Its lower border, however, projects beyond that of the muscle just named. The tendon of insertion is attached below that of the gluteus medius, being separated from the latter by the tendon of insertion of the obturator externus.

Nerve supply.—A branch from the anterior crural.

Variations.—In *Eudyptes chrysocome* from the Falklands, in *Eudyptes chrysolophus*, and in *Pygosceles tæniatus* the origin of the muscle is less extensive than above described, being confined to the posterior half of the iliac bone. In *Eudyptes chrysolophus*, moreover, the muscle cannot be separated without artificial dissection from the gluteus medius.

In *Aptenodytes* I observed a tendency on the part of this muscle to divide into two distinct portions, an upper and a lower, a cellular interval lying between them.

Remarks.—In a number of birds, *e.g.*, the common fowl, in addition to the gluteal muscles above described, there is one (the gluteus medius of Tiedemann, the iliaque antérieur of Vicq d'Azyr) which arises from the lower half of the anterior margin of the iliac bone, and is inserted into the great trochanter of the femur. Of this muscle the Penguins do not possess the slightest trace.

According to Gervais and Alix, the smallest gluteal muscle in *Eudyptes chrysolophus* is inserted into the inner surface of the femur. Neither in the species named, nor in any other species of Penguin, did I find this statement to be correct. On the contrary, in all the gluteus minimus is inserted, as above described, into the outer surface of the femur.

3. *Cruro-coccygeus.*

Cruro-coccygien, Vicq d'Azyr, 1774, p. 496, No. 3.
Schenkel-Steissbein-Muskel, Wiedemann, p. 98.
Erster Seitenmuskel des Schwanzes, Tiedemann, p. 294, No. 3.
Schwanzhuftmuskel, Merrem.

Muscle No. 5, Meckel, vol. vi. p. 83.
Described but not named, Reid, p. 143.
Adductor longus, Selenka, vol. vi. p. 141, No. 81.
Femoro-coccygien (faisceau caudal), Gervais and Alix, p. 32.

Attachments.—The cruro-coccygeus *arises* by means of a flattened tendon measuring half an inch in breadth from the middle third of the external border of the last coccygeal vertebra—the so-called ploughshare bone. It passes obliquely forwards and downwards, and is *inserted* along with the posterior fibres of the following muscle into the posterior surface of the shaft of the femur, immediately above the external condyle, and close to the attachment of the upper end of the fibrous pulley through which the tendon of insertion of the biceps passes.

Action.—This muscle, acting in concert with its fellow of the opposite side, depresses the tail. Taking its fixed point at the tail it extends the femur at the hip joint.

Relations.—The muscle is concealed on the outer side by the semi-tendinosus, which crosses it superficially. Its deeper surface rests against the adductor magnus. Its insertion is united with the posterior fibres of the adductor longus.

Nerve supply.—This muscle is furnished with nerves from two different sources. One branch is derived from the sciatic nerve, whilst another is derived from the trunk of one of the anterior coccygeal nerves.

4. *Adductor longus femoris.*

Le premier adducteur de la cuisse, Vicq d'Azyr, 1774, p. 507, No. 2.
Der erste Anzieher des Oberschenkels, Wiedemann, p. 96.
Der erste Anzieher des Oberschenkelbeins, Tiedemann, p. 326, No. 6.
L'adducteur inférieur, Meckel, vol. vi. p. 86, No. 8.
Triceps adductor femoris (third head of), Reid, p. 143.
Adductor longus femoris, Owen, p. 35.
Accessory femoro-caudal, Garrod, Proc. Zool. Soc., 1873, p. 629.
Adductor longus (?), Selenka, vol. vi. p. 141, No. 81.
Femoro-coccygien (faisceau iliaque), Gervais and Alix, p. 32.

Attachments.—This muscle *arises* from the posterior half of the upper (dorsal) border of the ischium. The muscular fibres pass obliquely forwards and downwards, and are *inserted* into the lower half of the posterior surface of the shaft of the femur.

Action.—It extends the femur at the hip joint.

Relations.—The muscle is concealed at its origin by the posterior fibres of the biceps cruris, and near the femur by the semi-tendinosus. At its origin it rests upon the obturator externus, and at its insertion upon the adductor magnus. Its posterior fibres are united at their insertion with the cruro-coccygeus.

Nerve supply.—A branch from the sciatic nerve, which enters the deeper surface of the muscle.

Variations.—The insertion of the combined cruro-coccygeus and adductor longus varies somewhat in different species. In *Spheniscus demersus* and *Spheniscus magellanicus* their insertion is confined to the middle third of the shaft of the femur; in *Eudyptes chrysolophus* they are attached to the lower third of that bone; whilst in *Aptenodytes* their insertion occupies the lower two-thirds of the shaft of the femur.

Remarks.—There is some difficulty with regard to the synonymy of this as well as of the preceding muscle. Both are described by Selenka under the name of adductor longus. According to this author, the muscle in some birds arises exclusively from the coccygeal vertebræ, while in others its origin is confined to the pelvis. In the former the muscle evidently corresponds to the cruro-coccygeus above described, while in the latter it represents my adductor longus. Selenka does not refer to the presence in any one bird of both the pelvic and coccygeal origins of his adductor longus, and yet this occurs in every species of Penguin which I have examined.

5. *Adductor magnus.*

Le deuxième abducteur de la cuisse, Vicq d'Azyr, 1774, p. 508, No. 3.
Der zweite Anzieher des Oberschenkels, Wiedemann, p. 97.
Der zweite Anzieher des Oberschenkelbeins, Tiedemann, p. 329, No. 7.
Adducteurs (one of), Cuvier, vol. i. p. 359.
Muscle No. 9, Meckel, vol. vi. p. 86, No. 9.
Triceps adductor femoris (part of), Reid, p. 143.
Adductor magnus, Owen, p. 35.
Adductor magnus, Selenka, vol. vi. p. 141, No. 80.
Adducteurs (one of), Gervais and Alix, p. 31.

Attachments.—The adductor magnus is a very powerful muscle. It *arises* from the whole length of the outer surface of the pubic bone, posterior to the acetabulum, as well as from its posterior cartilaginous extremity, and to a corresponding extent from the outer surface of the obturator membrane. The fibres pass obliquely downwards and forwards, and are *inserted* into the lower half of the posterior border (linea aspera) of the shaft of the femur. A few of the posterior fibres are inserted by means of a special tendon into a depression on the posterior surface of the femur, immediately above the internal condyle of that bone. To this tendon are attached a few of the fibres of the inner head of the gastrocnemius.

Action.—This muscle is a powerful extensor of the femur at the hip joint. Through its connection with the gastrocnemius it flexes the knee and extends the ankle joint.

Relations.—At its origin the muscle corresponds to the lower border of the obturator externus. On the outer side it is in contact with the adductor longus and cruro-coccygeus. Its posterior border lies parallel to, and in contact with the pubic head of origin of the semi-membranosus.

Nerve supply.—A branch from the obturator nerve.

Variations.—In *Pygosceles tæniatus* and *Spheniscus demersus* this muscle is to some extent separable into two distinct lamellæ—an internal and an external. No trace of this subdivision is observable in any other species. In *Pygosceles*, *Eudyptes chrysolophus*, and *Spheniscus magellanicus* the posterior half of its muscular fibres terminates on the tendon common to this muscle and to the inner head of origin of the gastrocnemius.

Remarks.—Gervais and Alix speak of the *adductores* in *Eudyptes chrysolophus* as being attached to the ischium and pubis. Neither in this species nor in any other have I been able to recognise more than a single adductor. In this connection it must be remembered, that the muscle which I have named adductor longus constitutes a portion of the femoro-coccygeus of these authors, and is not therefore regarded by them as constituting a second adductor. Meckel rightly observes that in the Penguin the posterior fibres of the adductor magnus are united with the origin of the gastrocnemius, much in the same way as are those of the semitendinosus in other birds.

6. *Obturator externus.*

Le muscle qui tient la place du quarré, Vicq d'Azyr, 1774, p. 496, No. 10.
Quarré de la cuisse, Cuvier, vol. i. p. 355, No. 5.
Der Schenkelroller, Wiedemann, p. 97.
Der äussere Hüftbeinloch-Muskel, Tiedemann, p. 328, No. 5.
Muscle No. 6, Meckel, vol. vi. p. 84.
Pyramidalis, Owen, p. 35.
Quadratus femoris, Selenka, vol. vi. p. 140, No. 79.
Le carré, Gervais and Alix, p. 32.

Attachments.—The obturator externus *arises* from the whole of the outer surface of the ischium, behind the sciatic foramen, and below the origin of the biceps femoris. The fibres pass horizontally forwards, to terminate on a stout tendon which is *inserted* into a depression on the outer surface of the great trochanter of the femur, between the insertions of the gluteus medius and gluteus minimus.

Action.—The muscle rotates the femur outwards, and consequently directs the foot inwards towards that of the opposite side. In this action the obturator externus is the antagonist of the gluteus medius and minimus.

Relations.—Superficially the muscle is concealed by the biceps and adductor longus, and is crossed by the sciatic nerve. Its deeper surface rests upon the ischium.

Nerve supply.—A branch from the obturator nerve.

7. *Obturator internus.*

L'Iliaque interne, Vicq d'Azyr, 1774, p. 505.
Der innere Darmbeinmuskel, Wiedemann, p. 98.
Der innere Darmbeinmuskel, Tiedemann, p. 330, No. 9.
L'obturateur interne, Cuvier, vol. i. p. 357.
Troisième adducteur (part of), Meckel, vol. vi. p. 87, No. 10.
Obturator internus, Owen, p. 35.
Obturator internus, Reid, p. 143.
Obturator internus, Selenka, vol. vi. p. 140, No. 79 (included along with the *Quadratus femoris*).
L'obturateur externe, Gervais and Alix, p. 31.

Attachments.—This muscle is of an elongated oval form. It *arises* from the inner (pelvic) surface of the lower half of the ischium posterior to the obturator foramen, from the inner surface of the pubic bone to a corresponding extent, and from the inner surface of the obturator membrane. The fibres pass forwards, and end on a tendon which, after escaping from the pelvis by the circular aperture which represents the anterior part of the obturator foramen, is *inserted* into a well-marked depression on the posterior border of the great trochanter of the femur, above and behind the insertion of the obturator externus.

Action.—The internal obturator co-operates with the obturator externus in rotating the femur outwards at the hip joint, in consequence of which the foot is directed inwards towards that of the opposite side.

Relations.—Within the pelvis the muscle lies in contact with the abdominal viscera. The tendon of insertion, after escaping from the pelvic cavity, is concealed by the obturator externus.

Nerve supply.—A branch which is given off from the obturator nerve before the latter escapes from the pelvic cavity.

8. *Gemellus.*

L'Accessoire de l'Iliaque interne, Vicq d'Azyr, 1774, p. 496, No. 9.
Troisième adducteur (part of), Meckel, vol. vi. p. 87, No. 10.
Gemellus, Owen, p. 35.

Attachments.—The gemellus is a small quadrilateral muscle, which *arises* from the exterior of the pelvis immediately in front of the obturator foramen. It passes outwards, and is *inserted*, along with the tendon of the obturator internus, into the posterior border of the great trochanter of the femur.

Action.—Its action resembles and supplements that of the internal obturator.

Relations.—The muscle is concealed by the obturator externus.

Nerve supply (?)

Variations.—In *Spheniscus minor*, *Pygosceles tæniatus*, and *Aptenodytes longirostris*, this muscle is divided at its origin by the tendon of the obturator internus into two slips—an upper and a lower. These slips, however, are united at their insertion into the femur.

Remarks.—This muscle is not referred to by Gervais and Alix in their description of *Eudyptes chrysolophus*, although it is present in that species. Reid apparently observed it in *Aptenodytes* (pp. 144 and 145), but his description is so meagre as to render difficult the identification of the muscle which he describes with my gemellus.

9. *Pectineus.*

Le muscle qui tient lieu du pectiné, Vicq d'Azyr, 1774, p. 530, No. 5.
Der tiefe Schenkelbeuger, Wiedemann, p. 98.
Der tiefe Schenkelbeuger, Tiedemann, p. 330, No. 8.
Muscle No. 3, Meckel, vol. vi. p. 80.
Iliacus internus, Owen, p. 34.
Described by Reid, p. 144.
Iliacus internus, Selenka, vol. vi. p. 140, No. 78.

Attachments.—The pectineus is a very small muscle, which *arises* from the external margin of the pelvic bone, immediately below the acetabulum. The muscle passes downwards and backwards, and winding round the inner side of the capsule of the hip joint, against which it rests, is *inserted* into the inner side of the shaft of the femur, at the junction of the latter with the lower surface of the neck. The point of insertion of this muscle in the bird corresponds with the position of the lesser trochanter of the femur in the mammal.

Action.—The muscle flexes the femur at the hip joint at the same time that it rotates the bone outwards.

Relations.—The muscle is concealed on the inner side by the origin of the "ambiens" muscle. Externally it is in contact with the gluteus minimus.

Nerve supply.—A branch from the crural nerve.

Remarks.—This muscle is not described by Gervais and Alix in *Eudyptes chrysolophus*. In the Penguin, according to Meckel, it is entirely wanting. These statements notwithstanding, I found it in every species of Penguin which I dissected. Its diminutive size explains its escape from the observations of the authors just mentioned.

(*b*) MUSCLES INSERTED INTO THE PATELLA, TIBIA, AND FIBULA.

1. *Sartorius.*

Couturier, Vicq d'Azyr, 1774, p. 494, No. 1.
Ausstreckende Schienbein-Muskel, Merrem, fig. 2, 3.
Der längste Schenkel-Muskel, Tiedemann, p. 331, No. 1.

Schneidermuskel, Wiedemann, p. 94.
Couturier, Meckel, vol. vi. p. 98, No. 8.
Couturier, Cuvier, vol. i. p. 371.
Sartorius, Owen, p. 36.
Rectus femoris, Reid, p. 143.
Sartorius, Selenka, vol. vi. p. 142, No. 82.
Couturier, Gervais and Alix, p. 30.

Attachments.—The sartorius is a very powerful muscle. It *arises* from the spines of the sixth, seventh, and eighth dorsal vertebræ, and by means of a distinct bundle of muscular fibres from the anterior border and outer surface of the iliac bone. The fibres pass obliquely forwards, and are *inserted* into the inner surface and anterior border of the patella, as also to a slight extent into the internal of the two anterior tibial crests.

Action.—It flexes the hip and extends the knee joint.

Relations.—The muscle is superficial, except at its origin, where it is in part concealed by the dorsal cutaneous muscle. Its posterior border lies parallel to, and almost in contact with the tensor fasciæ femoris. Its insertion conceals the tendon of the "ambiens," where the latter lies in the patellar groove.

Nerve supply.—A branch of the anterior crural nerve, which enters the posterior border of the muscle.

Variations.—The origin of the sartorius varies somewhat in different species. In *Spheniscus demersus* its iliac origin is extremely slight, whilst its attachment to the spine extends as far forwards as the spinous process of the fifth dorsal vertebra. In other species, again, *e.g.*, *Spheniscus magellanicus*, and especially in *Eudyptes chrysolophus*, the iliac origin is the more extensive, while that from the spine is correspondingly reduced in size. In the latter species, as well as in *Aptenodytes*, and in *Eudyptes chrysocome* from the Falklands, the sartorius is inserted exclusively into the patella.

2. *Rectus femoris.*

Le muscle du fascia lata, Vicq d'Azyr, 1774, p. 494, No. 2.
Der breite Schenkelmuskel (anterior part of), Wiedemann, p. 94.
Der breite Schenkelmuskel (anterior part of), Tiedemann, p. 331, No. 2.
Tenseur de l'aponévrose crurale, Meckel, vol. vi. p. 89, No. 1.
Tensor vaginæ et rectus femoris (anterior part of), Owen, p. 35.
Tensor vaginæ femoris (anterior part of), Reid, p. 143.
Rectus femoris, Selenka, vol. vi. p. 142, No. 83.
Tenseur du fascia lata, Gervais and Alix, p. 30.

Attachments.—The rectus femoris is represented by that portion of the broad musculo-aponeurotic sheet covering the outer side of the thigh, which lies in front of the cotyloid cavity. It *arises* by means of a fascial tendon from the coalesced spinous processes of the lumbo-sacral portion of the vertebral column, and extends from the posterior border of the sartorius backwards to the level of the acetabulum. The fibres descend almost vertically, and terminate on a flattened tendon common to this muscle and to the tensor fasciæ femoris, that portion of the tendon which receives the fibres of the rectus femoris passing to be *inserted* along with the subjacent inner portion of the extensor cruris into the truncated upper end of the patella.

Action.—This muscle flexes the hip and extends the knee joint. In both of these actions it co-operates with the sartorius.

Relations.—Superficial throughout, it rests upon the gluteus medius and extensor cruris. Its anterior border is separated by an interval from the sartorius, while its posterior border coalesces with the gluteus maximus.

Nerve supply.—A branch of the anterior crural which, after winding in front of the extensor cruris, enters the deeper surface of the muscle.

3. *Tensor fasciæ femoris*

Le grand fessier, Vicq d'Azyr, 1774, p. 494, No. 3.
Der breite Schenkelmuskel (posterior part of), Wiedemann, p. 94.
Der breite Schenkelmuskel (posterior part of), Tiedemann, p. 331, No. 2.
Grand fessier, Meckel, vol. vi. p. 89, No. 1.
Tensor vaginæ et rectus femoris (posterior part of), Owen, p. 35.
Tensor vaginæ femoris (posterior part of), Reid, p. 143.
Tensor vaginæ femoris, Selenka, vol. vi. p. 142, No. 84.
Grand fessier, Gervais and Alix, p. 30.

Attachments.—This muscle forms the posterior portion of the musculo-aponeurotic sheet on the outer side of the thigh, the anterior portion of which is formed by the rectus femoris. It *arises* by means of a fascial tendon from the coalesced spinous processes of the lumbo-sacral vertebræ directly above the acetabulum, as well as from the neighbouring border of the ischium. The fibres pass downwards, and terminate on an aponeurosis common to this and to the preceding muscle, that portion of the tendon which receives the fibres of the tensor fasciæ being *inserted* along with the subjacent outer portion of the extensor cruris into the outer side of the patella, as well as into the upper end of the external anterior tibial crest.

Action.—This muscle extends the hip and flexes the knee joint. It is thus the antagonist of the sartorius and rectus femoris.

Relations.—The posterior border is in contact with the biceps, whilst anteriorly it is continuous, both at its origin and insertion, with the rectus femoris.

Nerve supply.—This muscle is supplied by the same nerve that supplies the rectus femoris.

Remarks.—According to Garrod,[1] the post-acetabular portion of the tensor fasciæ

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[1] Proc. Zool. Soc. Lond., 1873, p. 643.

femoris (the tensor fasciæ above described) is absent in the Penguins. I have found it in every species, although reduced to a minimum in size.

4. *Biceps femoris.*

Muscle No. 2, Vicq d'Azyr, 1774, p. 506, No. 2.
Biceps, Cuvier, vol. i. p. 371.
Der zugespitzte Wadenbein-Muskel, Merrem.
Der vordere Beuger des Unterschenkels, Wiedemann, p. 96.
Der erste Beuger des Unterschenkels, Tiedemann, p. 334, No. 6.
Fléchisseur péronéal, Meckel, vol. vi. p. 90, No. 2.
Gluteus maximus, Reid, p. 143.
Biceps flexor cruris, Owen, p. 36.
Biceps, Selenka, vol. vi. p. 143, No. 86.
Biceps fémoral, Gervais and Alix, p. 32.

Attachments.—The biceps is a very powerful muscle, which *arises* from the whole length of the upper (dorsal) border of the ilium and ischium extending from the acetabulum backwards to the posterior extremity of the pelvis, as also by means of a separate bundle of fibres from the posterior border of the tendon of origin of the tensor fasciæ femoris. The muscular fibres end above the knee joint on a rounded tendon, which, after passing through a fibrous pulley lined by synovial membrane, is *inserted* into a well-marked tubercle, situated on the outer side of the fibula, at the junction of the upper and middle thirds of that bone. The tendon through which the tendon of this muscle passes consists of a fibrous loop, which is attached by its upper end to the outer side of the shaft of the femur, immediately above the outer condyle, whilst its lower end coalesces with the tendinous outer head of origin of the gastrocnemius muscle.

Action.—This muscle is the most powerful of the flexors of the knee joint. Indirectly it extends the femur at the hip joint.

Relations.—The muscle is superficially placed except at its insertion where its tendon intervenes between the outer head of origin of the gastrocnemius on the outer, and the flexor sublimis digitorum on the inner side. Its deeper surface rests upon the sciatic nerve which separates it from the semi-tendinosus muscle. Its anterior border lies parallel to and in contact with the posterior border of the tensor fasciæ.

Nerve supply.—Several branches of the sciatic nerve, which are given off directly after the latter has escaped from the pelvis. They enter the deeper surface of the muscle.

Remarks.—Tiedemann, followed by Selenka, identifies the muscle above described under the name of biceps, with the biceps of Vicq d'Azyr. A careful reading of the description of the last named author, shows that the biceps of Tiedemann and Selenka is the "demi-membraneux" of Vicq d'Azyr.

5. *Semi-tendinosus.*

Biceps (part of), Vicq d'Azyr, 1774, p. 307, No. 3.
Troisième fléchisseur de la jambe, Cuvier, vol. i. p. 371.
Der hintere Beuger des Unterschenkels, Wiedemann, p. 96.
Der dritte Beuger des Unterschenkels, Tiedemann, p. 335, No. 8.
Fléchisseur tibial, Meckel, vol. vi. p. 91, No. 3.
Pyriformis (?) (part of), Reid, p. 143.
Semi-tendinosus, Owen, p. 37.
Semi-tendinosus, Selenka, vol. vi. p. 143, No. 87.
Demi-tendineux, Gervais and Alix, p. 32.

Attachments.—This muscle *arises* from the posterior extremity of the upper (dorsal) border of the ischium, as well as from the transverse processes of the third, fourth, and fifth caudal vertebræ. The fibres pass obliquely downwards and forwards, and are *inserted* by means of a delicate, flattened tendon into the internal anterior tibial crest, half an inch below the upper end of that bone.

Action.—It flexes the knee and extends the hip joint. If the knee joint be fixed the posterior fibres of the muscle depress the tail.

Relations.—The semi-tendinosus lies parallel with the posterior border of the biceps. It rests upon the cruro-coccygeus, and is crossed superficially by the sciatic nerve. Its insertion into the tibia coalesces with, and lies behind that of the semi-membranosus.

Nerve supply.—A branch of the sciatic nerve, which enters the deeper surface of the muscle.

Remarks.—As observed by Gervais and Alix in *Eudyptes chrysolophus*, as well as by Meckel, the accessory or femoral head of origin of the semi-tendinosus is entirely absent in every species of Penguin. According to the last named anatomist, the same arrangement is met with in the majority of water birds.

6. *Semi-membranosus.*

Biceps (part of), Vicq d'Azyr, 1774, p. 307, No. 3.
Der dritte Beuger des Unterschenkels, Wiedemann, p. 97.
Der vierte Beuger des Unterschenkels, Tiedemann, p. 335, No. 9.
Semi-membraneux, Cuvier, vol. i. p. 371.
Muscle No. 4, Meckel, vol. vi. p. 93.
Semi-membranosus, Owen, p. 37.
Semi-membranosus, Selenka, vol. vi. p. 144, No. 88.
Le droit interne, Gervais and Alix, p. 32.

Attachments.—This muscle *arises* by two distinct heads, one from the pubic bone and the other from the aponeurosis of the abdominal muscles. The first, or pubic head, *arises* from about half an inch of the outer side of the posterior extremity of the os pubis, from the posterior cartilaginous extremity of that bone, and from the adjacent surface of the ischium. It passes obliquely downwards and forwards, and after being joined by the second head above the knee joint, is *inserted* by means of a flattened tendon into the anterior internal tibial crest, in front of the tendon of insertion of the semi-tendinosus. The second head is fan-shaped, and *arises* from the lateral surface of the abdominal wall, where it is attached to the aponeurosis of the abdominal muscles. The fibres converge as they pass outwards, and uniting with those of the pubic head, are *inserted* along with them into the anterior internal tibial crest. The two heads together thus arise from a semicircular origin, which extends from front to back of the limb, and the fibres form, so to speak, a sheath for the reception of the posterior muscles of the thigh.

Relations.—The pubic head is concealed externally by the semi-tendinosus and cruro-coccygeus. Its anterior border is in contact with the posterior border of the adductor magnus. The abdominal head is quite superficial at its origin.

Action.—The semi-membranosus co-operates with the biceps and semi-tendinosus in flexing the knee and extending the hip joint.

Nerve supply.—A branch from the sciatic supplies the posterior or pubic head of origin. The source of supply of the second or abdominal head of origin I failed to determine.

Variations.—In one specimen of *Eudyptes chrysolophus* I found the pelvic head of origin of the semi-membranosus transferred to the last coccygeal vertebra. In others, however, the muscle presented the arrangement above described. Such was also the case in the specimen dissected by MM. Gervais and Alix. In *Spheniscus magellanicus* the pelvic head of origin is attached to the whole breadth of the posterior border of the pelvis. In *Spheniscus minor* it is limited to the lower half of that border. In both these species, therefore, the attachment of the semi-membranosus to the ischium is more extensive than in *Eudyptes chrysocome.*

Remarks.—This muscle in the Penguins differs, so far as my own observations go, from the corresponding structure in every other bird in the possession of a second or abdominal head of origin. Nor can I find in the literature at my disposal any reference on the part of anatomists to a similar arrangement elsewhere. If farther research should fail to discover a similar arrangement in other species, then the possession by the semi-membranosus muscle of a second or abdominal head of origin must be regarded as one of the characteristic features in the anatomy of the group, seeing that it occurs in every species of Penguin which I have examined.

Meckel does not refer to the presence in the Penguins of an additional head of origin to this muscle.

7. *Gracilis.*

Der innere gerade Schenkelmuskel, Wiedemann, p. 95.
Der innere gerade Schenkelmuskel, Tiedemann, p. 333, No. 5.
"*A muscle from the interior and a small part of the anterior and posterior surfaces of the thigh bone*," Reid, p. 144.
Gracilis (part of), Owen, p. 37.
Muscle No. 6, Meckel, vol. vi. p. 96, No. 6.
Gracilis (!), Selenka, vol. vi. p. 143, No. 85.
Crural interne, Gervais and Alix, p. 31.

Attachments.—This is a slender muscle. It *arises* from the whole length of the inner surface of the shaft of the femur, reaching as high as the insertion of the gluteus minimus. The muscle terminates on a tendon immediately above the knee joint, and is *inserted* into the upper end of the internal anterior tibial crest, as well as into the inferior internal angle of the patella.

Action.—It extends the knee joint.

Relations.—The muscle rests upon the femur, lying between the origin of the extensor cruris on its outer, and the insertion of the adductor magnus on its inner side. It is concealed superficially by the ambiens muscle.

Nerve supply.—A branch from the anterior crural nerve.

Remarks.—At the date of writing the above, Selenka's description of the muscles is still incomplete. So far, his description of the gracilis corresponds closely with my own, but it is possible that when his description of the muscles of the leg is completed, it may appear that my gracilis is synonymous with the vastus internus of Selenka.

8. *Extensor cruris.*

Muscle crurale, Vicq d'Azyr, 1774, p. 506, No. 1.
Der eigentliche Schenkelmuskel, Wiedemann, p. 95.
Der innere grosse Muskel, Merrem.
Der Schenkel-Muskel mit dem äussern und innern dicken Schenkel-Muskel, Tiedemann, p. 332, No. 4.
Cruraeus and *vastus internus*, Owen, p. 37.
Extenseur de la jambe, Meckel, vol. vi. p. 97, No. 7.
Cruralis, Reid, p. 144.
Cruraeus et vastus externus, Selenka, vol. vi. p. 144, No. 89.
Crurale moyen et externe, Gervais and Alix, p. 31.

Attachments.—The extensor cruris consists of a single large fleshy mass, which is not divisible into separate muscles without artificial dissection. It *arises* from the whole of the outer and anterior surfaces of the shaft of the femur, and to a less extent from the inner surface of that bone, extending upwards as high as the insertion of the gluteus minimus, and downwards to the femoral condyles. That portion of the common muscular mass which arises from the anterior surface of the femur (cruræus) is the stronger, and is *inserted* into the upper truncated extremity of the patella, while the muscular fibres which arise from the outer surface of the femur (vastus externus) are *inserted*, for the most part, by means of a flattened tendon into the outer surface of the patella, and to a small extent into the upper end of the external anterior tibial crest. The two portions of the muscle, however, both at their origin and insertion, are quite continuous with one another.

Relations.—The muscle lies between the insertion of the adductor magnus on its outer, and the origin of the gracilis on its inner side. The tendon of insertion common to the tensor fasciæ femoris and rectus femoris is inseparably united with the extensor cruris, opposite the middle in length of the femur.

Action.—This muscle is the principal extensor of the knee joint.

Nerve supply.—The crural nerve gives off several twigs which enter this muscle.

Remarks.—Gervais and Alix describe the two portions of the extensor cruris as distinct muscles in *Eudyptes chrysolophus*.

9. *Popliteus.*

Le muscle poplité, Vicq d'Azyr, 1774, p. 514, No. 5.
Le muscle poplité, Meckel, vol. vi. p. 98, No. 9.
Der Kniekehlen-Muskel, Tiedemann, p. 336, No. 10.
Popliteus, Owen, p. 37.
Le poplité, Gervais and Alix, p. 33.

Attachments.—The popliteus *arises* immediately below the knee joint, from about half an inch in length of the postero-internal border of the tibia, as well as from a corresponding extent of the posterior surface of that bone. The fibres pass obliquely upwards and outwards, and are *inserted* into the posterior border of the upper end of the fibula.

Action.—This muscle approximates the posterior border of the fibula to the tibia, by rotating the former round the axis of the shaft of the bone. This movement is coincident with rotation inwards of the tibia upon the lower end of the femur.

Relations.—The origin of the muscle lies to the outer side, and in contact with that of the plantaris. It is concealed by the flexor perforatus digitorum.

Nerve supply.—A branch from the sciatic nerve.

(c) Muscles inserted into the Tarso-Metatarsus.

1. *Gastrocnemius.*

Les jumeaux, Vicq d'Azyr, 1774, p. 511, No. 1.
Der Wadenmuskel, Wiedemann, p. 101.
Der grosse Wadenmuskel, Merrem.
Der Wadenmuskel, Tiedemann, p. 336, No. 1.

Gastrocnémiens, Cuvier, vol. i. p. 383.
Gastrocnémien, Meckel, vol. vi. p. 103, No. 3.
Described by Reid, p. 144.
Gastrocnemius, Owen, p. 37.
Gastrocnémien and *Soléaire tibial*, Gervais and Alix, pp. 34 and 35.

Attachments.—The gastrocnemius *arises* by three distinct heads—an outer, an inner, and an anterior. The outer head is attached by means of a strong tendon to a depression on the posterior surface of the femur, immediately above the external condyle. To this tendon is attached the superficial head of origin of the flexor perforatus digitorum. The inner head arises from a depression on the posterior surface of the femur, immediately above the internal condyle. To this tendon are attached a number of the posterior fibres of the adductor magnus. The inner head, moreover, arises from the postero-internal border of the tibia, close to the attachment of the internal lateral ligament of the knee joint to that bone. The anterior head arises from the inner surface of the patella, from half an inch in length of the anterior internal tibial crest, and from so much of the subjacent aponeurosis which separates it from the tibialis anticus as corresponds to the upper third of the tibia. The tendon of insertion of the inner head unites with that of the anterior about the middle in length of the tibia, and is joined immediately above the ankle joint by the tendon of insertion of the outer head. After passing behind the ankle joint, the tendo Achillis divides into two slips, of which the outer is *inserted* into the outer side of the distal extremity of the fourth or external metatarsal bone, whilst the inner is attached to the inner side of the base of the second or internal metatarsal bone.

Relations.—The outer head lies at its origin between the insertion of the biceps on its inner, and the superficial origin of the flexor perforatus digitorum on its outer side. As this head passes downwards, it rests upon the deep portion of the flexor perforatus. The inner head at its origin is separated from the anterior head by the insertions of the semi-membranosus and semi-tendinosus, and rests upon the flexor digitorum perforatus. The anterior head rests upon the tibialis anticus above, and on the flexor digitorum perforatus below. Its patellar origin is in part continuous with the insertion of the sartorius.

Action.— The muscle flexes the knee and extends the ankle-joint.

Nerve supply.—The outer and inner heads are supplied by branches which are given off from the sciatic nerve above the knee joint. The anterior head is supplied by an indirect branch of the same trunk given off below that articulation.

Remarks.—Both Tiedemann and Wiedemann describe the gastrocnemius as arising by two heads. From their description, however, it is evident that they regard the inner and anterior heads, as above described, as constituting a single origin. My anterior head is described by Gervais and Alix as a distinct muscle under the name of tibial soléaire.

2. *Tibialis anticus.*

Tibial antérieur, Vicq d'Azyr, 1774, p. 510, No. 2.
Der Anzieher des Fusses, Merrem.
Der vordere Schienbeinmuskel, Wiedemann, p. 99.
Der vordere Schienbeinmuskel, Tiedemann, p. 338, No. 3.
Tibial antérieur, Meckel, vol. vi. p. 100, No. 1.
Described by Reid, p. 145.
Tibialis anticus, Owen, p. 40.
Jambier antérieur, Gervais and Alix, p. 33.

Attachments.—The tibialis anticus has two distinct heads of origin. The outer head *arises* inside the capsule of the knee joint, by means of a stout tendon from a pit on the lower surface of the external condyle of the femur, while the inner head is attached to the lower border of the patella, to the intermuscular septum which separates the tibialis from the anterior head of the gastrocnemius, to the anterior internal tibial crest, and to the upper fourth of the anterior internal border of the shaft of the tibia. The heads unite close to the knee joint, and immediately above the ankle give place to a tendon, which, after passing beneath the anterior annular ligament, is *inserted* into a tubercle situated at the junction of the upper and middle thirds of the middle (third) metatarsal bone.

Action.—This muscle flexes the ankle, and by means of its femoral origin extends the knee joint.

Relations.—The tibialis anticus at its origin is concealed superficially by the anterior head of the gastrocnemius, and by the peroneus longus. Its femoral head separates the patellar and fibular origins of the last-named muscle.

Nerve supply.—A branch of the anterior tibial nerve, given off so soon as the latter has reached the front of the leg.

Variations.—In *Spheniscus mendiculus* the tendon of insertion of this muscle divides into two slips, one of which is attached as above described, while the other is inserted into the contiguous border of the inner metatarsal bone. In *Spheniscus magellanicus*, as well as in *Eudyptes chrysocome* from the Falklands, its tendon of insertion is attached lower than in other species, being inserted into the distal end of the middle metatarsal bone.

3. *Peroneus brevis.*

Péronier, Vicq d'Azyr, 1774, p. 511, No. 4.
Der Wadenbeinmuskel, Wiedemann, p. 101.
Der Wadenbein-Muskel, Tiedemann, p. 339, No. 4.
Court péronier, Cuvier, vol. i. p. 386.
Muscle péronier, Meckel, vol. vi. p. 102, No. 2.
Described by Reid, p. 145.
Court péronier, Gervais and Alix, p. 34.

Attachments.—The peroneus brevis is a very slender muscle. It *arises* from the upper two-thirds of the anterior surface of the shaft of the fibula, from a corresponding extent of the adjacent border of the tibia, and from the interosseous membrane. Its tendon passes obliquely downwards and backwards, and after crossing the outer side of the ankle joint, is inserted into the posterior surface of the upper end of the fourth or external metatarsal bone.

Action.—This muscle flexes the ankle joint.

Relations.—The origin of the peroneus brevis lies in contact with, and separates the fibular origin of the peroneus longus from the tibialis anticus. As its tendon crosses the ankle joint it is concealed by that of the peroneus longus.

Nerve supply.—A branch from the anterior tibial nerve.

Remarks.—Meckel rightly observes that this muscle is extremely feeble in the Penguins as compared with other birds.

4. *Plantaris.*

La grêle plantaire, Vicq d'Azyr, 1774, p. 512, No. 2.
Muscle No. 4, Meckel, vol. vi. p. 106.
Described by Reid, pp. 144 and 145.
Soleus, Owen, p. 38.
Jambier postérieur, Gervais and Alix, p. 35.

Attachments.—The plantaris is a slender muscle. It *arises* from about one inch in length of the postero-internal border of the tibia, immediately below the upper end of that bone. The muscular fibres opposite the junction of the upper and middle thirds of the tibia give place to a tendon which is *inserted* into the upper border of the fibro-cartilage behind the ankle joint.

Action.—Inasmuch as the fibro-cartilage into which this muscle is inserted is attached by its lower border to the upper ends of the metatarsal bones, the plantaris will extend the foot at the ankle joint.

Relations.—The belly of the muscle lies immediately behind the internal lateral ligament of the knee joint, and rests against the inner border of the tibial head of the flexor perforans digitorum. Close to its insertion its tendon is crossed superficially by the tendon of insertion common to the inner and anterior heads of the gastrocnemius.

Nerve supply.—A branch of the sciatic nerve.

(*d*) MUSCLES INSERTED INTO THE PHALANGES.

1. *Musculus ambiens.*

Crural grêle, Vicq d'Azyr, 1774, p. 507, No. 1.
Der schlanke Schenkelmuskel, Wiedemann, p. 97.
Der schlanke Schenkel-Muskel, Tiedemann, p. 332, No. 3.

Muscle No. 5, Meckel, vol. vi. p. 93.
Pectineus, Owen, p. 40.
Described by Reid, p. 144.
L'accessoire iliaque du fléchisseur perforé, Gervais and Alix, p. 33.
Ambiens, Sundevall.

Attachments.—The ambiens muscle is of large size in the Penguins. At its *origin*, which measures an inch in breadth, it is attached to the lower border of the pubic bone, immediately below and behind the acetabulum. The flattened, muscular belly passes along the inner side of the thigh, and immediately above the knee joint ends on a slender tendon, which, after passing from within outwards across the front of the knee joint, where it lies in a groove on the anterior border of the patella, joins that head of the flexor digitorum perforatus which arises from the posterior surface of the lower end of the femur.

Action.—This muscle extends the hip, and through the flexor perforatus digitorum the ankle joint. By means of its connection with the latter it flexes the knee joint as well as the toes.

Relations.—The belly of the muscle is subcutaneous, and lies between the insertion of the adductor magnus internally, and the origins of the gracilis and extensor cruris externally. The tendon of insertion as it crosses the knee joint is concealed by the insertion of the sartorius.

Nerve supply.—A branch from the crural nerve.

2. *Flexor perforatus digiti interni.*

Fléchisseur perforé (part of), Vicq d'Azyr, 1774, p. 512, No. 3.
Der tiefe Beuger des ersten Gliedes der innern Zehe, Wiedemann, p. 105.
Der tiefe Beuger des ersten Gliedes der innern Zehe, Tiedemann, p. 344, No. 6.
Muscle No. 2 (part of), Meckel, vol. vi. p. 117.
Fléchisseur commun perforé, Cuvier, vol. i. p. 396.
Flexor perforatus (part of), Reid, p. 144.
Flexor perforatus digitorum pedis, second (?) portion, Owen, p. 39.
Fléchisseur perforé, couche profonde, Gervais and Alix, p. 36.

Attachments.—This muscle *arises* from the depression on the posterior surface of the femur above the internal condyle. After being joined by a portion of the tendon of the ambiens muscle, it separates from the common muscular mass about the middle in length of the tibia. The muscular fibres end on a single tendon, which, after passing through a canal in the fibro-cartilage behind the ankle joint, is *inserted* into the base of the first phalanx of the second (inner) toe.

Action.—It flexes the second toe.

Relations.—The muscle separates the flexor perforatus digiti medii from the flexor digitorum perforatus.

Nerve supply.—A branch of the sciatic nerve.

3. *Flexor perforatus digiti medii.*

Le fléchisseur perforé (part of), Vicq d'Azyr, 1774, p. 512, No. 3.
Der durchbohrte Beuger der mittleren Zehe, Tiedemann, p. 341, No. 3.
Der durchbohrte Beuger der Mittelzehe, Wiedemann, p. 103.
Fléchisseur commun perforé, Cuvier, vol. i. p. 396.
Muscle No. 2 (part of), Meckel, vol. vi. p. 116.
Flexor perforatus (part of), Reid, p. 144.
Flexor perforatus digitorum pedis, third (?) part, Owen, p. 39.
Fléchisseur perforé, couche profonde, Gervais and Alix, p. 36.

Attachments.—This muscle *arises*, along with the preceding, from the depression above the internal condyle of the femur. The belly of the muscle becomes distinct from the common muscular mass opposite the junction of the upper and middle thirds of the tibia, and is joined by a portion of the tendon of the ambiens muscle. The muscular fibres terminate on a tendon, which, after passing through a canal in the fibro-cartilage behind the ankle joint, and being slit for the transmission of the tendons of the flexor perforans et perforatus, as well as for that of the flexor perforans, is *inserted* into the base of the second phalanx of the third (middle) toe. This tendon is united to that of the peroneus longus by means of the transverse slip described in connection with that muscle (*see* peroneus longus, p. 123).

Action.—This muscle flexes the middle toe.

Relations.—The muscle is concealed superficially by the flexor perforatus of the outer toe. It rests upon the flexor perforatus of the inner toe.

Nerve supply.—A branch from the sciatic nerve.

4. *Flexor perforatus digiti externi.*

Le fléchisseur perforé (part of), Vicq d'Azyr, 1774, p. 512, No. 3.
Der durchbohrte Beuger der äusseren Zehe, Wiedemann, p. 104.
Der durchbohrte Beuger der äusseren Zehe, Tiedemann, p. 342, No. 4.
Fléchisseur commun perforé, Cuvier, vol. i. p. 396.
Muscle No. 2 (part of), Meckel, vol. vi. p. 116.
Flexor perforatus digitorum pedis (fourth portion), Owen, p. 39.
Flexor perforatus (part of), Reid, p. 144.
Fléchisseur perforé, couche profonde, Gervais and Alix, p. 36.

Attachments.—This and the two preceding muscles together form a single muscular mass, which *arises* from a deep depression on the posterior surface of the femur, immediately above the internal condyle.

The flexor perforatus of the outer toe is the most superficially placed of the three. It becomes distinct from the common mass one inch below the knee joint, and is here joined by a portion of the tendon of the ambiens muscle. The muscle terminates on a single tendon, which, after passing through a canal in the fibro-cartilage behind the ankle joint, divides into two slips, one of which is *inserted* into the base of the second phalanx of the fourth or outer toe, while the other, after being slit to allow of the transmission of the tendon of the flexor perforans, is *inserted* into the base of the third phalanx of that toe.

Action.—The muscle flexes the outer toe.

Relations.—Concealed superficially by the outer head of the gastrocnemius, it rests upon the flexor perforatus digiti medii.

Nerve supply.—A branch of the sciatic nerve.

Variations.—In *Pygosceles tæniatus* the tendon of insertion of this muscle gives off an additional slip, which is inserted into the base of the fourth phalanx of the outer toe. In *Spheniscus mendiculus*, on the other hand, the tendon divides into two slips, both of which are inserted into the base of the second phalanx. Between these the tendon of the flexor perforans passes forwards to its insertion.

5. *Flexor perforatus et perforans digiti interni.*

Le fléchisseur perforant et perforé (part of), Vicq d'Azyr, 1774, p. 512, No. 4.
Der durchbohrte Beuger der innern Zehe, Wiedemann, p. 102.
Der durchbohrte Beuger der innern Zehe, Tiedemann, p. 341, No. 2.
Fléchisseur perforant et perforé (part of), Cuvier, vol. i. p. 396.
Muscle No. 1 (part of), Meckel, vol. vi. p. 113.
Flexor perforatus (part of), Reid, p. 144.
Flexor perforatus of the inner toe, Owen, p. 33.
Fléchisseur perforé, couche superficielle (part of), Gervais and Alix, p. 37.

Attachments.—The flexor perforatus et perforans of the inner toe *arises* from the posterior border of the tendon of insertion of the extensor cruris muscle, as well as from the tendon of origin of the outer head of the gastrocnemius. The muscle ends on a delicate tendon, which, after passing through a special canal in the fibro-cartilage behind the ankle joint, is *inserted* by means of two slips into the base of the second phalanx of the inner toe. Between these slips the tendon of the flexor perforans to this toe passes onwards to its insertion into the last phalanx.

Action.—This muscle flexes the inner toe.

Relations.—The muscle lies between the outer head of the gastrocnemius behind, and the origin of the flexor perforans et perforatus in front. It rests on the deeper portion of the flexor perforatus.

Nerve supply.—A direct branch of the sciatic nerve.

Remarks.—According to Gervais and Alix, this muscle in *Eudyptes chrysolophus* takes an additional origin from the tibia and fibula. This I failed to recognise in the specimens of that bird which I examined.

6. *Flexor perforatus et perforans digiti medii.*

Le fléchisseur perforant et perforé (part of), Vicq d'Azyr, 1774, p. 512, No. 4.
Der durchbohrende und durchbohrte Beuger der Mittelzehe, Wiedemann, p. 102.
Der Fingerschliesser, Merrem.
Flexor perforatus et perforans digiti medii, Tiedemann, p. 344, No. 7.
Le muscle perforant et perforé (part of), Cuvier, vol. i. p. 596.
Muscle No. 1 (part of), Meckel, vol. vi. p. 114.
Flexor perforatus (part of), Reid, p. 144.
Flexor perforatus of the middle toe, Owen, p. 39.
Fléchisseur perforé, couche superficielle (part of), Gervais and Alix, p. 37.

Attachments.—This muscle, much stronger than the preceding, *arises* along with it from the tendon of origin of the outer head of the gastrocnemius behind, while in front it is attached to the posterior surface of the fibular aponeurotic origin of the peroneus longus. Between these points it arises from the lower border of the outer surface of the patella. The tendon of insertion of this muscle, after passing through a canal in the fibro-cartilage behind the ankle joint, perforates the tendon derived from the deeper portion of the flexor perforatus going to the same toe, and, dividing into two slips, between which the tendon of the flexor perforans passes forwards, is *inserted* into the base of the third phalanx of the middle toe.

Action.—It flexes the middle toe.

Relations.—This muscle lies between the flexor perforatus digiti interni behind, and the origin of the peroneus longus in front. It rests upon the deeper portion of the flexor perforatus digitorum.

Nerve supply.—A branch of the sciatic nerve.

Variations.—In *Eudyptes chrysocome* from Kerguelen, I found the tendon of this muscle inserted into the base of the second phalanx of the middle toe.

7. *Peroneus longus.*

L'accessoire des fléchisseurs des doigts du pied, Vicq d'Azyr, 1774, p. 510, No. 1.
Der äussere Fusswurzelstrecker, Wiedemann, p. 99.
Der innere Beinmuskel, Merrem.
Der hintere Schienbein-Muskel, Tiedemann, p. 337, No. 2.
Péronier supérieur, Meckel, vol. vi. pp. 107 and 117.
Péronier moyen, Cuvier, vol. i. p. 386.
Described by Reid, p. 145.
Peroneus longus, Owen, p. 40.
Long péronier, Gervais and Alix, p. 34.

Attachments.—The peroneus longus is situated on the outer side of the leg. It is attached by means of a delicate fascia to the lower border of the outer side of the patella, and through the intervention of a strong aponeurosis to the whole length of the outer border of the fibula. The muscular fibres give place to tendon above the ankle joint. This tendon, as it passes along the outer side of the ankle joint, gives off a flattened expansion which is attached to the fibro-cartilage behind that articulation, and thereafter divides into two slips. Of these, one passes to the sole of the foot and unites with the tendon of the flexor perforatus to the middle toe, while the other passes onwards to be *inserted* into the penultimate phalanx of the outer toe.

Action.—This muscle abducts the foot at the ankle joint. Through its insertion into the outer toe it expands the foot by separating the outer from the remaining toes. By its connection with the flexor perforatus it assists in flexing the middle toe.

Relations.—The muscle lies between the anterior head of origin of the gastrocnemius in front, and the superficial origin of the flexor perforatus behind. It rests upon and conceals the upper portion of the tibialis anticus.

Nerve supply.—A branch from the anterior tibial nerve.

8. *Flexor perforans digitorum.*

Fléchisseur perforant, Vicq d'Azyr, 1774, p. 512, No. 5.
Der zweiköpfige Muskel, Merrem.
Der dreispaltige tiefe Zehenbeuger, Wiedemann, p. 104.
Der dreispaltige tiefe Zehenbeuger, Tiedemann, p. 343, No. 5.
Le troisième long fléchisseur, Meckel, vol. vi. p. 120.
Fléchisseurs perforans, Cuvier, vol. i. p. 396.
Flexor perforans digitorum, Owen, p. 40.
Flexor perforans, Reid, p. 144.
Long fléchisseur du pouce and *fléchisseur profond*, Gervais and Alix, p. 35.

Attachments.—The flexor perforans *arises* by two distinct heads of origin. Of these the *first*, which undoubtedly corresponds to the flexor longus hallucis of the majority of birds, is attached along with the flexores perforati digiti interni, digiti medii, and digiti externi to the depression on the posterior surface of the femur immediately above the condyles. A small portion of this head is distinct from the common muscular mass, and arises above the external condyle of the femur. The first head has no connection with the tendon of the ambiens. It separates from the common muscular mass opposite the junction of the upper and middle thirds of the tibia. Its tendon of *insertion*, after passing through a canal in the fibro-cartilage behind the ankle joint terminates by dividing into three slips, which unite with those derived from the tendon of insertion of the second head opposite the base of each of the anterior toes. The *second* head of the flexor perforans *arises* from the upper three-fourths of the posterior surface of the tibia below the origin of the popliteus, from the middle third of the inner surface of the same bone, from the whole length of the posterior border of the fibula, and from the interosseous membrane. The muscular fibres immediately above the ankle joint give place to a tendon which, after perforating the fibro-cartilage behind the ankle joint, divides into three slips. These, after uniting with the corresponding slips derived from the tendon of the first or femoral head of the muscle, pass forwards, to be *inserted* into the terminal phalanges of the second, third, and fourth toes. They perforate the tendons of the flexor perforatus to the same toes.

Action.—This muscle flexes the toes.

Relations.—The first or femoral head of origin of this muscle lies under cover of the flexor perforatus, and rests upon the second or tibial head. The second head rests upon the tibia and fibula, from which bones it arises.

Nerve supply.—Both heads are supplied by branches from the sciatic nerve.

Variations.—In addition to the three tendons above described, I found in *Spheniscus demersus*, *Spheniscus mendiculus*, *Spheniscus magellanicus*, and *Eudyptes chrysocome* from the Falklands, a fourth very delicate slip, which was given off from the tendon of insertion of the second head of this muscle. This minute tendon passes along the under surface of the first or rudimental toe, and is inserted into the terminal phalanx of that digit.

In *Spheniscus magellanicus* the femoral head of the muscle takes an additional attachment to the upper extremity of the fibula.

In *Pygosceles tæniatus* the tendon of insertion of the femoral head unites with that of the tibial head, previous to the sub-division of the latter into its three slips.

Remarks.—Gervais and Alix describe the femoral head of origin of this muscle under the name of "fléchisseur du pouce." As already observed, it undoubtedly represents that muscle, but by reason of the rudimentary condition of the hind toe in the Penguins, instead of being chiefly attached as in many birds to that toe, it incorporates itself with the tendon of the second or tibial portion of the muscle, which in other birds exclusively represents the flexor perforans. In *Eudyptes chrysolophus*, according to Gervais and Alix, the tendon of the flexor perforans does not give off any slip to the rudimental toe. That slip, according to these authors, is replaced by a tendinous band, which passes between the sheath of the flexor perforans and the second phalanx of the rudimental toe.

9. *Flexor brevis hallucis.*

Fléchisseur du doigt postérieur, Vicq d'Azyr, 1774, p. 517, No. 1.
Der Daumenbeuger, Wiedemann, p. 106.
Der Beuger des Daumens, Tiedemann, p. 345, No. 9.
Muscle No. 4, Meckel, vol. vi. p. 126.
Flexor of the thumb, Reid, p. 145.
Court fléchisseur du pouce, Gervais and Alix, p. 38.

Remarks.—Gervais and Alix describe this muscle in *Eudyptes chrysolophus* as being attached to the middle plantar tuberosity of the metatarsus, and to the base of the first phalanx of the hallux. Reid also refers to the presence of a flexor brevis hallucis in *Aptenodytes*. On the other hand, Meckel (vol. vi. p. 127) asserts the absence of this muscle in the Penguin. My own observations agree with those of Meckel, inasmuch as I have failed to recognise this muscle in any species of Penguin which I have examined. It is right, however, to state that the mode of preservation, and the consequent hardening of the feet of the Challenger specimens, rendered it not a little difficult to isolate the smaller muscles from the surrounding tissue. In view, therefore, of the recognition of this muscle in two different species by separate observers, and bearing in mind the remarkable similarity in structure otherwise of the various species of Penguin, it seems not improbable that farther research will corroborate the observations of Reid and Gervais, and affirm the existence of this muscle in every species of Penguin.

10. *Extensor communis digitorum.*

L'extenseur commun des doigts, Vicq d'Azyr, 1774, p. 511, No. 3.
Der gemeinschaftliche Fingerstrecker, Wiedemann, p. 100.
Der Schienbein-Muskel, Merrem.
Der gemeinschaftliche Fingerstrecker, Tiedemann, p. 340, No. 1.
Long extenseur des doigts antérieurs, Cuvier, vol. i. p. 392.
Long extenseur commun des orteils, Meckel, vol. vi. p. 107, No. 1.
Described by Reid, p. 145.
Extensor longus digitorum, Owen, p. 40.
L'extenseur commun des doigts, Gervais and Alix, p. 33.

Attachments.—The extensor communis digitorum *arises* from the lower border of the patella, from the deep groove on the front of the upper end of the tibia between the tibial crests, from the upper half of the anterior internal border of the tibia, and from a strong intermuscular septum which separates this muscle from the anterior head of the gastrocnemius. The muscle terminates on a single tendon which passes along with that of the tibialis anticus beneath the anterior annular ligament, and thereafter through an osseous canal situated at the lower end of the tibia. Below that bone the tendon passes beneath a second annular ligament attached to the second metacarpal bone, and forms a flattened expansion which divides into four distinct slips. Of these slips the second toe receives one, the third two, and the fourth one. The tendon to the second toe gives off two lateral bands, which are inserted into the base of the second phalanx, and thereafter passes to be attached to the terminal phalanx. Of the two tendons supplied to the third toe, one is inserted into the base of the second phalanx, while the other, after giving off lateral bands to the base of each of the succeeding, is inserted into the last phalanx. The tendon supplied to the fourth toe is inserted into the terminal phalanx and gives off lateral bands to the base of each of the proximal phalanges of that toe as it passes to its insertion.

Action.—The muscle extends the toes.

Relations.—The muscle rests against the front of the tibia, and is concealed by the tibialis anticus.

Nerve supply.—A branch from the anterior tibial nerve, given off so soon as that nerve reaches the front of the leg.

Variations.—In all the species of Penguin dissected, with the exception of *Eudyptes chrysocome* from Tristan d'Acunha, and *Spheniscus demersus*, the tendon of the extensor digitorum divides into three instead of into four slips. In these, therefore, the third toe is provided with a single tendon, instead of two, as above described. In *Spheniscus demersus* the distribution of the tendons exactly resembles that which obtains in *Eudyptes chrysocome* from Tristan d'Acunha.

Remarks.—According to Meckel, in the Penguin the tendon of the extensor communis divides as described above in *Eudyptes chrysocome* from Tristan d'Acunha.

The annular ligaments beneath which the tendon of the extensor digitorum passes are two in number. The upper is attached to the lower end of the tibia, and is oblique from above downwards and outwards. Its inner end is fixed to a ridge immediately above the internal condyle of the lower extremity of the tibia, whilst its outer end is attached to the front of the external condyle. Beneath this ligament pass the tendons of the tibialis anticus and extensor digitorum. The lower ligament is attached to the upper end of the second metatarsal bone. Through it passes the tendon of the extensor digitorum alone.

11. *Extensor brevis hallucis.*

L'abducteur du doigt opposé, Vicq d'Azyr, 1774, p. 516, No. 1.
Der Daumenstrecker, Wiedemann, p. 106.
Der Strecker des Daumens, Tiedemann, p. 345, No. 8.
Muscle No. 2, Meckel, vol. vi. p. 109.
L'extenseur du pouce, Cuvier, vol. i. p. 393.
Extensor pollicis brevis, Owen, p. 40.
Extensor of the thumb, Reid, p. 145.
Extenseur du pouce, Gervais and Alix, p. 38.

Attachments.—The short extensor of the hallux is a very delicate muscle. It *arises* from the metatarsal bone of the first or rudimental toe, as well as from the ligament which connects the first to the second metatarsal bone. Its tendon passes along the dorsum of the first metacarpal bone, and is *inserted* into the base of the first phalanx of the hallux.

Action.—It extends the toe.

Nerve supply (?)

Remarks.—Meckel notes the occurrence of this muscle in the Penguin. According to Gervais and Alix, its tendon is inserted into the terminal phalanx of the rudimental toe in *Eudyptes chrysolophus*.

12. *Extensor proprius digiti medii.*

Le muscle pédieux (part of), Vicq d'Azyr, 1774, p. 516, No. 2.
L'extenseur propre du médius, Cuvier, vol. i. p. 393.
Muscle No. 3, Meckel, vol. vi. p. 110.
Described by Reid, p. 145.
Dorsal du troisième doigt, Gervais and Alix, p. 37.

Attachments.—This, the second dorsal interosseous muscle, *arises* from the upper half of the anterior surface of the third metatarsal, and to a small extent from the adjoining surface of the second metatarsal bone. The muscle passes vertically downwards, and is *inserted* into the dorsal aspect of the base of the first phalanx of the third toe.

Action.—It extends the third toe.

Nerve supply.—A branch from the anterior tibial nerve.

13. *Abductor digiti interni.*

Le muscle pédieux (part of), Vicq d'Azyr, 1774, p. 516, No. 2.
Muscle No. 5, Meckel, vol. vi. p. 110.
Described by Reid, p. 145.
Dorsal du deuxième doigt, Gervais and Alix, p. 37.

Attachments.—This muscle *arises* from the upper half of the anterior surface of the second metatarsal bone. It passes obliquely downwards and inwards, and is *inserted* into the inner side of the base of the first phalanx of the second toe.

Action.—It extends the toe and abducts it from the middle line of the foot.

Nerve supply.—A branch from the anterior tibial nerve.

14. *Adductor digiti externi.*

Le muscle pédieux (part of), Vicq d'Azyr, 1774, p. 516, No. 2.
Muscle No. 4, Meckel, vol. vi. p. 110.
Described by Reid, p. 145.
Dorsal du quatrième doigt, Gervais and Alix, p. 37.

Attachments.—This muscle *arises* from the upper half of the anterior surfaces of the third and fourth metatarsal bones, as well as from the groove between them. It passes vertically downwards, and its tendon, after passing between the pulley-like lower extremities of the third and fourth metatarsal bones, is inserted into the inner side of the base of the first phalanx of the fourth or outer toe.

Action.—The muscle extends and adducts the toe towards the middle line of the foot.

Nerve supply.—A branch from the anterior tibial nerve.

Remarks.—Meckel (vol. vi. p. 111) remarks upon the peculiarity of the insertion of this muscle into the *inner* side of the base of the first phalanx. As a rule, in other birds it is inserted into the *outer* side of the base of that phalanx. In the latter, therefore, it is an *abductor*, whilst in all the Penguins it is an *adductor* of the toe towards the middle line of the foot.

15. *Abductor digiti externi.*

Adducteurs des doigts (one of), Vicq d'Azyr, 1774, p. 517, No. 2.
Der Abzieher der äusseren Zehe, Wiedemann, p. 106.
Der Abzieher der äussern Zehe, Tiedemann, p. 346, No. 10.
Plantaire du quatrième doigt, Gervais and Alix, p. 38.

Attachments.—This muscle *arises* from the upper half of the plantar surface of the fourth metatarsal bone. It passes downwards, and is *inserted* into the outer side of the base of the first phalanx of the fourth or outer toe.

Action.—This muscle flexes and abducts the outer toe from the middle line of the foot.

Nerve supply (?)

Comparative Remarks.

MM. Gervais and Alix sum up the myological characteristics of the leg of the Penguin as follows:[1]—

"The arrangement" (of the muscles of the leg) "is less characteristic" (than is that of the wing). "We perceive in it that which characterises the palmipedes in general.

"We note the size and strength of the ambiens muscle coincident with the atrophy of the pectineal apophyses, as also the depth of the patellar groove in which the tendon of the ambiens glides; the strength of the sartorius which takes an attachment to the dorsal vertebræ; the strength of the tensor fasciæ latæ (rectus femoris), developed to a similar extent in the Grebes, which, however, do not possess the ambiens; the feeble development of the gluteus maximus (tensor fasciæ femoris), which constitutes a difference between *Eudyptes* and Grebe, in the latter of which of all birds the gluteus maximus (tensor fasciæ femoris) attains the largest dimensions, at the same time that it approximates *Eudyptes* to the Swan and to the raptorial birds; the great size of the quadratus femoris (obturator externus); the presence of two distinct heads of the femoro-coccygeus (cruro-coccygeus and adductor longus), which separates *Eudyptes* from the Grebe, in the

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[1] In translating the following summary, I have inserted in brackets the names used in the text to designate the various muscles referred to by MM. Gervais and Alix.

latter of which only the iliac origin (adductor longus) is present; the absence of an accessory semi-tendinosus, and the union of the inner head of the gastrocnemius with the adductor (adductor magnus), two characters which we find in the Raptores; the exceptional presence of an abdominal origin of the rectus internus (semi-membranosus); the great development of the soleus (anterior head of gastrocnemius), which, however, only possesses one of the two tibial origins which we find in the Grebes; the strength of the tibialis posticus (plantaris); the entomyic type (type entomyen) of the deep portion of the superficial flexor, its arrangement resembling that which is seen in the Grebe and certain of the lamellirostral palmipedes (Swan, Goose, and Duck); the delicacy of the flexor tendon of the hallux, not connected directly with the long femoral head, but lost in the fibrous sheath of the latter; the small size of the short muscles of the hallux; the absence of short muscles belonging to the second and third toes; the non-division of the tendon of the tibialis anticus; the sub-division of the tendon of the peroneus longus into three parts, one of which is attached to the base of the outermost toe."

MUSCLES OF MASTICATION.

1. *Digastric muscle.*

Der Mundöffner, Merrem.
Le Crotaphite, Vicq d'Azyr, 1773, p. 584, No. 1.
Der Schnabelöffner, Wiedemann, p. 74.
Der pyramidenförmige Schnabelöffner, Tiedemann, p. 383, No. 1.
Digastrique (part of), Cuvier, vol. iii. p. 69.
L'abaisseur de la mâchoire inférieure, Meckel, vol. viii. p. 162.
L'abaisseur de la mâchoire inférieure, Gervais and Alix, p. 19.

Attachments.—This muscle consists of two portions, a superficial and a deep. The superficial portion is oval in form, and *arises* from the great transverse occipital crest, the origin extending from the upper extremity of the latter downwards as far as the base of a nipple-shaped projection of the temporal bone, which is situated immediately behind the articulation of the occipital bone with the os quadratum, with which projection the transverse ridge is continuous. The deep portion *arises* from the outer surface of the nipple-shaped process above referred to, as well as from that of the horizontal ridge with which it is continuous in front. The fibres of both heads unite to form a single muscle which is *inserted* into the posterior extremity of the ramus of the lower jaw.

Action.—This muscle acting upon the posterior extremity of the lower jaw behind the articulation of the latter with the quadrate bone, depresses that bone in front of the articulation and opens the mouth.

Relations.—The digastric lies behind the external auditory meatus. It is concealed by the anterior fibres of the cervical cutaneous muscle, and rests against the side of the skull.

Nerve supply (?)

Variations.—In the different species of *Spheniscus* which I have examined, I find the origin of this muscle more extensive than in other genera, its origin reaching the upper surface of the skull, and coming into close relation with the muscle of the opposite side. In them, also, its origin extends farther forwards than in the species of other genera, so much so that the origin of the digastric to a considerable extent overlaps that of the temporal muscle.

2. *Temporal muscle.*

Le Masseter, Vicq d'Azyr, 1773, p. 584, No. 2.
Der Schläfenmuskel, Tiedemann, p. 385, No. 1.
Der Schläfenmuskel, Wiedemann, p. 72.
Masseter et Crotaphite, Cuvier, vol. iii. p. 70.
L'élévateur de la mâchoire inférieure, Meckel, vol. viii. p. 161, No. 1.
Le temporal, Gervais and Alix, p. 19.

Attachments.—The temporal muscle *arises* by means of two heads, a superficial and a deep. The superficial head *arises*, without the intervention of tendon, from the whole of the depressed lateral surface of the skull (temporal fossa) situated between the transverse occipital crest behind and the post-orbital process in front. The deep head *arises* by means of a pointed tendon from the lower surface of the projecting ledge of bone which overhangs the quadrato-temporal articulation. This tendon gives place to muscular fibres, which, after passing beneath the zygoma, are *inserted* along with, but behind that of the superficial head into the outer surface of the ramus of the lower jaw. The attachment of both heads into the lower jaw extends from the quadrato-maxillary articulation behind, to the angle of the mouth in front.

Action.—This muscle is the principal elevator of the lower jaw.

Relations.—This muscle is overlapped behind by the digastric, from which it is separated by the auditory passage. The deeper head is concealed at its origin by the superficial, but at its insertion lies alongside of, and behind the latter.

Nerve supply (?)

Remarks.—The deep portion of the muscle, as above described, is the "faisceau zygomatique" of Gervais and Alix.

3. *Pterygoid muscle.*

Le muscle abaisseur du bec supérieur, Herissant, 1748, p. 345.
Der Flügelmuskel, Wiedemann, p. 74.
Der Flügelmuskel, Tiedemann, p. 388, No. 6.
Ptérygoïdien, Cuvier, vol. iii. p. 72.
Muscle No. 3, Meckel, vol. viii. p. 161, No. 3.
Ptérygoïdien, Gervais and Alix, p. 19.

Attachments.—The pterygoid muscle is of great size. It *arises* from the posterior extremity of the lower jaw bone, behind the articulation of that bone with the os quadratum, its fibres being attached to the outer, inner, and lower surfaces of the bone. The fibres pass obliquely forwards, upwards, and inwards, and are *inserted* into the lower surface of the pterygoid bone, as well as into the whole length of the lower surface and external margin of the palate bone. The external fibres of the muscle are to some extent separated from the rest by connective tissue, and are inserted by means of a stout tendon into the anterior extremity of the palate bone, close to the articulation of the latter with the superior maxillary bone.

Action.—This muscle approximates the upper and lower jaws, and assists in closing the mouth.

Relations.—The origin of this muscle lies immediately in front of that of the retractor linguæ. At its insertion it is in contact with its fellow of the opposite side, and is concealed by the papillated mucous membrane of the roof of the mouth.

Nerve supply (?)

4. *Orbito-maxillaris.*

Der Augenhöhlenkiefermuskel, Wiedemann, p. 73.
Der Augenhöhlen-Unterkiefer-Muskel, Tiedemann, p. 387, No. 4.
La quatrième portion du masséter, Cuvier, vol. iii. p. 71.

Attachments.—The orbito-maxillary muscle *arises* from the lower surface of the skull, below a ridge extending from the post orbital process, obliquely backwards and downwards to the quadrato-temporal articulation. The muscle is triangular in form, and terminates on a strong tendon, which is *inserted* into a well-marked tubercle on the inner surface of the lower jaw, immediately in front of the articular surface of that bone.

Action.—This muscle, in conjunction with the temporal, elevates the lower jaw.

Relations.—The orbito-maxillaris is concealed superficially by the temporal muscle, the inferior maxillary nerve passing forwards between them.

Nerve supply (?)

Remarks.—This muscle is not described by Gervais and Alix, who have doubtless regarded it as a portion of the temporal muscle. It is, however, quite distinct from the latter, being separated from it by the inferior maxillary nerve.

5. *Quadrato-maxillaris.*

Der Quadratknochen-Unterkiefer-Muskel, Tiedemann, p. 383, No. 5.
Der Gelenkbeinkiefermuskel, Wiedemann, p. 73.
Muscle No. 2, Meckel, vol. viii. p. 161.
Le premier muscle externe de l'os quarré, Cuvier, vol. iii. p. 73.

Attachments.—The quadrato-maxillaris is a small muscle, which *arises* from the orbital process of the quadrate bone. Its fibres pass obliquely downwards and outwards, and are *inserted* into the upper border of the ramus of the lower jaw, immediately in front of the articular surface of that bone.

Action.—This muscle co-operates with the temporal and orbito-maxillary muscles in raising the lower jaw and closing the mouth.

Relations.—It is concealed on the outer side by both the temporal and orbito-maxillary muscles.

Nerve supply (?)

Remarks.—The quadrato-maxillaris apparently corresponds to the quadrato-pterygoidien of Gervais and Alix. I failed, however, to recognise the insertion of any portion of its fibres into the pterygoid bone, as described by these authors.

6. *Levator quadrati.*

Augenhöhlenpaukenbeinmuskel, Wiedemann, p. 74.
Augenhöhlen-Quadratknochen-Muskel, Tiedemann, p. 389, No. 1.
Le quatrième muscle qui concourt à l'élévation du demi bec supérieur, Hérissant, 1748, p. 345.
Le second muscle externe de l'os quarré, Cuvier, vol. iii. p. 73.

Attachments.—The levator quadrati *arises* from the posterior part of the roof of the orbital cavity, below and under cover of the post-orbital process. Its fibres pass vertically downwards, and are *inserted* into the upper border of the orbital process of the quadrate bone.

Action.—This muscle elevates the quadrate bone, and with it the upper jaw.

Relations.—The levator quadrati lies in contact with the inner surface of the orbito-maxillary muscle.

Nerve supply (?)

7. *Pterygo-maxillaris.*

Attachments.—This is a quadrilateral plate of muscular fibres which *arises* from the upper surface of the pterygoid, and to a slight extent from the outer margin of the palate bone. The fibres pass horizontally outwards and backwards, and are *inserted* into a well-marked depression on the inner surface of the ramus of the lower jaw, immediately below the articular surface of that bone.

Action.—This muscle elevates the lower jaw and directs its anterior extremity towards the opposite side of the body.

Relations.—It lies on the floor of the orbital cavity, and rests upon the upper surface of the pterygoid muscle. The depressor of the lower eyelid is in contact with its upper surface.

Nerve supply (?)

Remarks.—If this muscle does not correspond to the quadrato-sphénoidal of Gervais and Alix, I have failed to identify the latter.

MUSCLES OF THE HYOID BONE.

In describing these muscles, I have made use of the terms employed by Geoffroy St. Hilaire, to designate the various elements which constitute the hyoid bone of birds. I have done so for the reason that whilst these names serve sufficiently the purposes of accurate description, their adoption does not necessarily commit the author to any particular theory regarding the morphological equivalence of the elements in question.

The muscles arising from each hyoid cornu together form a muscular sheath, which invests the whole of the cerato-hyal, as well as the posterior half of the apo-hyal bone. This sheath becomes separated anteriorly into three distinct muscles. The first of these is the

1. *Cerato-glossus.*

Cérato-glosse, Cuvier, vol. iii. p. 268, No. 1.
L'abaisseur de la langue, Meckel, vol. viii. p. 172, No. 1.
L'hyo-glosse, Gervais and Alix, p. 18.

Attachments.—The cerato-glossus is a very delicate muscle, which, after being differentiated from the muscular sheath above referred to, terminates on a slender tendon which courses along the lower surface of the hyoid cornu, and is *inserted* into the anterior extremity of the glosso-hyal cartilage, close to the tip of the tongue.

Action.—This muscle, acting in conjunction with its fellow of the opposite side, depresses the free extremity of the tongue.

Nerve supply (?)

2. *Cerato-transverse muscle.*

Zungenbeinhornmuskel, Tiedemann, p. 121, No. 3.
Cérato-hyoïdien, Cuvier, vol. iii. p. 247, No. 4.
Muscle No. 4, Meckel, vol. viii. p. 177.
Cératoïdien transverse, Gervais and Alix, p. 19.

Attachments.—This, the second muscle derived from the common muscular sheath which envelops the cornu of the hyoid bone, separates from the common muscular mass opposite the junction of the cerato- and apo-hyal elements of that bone. It passes obliquely forwards and inwards, and is *inserted*, along with its fellow of the opposite side, midway between the two halves of the lower jaw into a strong fascia which covers the lower surface of the mylo-hyoid muscle.

Action.—This muscle co-operates with the next in protracting the hyoid bone and tongue.

Relations.—The cerato-transverse muscle rests against the mylo-hyoid muscle.

Nerve supply (?)

3. *Protractor linguæ.*

Kegelformiger Kiefer-Zungenbeinmuskel, Tiedemann, p. 121, No. 3.
Vorwärtszieher der Zunge, Wiedemann, p. 71.
Muscle conique, Vicq d'Azyr, 1773, p. 585, No. 3.
Génio-hyoïdien, Cuvier, vol. iii. p. 246, No. 3.
Protracteur ou mylo-hyoïdien profond, Meckel, vol. viii. p. 176, No. 3.
Protracteur de l'hyoïde (génio-hyoïdien), Gervais and Alix, p. 18.

Attachments.—This, the third muscle derived from the muscular sheath enveloping the cornu of the hyoid bone, passes obliquely forwards and outwards, and is *inserted* into the inner surface of the ramus of the lower jaw, midway between the junction of the latter with its fellow of the opposite side and its articulation with the quadrate bone.

Action.—Taking its fixed point at the lower jaw, this muscle draws forwards the hyoid bone and tongue.

Relations.—The protractor arises along with the two preceding muscles from the cornu of the hyoid bone. As it passes forwards to its insertion it is crossed superficially by the retractor linguæ.

Nerve supply (?)

4. *Retractor linguæ.*

Milo-hyoïdien, Vicq d'Azyr, 1773, p. 585, No. 2.
Serpi-hyoïdien, Cuvier, vol. iii. p. 246, No. 2.
Rückwärtszieher der Zunge, Wiedemann, p. 71.
Schiefer Kieferzungenbeinmuskel, Tiedemann, p. 120, No. 2.
L'élévateur de l'os hyoïde, Meckel, vol. viii. p. 174, No. 1.
Rétracteur de l'hyoïde ou serpi-hyoïdien, Gervais and Alix, p. 18.

Attachments.—The retractor linguæ is a riband-like muscle, which *arises* from a well-marked process (serpiform process) situated on the posterior or articular extremity of the lower jaw bone. The fibres pass obliquely forwards and inwards, and after crossing the superficial aspect of the protractor linguæ, are *inserted* chiefly into the anterior third of the apo-hyal element, and to a less extent into the uro-hyal cartilage.

Action.—This is the principal retractor of the hyoid bone and tongue.

Nerve supply (?)

5. *Transverse hyoid muscle.*

Muscle No. 7, Owen (Cyclopædia of Anatomy), vol. i. p. 318.
Hyo-glosse transverse, Cuvier, vol. iii. p. 269, No. 2.
Releveur de la langue, Meckel, vol. viii. p. 173, No. 2.
Hyoïdien transverse, Gervais and Alix, p. 18.

Attachments.—This muscle is composed of a single bundle of transversely arranged muscular fibres, which stretch across the lower surface of the hyoid bone, immediately in front of the articulation of the apo-hyals with the basi-hyal element. Its fibres are in part *inserted* into the lateral borders of the base of the glosso-hyal cartilage, and in part into those of the basi-hyal bone.

Action.—In contracting, this muscle arches the dorsal surface of the tongue and depresses the tip of that organ. It thereby renders prominent the large papillæ which invest the dorsal surface of the tongue.

Nerve supply (?)

6. *Mylo-hyoid muscle.*

Genio-hyoïdien, Vicq d'Azyr, 1773, p. 565, No. 1.
Der rautenförmige Kehlmuskel, Wiedemann, p. 70.
Quer-Kiefer-Zungenbeinmuskel, Tiedemann, p. 120, No. 1.
Mylo-hyoïdien, Cuvier, vol. iii. p. 245, No. 1.
Muscle transverse de la mâchoire inférieure, Meckel, vol. viii. p. 175, No. 2.
Mylo-hyoïdien, Gervais and Alix, p. 19.

Attachments.—The mylo-hyoid muscle consists of a number of muscular fibres, which fill up the interval between the rami of the lower jaw, to both of which they are attached posteriorly to the symphysis. A few of the posterior fibres extend beyond the rami of the lower jaw, and are attached to the zygomatic arch of each side.

Action.—This muscle elevates the hyoid bone and tongue.

Relations.—The mylo-hyoid muscles of opposite sides form, as it were, a floor upon which the hyoid bone and its muscles already described rest. Posteriorly its fibres are in series with the circular fibres of the cutaneous muscle of the neck. It takes no attachment to the hyoid bone.

Nerve supply (?)

7. *Thyro-hyoid muscle.*

Thyro-hyoïdien, Vicq d'Azyr, 1773, p. 581, No. 2.
Kehlkopf-Zungenbeinmuskel, Tiedemann, p. 122, No. 5.
Thyro-hyoïdien, Gervais and Alix, p. 18.

Attachments.—This muscle may be regarded as a continuation forwards of the contractor tracheæ muscle. It *arises* from the lower as well as from the lateral surface of the thyroid cartilage, close to the posterior border of the latter. The fibres converge as they pass forwards, and are *inserted* into the basi-hyal, into the uro-hyal, and to a small extent into the base of the apo-hyal bone.

Action.—The thyro-hyoid muscle approximates the larynx to the hyoid bone.

Relations.—This muscle is separated from its fellow by the uro-hyal cartilage. Its origin corresponds to the insertion of the contractor-tracheæ muscle.

Nerve supply (?)

CONCLUDING OBSERVATIONS.

A consideration of the facts above detailed regarding the muscular system of the Spheniscidæ, leads to the conclusion that so far as their muscular system is concerned, these birds constitute a clearly defined group of the Palmipedes. Agreeing essentially with that of the order just named, the muscular system of the Spheniscidæ nevertheless presents certain modifications which, occurring in every member of the group, justify us in associating together the various individuals composing it as members of a natural family, at the same time that they enable us to separate that family from those which in respect of muscular arrangement most nearly approach it. These modifications are most observable in the muscles of the wing, and to a less extent in those of the leg, and stand in direct relation to the habits of the various members of the group.

The wing of the Penguin is useless as an organ of flight, but is of first-rate importance as a paddle wherewith the bird may propel itself through the water. In accordance with this modification in function of the wing, we find an enormous development of the muscles which act at the shoulder joint, that is, on the wing as a whole. These muscles, together with those which act upon the scapula, are developed in the Penguin to an extent observable in no other bird, and enable the wing, converted into a paddle, to act as a powerful propulsive organ of the body of the bird through the relatively dense medium in which the greater part of the life of the animal is passed. This arrangement would be superfluous in the case of birds adapted to an aerial existence, the medium in which they live offering much less resistance to locomotion than the water in which the Penguin spends the greater part of its life. On the other hand, the atrophy of the muscles of the forearm and hand of the Penguin is consequent upon the comparative fixity of the joints below the elbow, and prevents the performance of those delicate movements of flexion, extension, and rotation that are essential to flight—movements, the ability to perform which would be positively prejudicial to an organ whose principal function is that of an oar or screw.

The leg of the Penguin, except in respect of the great development of the muscles as a whole, does not present any peculiarities worthy of note beyond those already referred to at page 129.

The most striking features of the muscular system of the Spheniscidæ, apart from those above referred to in connection with the wing, appear to me to lie in the extraordinary development of the extensor muscles of the vertebral column—a development which is correlated to the exceptionally erect attitude maintained by the various members of the group while on *terra firma*. This erect attitude is assumed by these birds so soon as they leave the water, and is maintained not only when at rest but even during the act of progression. The spinal muscles are therefore developed to an extent unknown in other birds, in all of which, with the exception of the Spheniscidæ, the trunk of the body occupies a more or less horizontal position during progression, and the necessity of powerful extensor muscles to act on the vertebral column is correspondingly diminished.

IV.—ANGEIOLOGY.

THE HEART.

The heart (Pl. XI. fig. 1) occupies the middle line of the thorax, its apex being accommodated in a depression between the right and left lobes of the liver. From its base the trunk of the aorta passes off, and from the latter the right and left innominate arteries pass obliquely forwards and outwards, being placed symmetrically on either side of the middle line. To the outer side, and rather above the level of the innominate arteries, the corresponding venæ cavæ superiores pass backwards to the right auricular cavity. The right and left pulmonary vessels extend forwards from the base of the heart, while the inferior vena cava passes onwards from behind to join the right auricle. The heart, as usual, is enclosed in a special pouch of the general serous membrane which constitutes the pericardium.

The heart in *Eudyptes chrysocome* from Tristan d'Acunha measures 2¼ inches in length, and 2 inches in breadth at the base. The organ is slightly bent upon itself, so that the apex instead of projecting directly backwards is directed backwards and to the right. The grooves which indicate the separation of the auricles from the ventricles, and of the auricles from one another, are clearly defined externally, but the interventricular grooves are scarcely recognisable.

On opening the right auricular cavity (Pl. XI. fig. 2) the walls are seen to be almost smooth and devoid of special muscular bands, except at the orifice of the right superior vena cava, where there is a slight indication of their presence. The orifices of the three venæ cavæ occupy the usual positions. The valve in connection with these orifices consists of two segments, a right and a left, which come into contact in front of the orifice of the right superior vena cava, and behind that of the inferior vena cava. Consequently, both these orifices are guarded by the segments of the valve in question, one segment lying to the right and the other to the left of each. The left segment of the valve is, moreover, prolonged transversely across the wall of the auricle, and comes into relation with the orifice of the left superior cava, which it in part defends. The valvular apparatus at the mouth of the left superior cava, however, is much less effective than that met with in connection with the other two caval orifices. The fossa ovalis is well marked. Beneath the raised margin which surrounds it, a small cul-de-sac extends forwards from the auricular cavity. There is no aperture of communication between the right and left auricles, but doubtless the presence of the cul-de-sac in question is due to the closure of the originally open foramen ovale.

The cavity of the right ventricle (Pl. XI. fig. 2) resembles in form that of other birds. The wall which is formed by the septum ventriculorum is almost smooth and devoid of muscular bands, while the opposite or anterior wall is rough, owing to the presence of numerous decussating muscular bundles. The right auriculo-ventricular valve is arranged as in the majority of birds, but the two muscular flaps which form it are relatively stronger than in most. The left or smaller flap, which in some birds, *e.g.* the Emeu, is so small as to be scarcely distinguishable, is in the Penguins of large size, although of course smaller than the right flap, which in all birds is the larger of the two. The orifice of the pulmonary artery is provided with three semi-lunar valves.

The cavity of the left auricle (Pl. XI. fig. 3) receives the pulmonary veins—one from each lung. They open on the upper wall of the left auricle. These orifices are usually described as being destitute of any valves, but in the Penguins I find a muscular structure, which may, and I believe does, act as an incomplete valve to these orifices. This structure consists of a shelf-like muscular fold, which extends across the upper wall of the auricle from side to side, being attached to the auricular wall in front of the two openings of the pulmonary veins, over which it hangs like a curtain. It appears to me that when the auricle contracts this curtain must be thrown across the orifices of the pulmonary veins, and thus prevent the regurgitation of blood from the auricular cavity into these vessels. The lower wall of the left auricle presents a few muscular bundles, but the upper wall is uniformly smooth.

The wall of the left ventricle (Pl. XI. fig. 3) is nearly twice as thick as that of the right. It is provided with numerous columnæ carneæ, which have a very regular arrangement, and decussating with one another at regular intervals form the boundaries of small diamond-shaped spaces on the ventricular wall. The columnæ carneæ are met with on every portion of the wall of this ventricle. In section this ventricle is circular, while the right is semi-lunar in form. The left auriculo-ventricular valve consists of two cusps, which are disposed much as in the mammalian heart. The chordæ tendineæ attached to them spring in some species from the wall of the heart, in others from rudimental papillary muscles. The latter, when present, are, so far as I have observed, always three in number. Two are placed opposite the intervals between the two cusps composing the valve, to both of which they supply chordæ tendineæ, while the third papillary muscle supplies additional tendinous cords to the left cusp of the valve only. The cusps lie one on either side of the auriculo-ventricular orifice, which, on the left side of the heart does not exceed one-third of the diameter of the corresponding orifice of the right side. The aortic orifice is provided as in other birds with three semi-lunar valves.

Variations.—Except in *Spheniscus demersus*, in which I found that the two valves, which in other species meet both in front of and behind the orifices of the right superior and inferior venæ cavæ, are only continuous with one another in front of, and not behind these orifices, I have observed no variations in the hearts of the various Penguins examined. The following table gives the dimensions of the heart of different species in inches.

Species.	Length of heart from base to apex.	Greatest breadth of heart at base.
Eudyptes chrysocome, from Tristan, ...	2¼	2
Eudyptes chrysocome, from the Falklands, ...	2¼	2
Eudyptes chrysocome, from Kerguelen, ...	2¼	2
Eudyptes chrysolophus, ...	3	2½
Spheniscus demersus, ...	2¼	1¾
Spheniscus magellanicus, ...	2⅛	2¼
Spheniscus mendiculus, ...	1½	1¼
Spheniscus minor, ...	1½	1⅛
Pygoscelis tæniatus, ...	3	4
Aptenodytes longirostris, ...	3½	3

ARTERIAL SYSTEM.

THE PULMONARY ARTERY.

The *pulmonary artery* (Pl. XI. fig. 1), after leaving the right ventricle, divides into two main trunks, one for each lung. Each of these trunks as it passes outwards lies above the corresponding superior vena cava, and below the bronchus. Each divides into two subordinate branches, which enter the lung substance separately. The pulmonary artery is situated ventrad of the other constituents of the root of the lung.

THE AORTA.

The aorta of *Eudyptes chrysocome* (Pl. XI. fig. 1), after leaving the left ventricle, appears at the base of the heart lying to the right of the inter-auricular sulcus. It then arches as usual over the right bronchus, and continues along the lower surface of the vertebral column as far as the last lumbo-sacral vertebra, where it terminates by dividing into three branches, to be afterwards described. In this course it rests against the right side of the large hypapophyses of the dorsal region. Below the artery are the root of the right lung, the liver, and the coils of the small intestine.

The aorta gives off the following branches.

I.—The Innominate Arteries.

These pass off from the summit of the aortic arch, on either side of the middle line. They extend obliquely forwards and outwards, and terminate by dividing into the common carotid and subclavian arteries. In the fork formed by the innominate arteries lie the trachea and œsophagus.

(1.) *The Subclavian Artery.*

In *Eudyptes chrysocome* this artery does not exceed ¼th of an inch in length. It extends from its origin obliquely outwards and forwards, and arching over the apex of the lung terminates under cover of the coracoid bone, by dividing into the thoracic and brachial arteries. Prior to its termination the subclavian artery gives off two branches, which may be named the middle pectoral and the internal mammary arteries.

The Middle Pectoral Artery comes off from the subclavian immediately before its termination. It passes directly downwards, pierces the coraco-brachialis muscle, and comes into relation with the inner border of the coracoid bone. Here it passes through a foramen, bounded on the outer side by the coracoid bone, and on the inner side by a ligamentous band, which is attached to that bone. After passing through this foramen along with the accompanying vein, the artery enters the substance of the pectoralis medius muscle, which it supplies.

The Internal Mammary Artery arises from the subclavian close to the termination of the latter. It passes horizontally backwards within the cavity of the thorax, and applying itself to the margin of the sternum, extends for some distance along that bone. It terminates by breaking up into branches for the supply of the triangularis sterni, and sternal intercostal muscles.

The Thoracic Artery.—This, which is the larger of the two terminal branches of the subclavian passes outwards, lying between the pectoralis minor below and the serratus anticus minor above. It divides almost at once into three or four branches, which again subdivide before entering the substance of the pectoralis major, which they supply. One constant and special branch of this artery applies itself to the outer border of the pectoralis major, by means of which it is conducted as far back as the knee joint, where it breaks up into numerous minute twigs.

The Brachial Artery (Pl. XI. figs. 4 and 5).—The brachial artery in every species of Penguin which I have dissected, differs from that of other birds, inasmuch as it breaks up into a rete mirabile. The artery, as an undivided trunk, does not exceed, even in *Aptenodytes*, $\frac{1}{4}$th of an inch in length, for before it reaches the axilla it gives off several branches which are distributed partly to the coraco-brachialis muscle, and partly to the shoulder joint. Thereafter the brachial artery passes out of the thoracic cavity, lying between the infra-spinatus muscle and the axillary margin of the scapula above and the pectoralis minor below. Here the parent trunk breaks up into seven or eight separate branches which lie parallel with one another in contact with the inner surface of the humerus. They anastomose freely by means of more or less transversely-arranged communicating twigs. In *Aptenodytes* the vessels composing the rete equal in size that of a digital artery of the human hand. The rete extends from the axilla downwards as far as the middle in length of the humerus. At this point the vessels forming the rete begin to coalesce, and the number of parallel vessels becomes gradually smaller, until opposite the lower end of the humerus there are only two separate trunks. These two vessels run parallel to one another across the inner side of the elbow joint, and may for descriptive purposes be termed the radial and ulnar arteries, although they by no means resemble the vessels so named in other birds. Having reached the forearm, they lie between the radius and ulna, and are crossed superficially by the tendons in this region. The radial artery then passes from front to back of the wing, through the interosseous space, and thereafter extends along the dorsal surface of the organ as far as the wrist joint. The ulnar artery, rather larger than the radial, after crossing the front of the wrist joint, passes along the palmar surface of the wing as far as the inter-metacarpal space, through which it passes from the palmar to the dorsal surface of the wing, and after inosculating with the terminal branches of the radial artery, is prolonged onwards to the free extremity of the wing.

The following branches are given off from one or other of the vessels just described:—

(a) *The Profunda Artery.*—This branch passes off from the arterial rete close to the axilla. It bends round the posterior border of the humerus, along with the musculo-spiral nerve, and is distributed to the cutaneous structures covering the lower half of the outer surface of the humerus and elbow joint.

(b) *A branch*, which, arising from the commencement of the radial artery, passes transversely outwards and supplies the brachialis internus muscle.

(c) *A branch*, which, arising from the ulnar artery immediately below the elbow joint, passes transversely inwards, and close to the posterior border of the ulna divides into two. Of these one passes upwards and supplies the elbow joint, while the other passes downwards parallel with, and close to the posterior border of the ulna. It terminates by anastomosing with the next branch.

(d) *A branch* coming off from the ulnar artery, just before the latter leaves the palmar surface of the wing, passes obliquely downwards and inwards below the wrist joint, and reaching the posterior border of the wing extends as far as the tip of that organ. By means of the anastomosis of this with the preceding branch, there is formed a vessel which extends along the whole length of the posterior margin of the wing from the elbow joint to the tip. This vessel lies alongside of the brachial vein.

(2.) *The Common Carotid Artery.*

In all the Penguins which I have examined, there are two common carotid arteries of equal size, both of which occupy the inferior middle line of the neck. Each after separating from the trunk of the innominate artery is directed forwards and inwards, and gains the middle line of the neck at a point which corresponds to the great inferior convexity of that portion of the vertebral column. Here the arteries of opposite sides come into contact. Thereafter they pass directly forwards, lying in the interval between the longi colli muscles of opposite sides, the artery of the left lying slightly below (in front of) that of the right side. The arteries lie in contact as far as the middle in length of the groove between the recti antici majores muscles, but beyond this point diverge from one another, and after crossing the front of the corresponding rectus anticus muscle, each divides opposite the posterior extremity of the mandible into the carotis cerebralis and the carotis facialis. The two common carotid arteries are of equal size, and have similar relations except at their terminations. The artery of the right side, in consequence of the deviation of the trachea and œsophagus from the middle line crosses these tubes, while the left carotid artery has no relation to them.

In *Aptenodytes*, on account of the lesser deviation of the œsophagus and trachea from the middle line of the neck in that genus than in *Eudyptes*, both the common carotid arteries at their termination come into relation with these tubes.

The common carotid artery, in addition to the external and internal carotids, gives off four named branches, all of which arise from the parent trunk one inch from its commencement. They are the œsophageal, the transversalis colli, the vertebral, and the arteria cutanea colli.

The Œsophageal Artery.—This is a small branch which comes off from the common carotid close to the thyroid gland. It passes obliquely forwards and inwards, and coming into contact with the œsophagus, supplies the walls of that tube.

The Transverse Cervical Artery is likewise a small branch, which, after leaving the common carotid, passes transversely outwards, and supplies the soft parts in the neighbourhood of the shoulder joint and on the dorsal surface of the scapula.

The Vertebral Artery.—After leaving the carotid trunk this branch is directed obliquely forwards and upwards, and comes into close relation with the cervical air sac. It passes into the foramen of the transverse process of the first dorsal vertebra,[1] and thereafter extends forwards, lying in the bony canal formed by the transverse processes of the cervical vertebræ as far as the cephalic extremity of the neck. Its exact mode of termination I could not make out in any species, with the single exception of *Spheniscus mendiculus*, because of the impossibility of completely injecting it. In the species named, however, I found that the vertebral artery after escaping from the bony canal between the second and third cervical vertebræ, terminated by inosculating with the occipital artery. In all probability, therefore, in the Penguins as in the majority of birds, according to Barkow,[2] this is the normal mode of termination of the vertebral artery.

The Subcutaneous Cervical Artery[3] comes off from the common carotid close to the vertebral artery. It passes obliquely forwards and outwards, and crossing the jugular vein reaches the deeper surface of the panniculus carnosus muscle. Here it applies itself to the vagus nerve, and accompanies it together with the jugular vein as far forward as the posterior extremity of the mandible. Having reached this point, the artery passes inwards, resting upon the lower surface of the rectus capitis anticus muscle, and terminates by inosculating with a branch of the external carotid.

(A) *The External Carotid Artery*

Is very short. In the King Penguin it does not exceed ¼th of an inch in length. From its origin it passes obliquely outwards to gain the inner surface of the posterior extremity of the mandible, where it divides into three terminal branches. These branches are the lingual, the palatine, and the anastomotic. Of these the two former pass forwards while the latter passes backwards.

(a) *The Lingual Artery* at its origin is superficially placed. It extends from the external carotid almost horizontally forwards, lying along the inner side of the corresponding half of the lower jaw bone. At first it lies under cover of (above) the cornu of the hyoid bone, but farther forward it lies in the interval between the ramus of the lower jaw bone on the outer, and the hyoid cornu on the inner side. Towards its termination it rests upon the surface of the mylo-hyoid muscle, and having reached the symphysis of the lower jaw bone, inosculates with its fellow of the opposite side. The lingual artery, close to its origin, gives off a branch of some size which passes to supply the walls of the

[1] I consider the vertebra referred to to be the first dorsal, because the anterior bar of its transverse process is moveably articulated, both with the body of the vertebra and with the extremity of the posterior bar of its transverse process. The anterior bar of this transverse process thus forms a rudimental rib. By some authors this vertebra is considered to be the last member of the cervical series.

[2] Meckel's Archiv für Anatomie und Physiologie, 1829, p. 305.

[3] The arrangement of this artery in the Hornbill is carefully described by Ottley in the Proc. Zool. Soc., 1879. In that bird the subcutaneous cervical artery inosculates with the vertebral artery, whereas in the Penguin it anastomoses with the external carotid. Ottley terms this artery the "arteria comes nervi vagi."

anterior portion of the œsophagus. This branch evidently represents the "arteria œsophagea descendens" of Barkow.

(b) *The Palatine Artery* arises from the external carotid above the origin of the lingual artery, and passes forwards to gain the roof of the mouth. Here it lies between the pterygoid muscle and the papillated mucous membrane of the palate, and after extending forwards parallel to the palatal fissure, terminates close to the anterior extremity of the bony palate, by inosculating with its fellow of the opposite side. A number of small branches are supplied by the palatine artery to the anterior portion of the œsophagus, as well as to the soft parts in the neighbourhood of the palate.

As the palatine artery passes forwards it gives off a branch of considerable size, which winds upwards round the inner border of the pterygoid muscle, to gain the upper or orbital surface of that structure, where it develops a coarse arterial *rete*, which occupies the floor of the orbit. This rete, moreover, receives a communicating branch from the trunk of the internal carotid artery after that vessel has passed into the interior of the skull. From the plexus of blood-vessels so formed, numerous branches are given off. A few of these branches supply the pterygoid muscle, but much the greater number pass forwards, and terminate by supplying the structures occupying the anterior inferior angle of the orbit, and the basal region of the superior maxillary bone.

(c) *The Anastomotic Artery.*—The artery which I have thus named comes off from the external carotid artery, and passes obliquely backwards and outwards to gain the deeper surface of the panniculus carnosus muscle. Here it gives off numerous branches to the superior and lateral surfaces of the neck, and terminates by inosculating with the subcutaneous cervical artery. It thereby completes an important anastomosis between the commencement of the common and that of the external carotid arteries. This artery, like the subcutaneous cervical, lies alongside of the vagus nerve and jugular vein.

In *Pygoscelis tæniatus* the anastomotic artery is given off from the internal carotid, ¼th of an inch from the origin of the latter.

(B) *The Internal Carotid Artery.*

After separating from the external carotid, the internal cartoid artery passes inwards to reach the base of the skull, where it traverses the carotid canal, and thereby reaches the interior of the cranium. Here it divides into two terminal branches, an anterior and a posterior. The anterior extends alongside of the sella turcica, and divides into two branches, of which one passes vertically upwards to supply the cerebral hemisphere, while the other (the ethmoidal) leaves the front of the cranial cavity by means of a special foramen, and reaching the orbit, terminates by breaking up into branches for the supply of the straight muscles of the eyeball. The posterior terminal branch of the internal carotid passes backwards and supplies the cerebellum.

From the internal carotid artery, in addition to the terminal branches just described, the following are given off,—the occipital, the internal maxillary, the inferior orbital, and the superior orbital.

(a) *The Occipital Artery* passes backwards from the internal carotid, and gaining the lateral aspect of the neck immediately behind the occiput terminates by breaking up into branches for the supply of the extensor muscles of the neck, as well as for that of the digastric muscle.

In *Pygoscelis* this branch is given off from the anastomotic artery, which in that species is derived from the internal and not from the external carotid artery, as in the other species examined.

(b) *The Internal Maxillary Artery* passes forwards from the internal carotid previous to the passage of the latter through the carotid canal. It winds round the outer side of the quadrate bone, lying under cover of the digastric muscle, and then passes horizontally forwards, parallel with and to the inner side of the jugal arch, to terminate by supplying the pterygoid muscle together with the soft parts which occupy the anterior portion of the floor of the orbit immediately behind the angle of the gape.

(c) *The Inferior Orbital Artery* also arises from the internal carotid previous to the passage of the latter into the cranium. It passes obliquely forwards and downwards, lying internal to the quadrate bone, which thus separates it from the internal maxillary artery. It is concealed by the digastric muscle, in front of which it rests upon the upper or orbital surface of the pterygoid muscle, and terminates by supplying these two structures. Previous to its termination, it lies upon the outer surface of the insertion of the temporal muscle immediately below the jugal arch.

(d) *The Superior Orbital Artery* arises from the internal carotid, close to the origin of the inferior orbital branch. It passes obliquely upwards and forwards, and enters a bony canal, which surrounds the upper half of the fenestra ovalis. Escaped from this canal into the orbit, it breaks up into a number of small branches, which, along with others supplied by neighbouring branches, constitute a close arterial *rete mirabile* situated between the posterior wall of the orbit and the lachrymal gland. From this rete a branch of considerable size, which may be named the *temporal* artery, passes vertically upwards under cover of the digastric muscle, and supplies the latter as well as the temporal muscle. After forming the *rete mirabile*, the superior orbital artery passes forwards, and divides into two branches. Of these the first and larger runs downwards and forwards, lying in contact with the roof of the orbit, and terminates at the base of the maxillary bone by passing into the nasal region, where it is distributed. The second and smaller branch passes downwards to reach the entrance of the optic nerve into the eyeball, where it breaks up into branches which in part contribute to the formation of the orbital plexus, and in part supply the muscles of the eyeball.

From the preceding description of the arteries of the head, it will be observed that there are two distinct arterial plexuses in each orbit. One of these, the orbital plexus proper, is developed in connection with the superior orbital artery, and occupies the upper and posterior part of the orbital cavity. The second plexus, which is composed of larger vessels than those of the orbital plexus, may be named the maxillary plexus. It lies in contact with the upper surface of the pterygoid muscle, and is formed by the anastomosis of branches derived principally from the inferior orbital artery, to which, however, are united a large branch of the palatine, and a communicating branch of considerable size, which unites the orbital with the maxillary plexus.

II.—The Bronchial Arteries

Come off from the aorta, just beyond the arch. They pass transversely outwards, and enter the lungs along with the other constituents of the root.

III.—The Intercostal Arteries

Are six to nine in number on either side. They are distributed to the intercostal spaces. The anterior arteries follow an oblique course forwards and outwards, while the posterior course almost transversely outwards. These arteries, for the most part, lie in the hollowed lateral surfaces of the bodies of the vertebræ, but the anterior, owing to their oblique course, cross the bodies of two or more vertebræ.

IV.—The Cœliac Axis.[1]

The cœliac axis arises from the abdominal aorta, opposite the head of the seventh vertebral rib. It passes obliquely downwards and backwards, and immediately above the right lobe of the liver divides into the four following branches,—the splenic, anterior gastric, posterior gastric, and intestinal arteries.

(1) *The Splenic Arteries* are three or four in number. They are short arteries of small size, which at once enter the substance of the spleen.

(2) *The Anterior Gastric Artery* is of considerable size. It passes horizontally backwards to reach the right margin of the stomach, along which it travels backwards as far as the angle of junction of the glandular and muscular portions of that viscus, where it breaks up into its terminal twigs. As it passes backwards, the anterior gastric artery

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[1] Reid (Proc. Zool. Soc., 1835, p. 145) thus describes the distribution of the cœliac axis in *Aptenodytes patachonica*:—"The cœliac axis comes off on a level with the fifth rib; it passes a little forwards, and divides into the *coronaria ventriculi*, the hepatic, and the splenic. The *coronaria ventriculi*, just after its origin, divides into the superior and inferior coronaries: the superior passes round the large curvature of the stomach, and near the *pylorus* gives off the superior pyloric and left hepatic; the inferior passes down the right side of the stomach, and disappears at the *pylorus*, being here minutely ramified upon it. The hepatic gives off the right gastro-epiploic, which goes on the inferior angle of the stomach; and the right gastric, which goes on the *pylorus* and superior part of the stomach, anastomosing with the superior pyloric and inferior coronary arteries. The splenic gives off a small artery distributed on the cardiac portion of the stomach, and some vasa *brevia*, which are distributed to the left portion of the stomach." In respect of details this description does not correspond with what I have seen in any species of Penguin, in all of which the arteries are distributed as described in the text.

VI.—The Ovarian Artery

Comes off from the abdominal aorta, half an-inch behind the origin of the superior mesenteric artery. It passes to the left side, and after giving off a branch for the supply of the anterior half of the oviduct, terminates in the substance of the ovary.

VII.—The Renal Arteries.

These are three in number on each side. The two anterior come off from the aorta half an inch in front of the crural artery. They pass outwards and backwards, and supply the anterior or larger of the two renal lobes. The posterior renal artery arises from the aorta behind the origin of the crural, and passes outwards to supply the posterior or smaller of the lobes of the kidney. All three arteries inosculate freely with one another in the substance of the kidney.

VIII.—The Lumbar Arteries

Are in series with the intercostals. They are of small size, and arise partly in front of and partly behind the renal arteries. They are distributed somewhat irregularly to the superior and lateral abdominal walls.

IX.—The Inferior Mesenteric Artery

Is given off from the abdominal aorta close to its termination. It passes backwards between the folds of the meso-rectum, and supplies the great intestine between the cœca and cloaca.

X.—The Hypogastric Arteries

Are two in number. They leave the aorta opposite the last lumbo-sacral vertebra, and accompany the ureters as far as the cloaca, which together with the bursa fabricii they supply.

XI.—The Middle Sacral Artery.

This, the termination of the aorta, extends backwards, lying along the inferior middle line of the coccygeal vertebræ. It terminates by breaking up into small branches for the supply of the depressores coccygis muscles and neighbouring parts.

XII.—The Crural Artery

Arises from the abdominal aorta in front of the posterior renal artery. It passes obliquely outwards and backwards above the fissure which separates the two lobes of the kidney, and escapes from the abdominal cavity by passing over the anterior border of the iliac bone. It then passes along the inner side of the thigh, lying under cover of the ambiens muscle, as far as the upper border of the adductor magnus, where it terminates by dividing into the femoral and sciatic arteries.

From the crural artery the following branches are given off.

(1) *A branch,*

Which passes off from the crural before that artery leaves the abdomen, runs backwards along the external margin of the pelvic bone, and supplies the neighbouring structures. From this artery a subordinate branch of small size is given off. It passes inwards, and accompanies the obturator nerve through the foramen ovale.

(2) *The External Circumflex Artery*

Is given off from the crural artery so soon as the parent trunk reaches the inner side of the thigh. It passes outwards, and under cover of the sartorius divides into three or four branches which supply the extensor muscles of the knee joint, including the sartorius. These branches form an anastomotic chain of arteries which extends from the hip to the knee joint.

(3) *The Femoral Artery*

Arises from the crural trunk at the upper border of the adductor magnus. It rests against the adductor magnus, and extends along the inner side of the thigh as far as the knee joint, where it breaks up into its terminal twigs. Differing in its mode of origin, the femoral artery of the Penguins agrees with that of other birds in respect of its distribution.

(4) *The Sciatic Artery.*

This artery extends from the termination of the crural artery downwards to the back of the knee joint. Separating from the femoral artery opposite the upper border of the adductor magnus muscle, the sciatic artery passes at once from the inner to the outer side of the thigh. Having gained this region, it rests upon the outer surface of the adductor magnus, as far as the knee joint, where it divides into the anterior and posterior tibial arteries. As it lies along the outer side of the thigh it is concealed superficially by the biceps and adductor longus muscles.

In *Spheniscus demersus* the sciatic artery gives off a branch which passes along the back of the thigh close to the femur. It terminates at the outer side of the knee joint, by inosculating with the other branches in that region. This branch I failed to recognise in any other species of Penguin.

From the above description, it will be observed that in the Penguins the sciatic and femoral arteries, instead of coming off as separate branches from the abdominal aorta, as in the majority of birds, are branches of a single trunk, the crural artery, the origin of which corresponds to that of the femoral in the majority of birds. This somewhat exceptional arrangement of these arteries obtains also, as I am informed by Mr. Forbes, in certain other genera, but in none that can be supposed to be in any way allied to the Penguins.

The sciatic artery gives off two branches—the posterior tibial and the anterior tibial.

(a) *The Posterior Tibial Artery* extends from the back of the knee joint downwards to below the ankle. In this course the artery is quite superficially placed, being covered only by the skin, and resting against the inner head of the gastrocnemius. It terminates as a small vessel which extends as far down as the middle in length of the metatarsal bone. As the posterior tibial artery passes downwards it gives off numerous small branches to the outer and inner heads of the gastrocnemius muscle.

(b) *The Anterior Tibial Artery* extends from the termination of the sciatic artery behind the knee joint forwards between the inner and outer heads of the gastrocnemius, to reach the posterior surface of the tibia above the popliteus muscle. Here it comes into contact with the posterior surface of the interosseous membrane, and passing downwards under cover of the flexor perforans, as far as the middle in length of the tibia, pierces that membrane and gains its anterior surface. Here the artery lies, along with the anterior tibial nerve, between the tibialis anticus and the peroneus longus, and coursing as far as the annular ligament above the ankle joint, terminates by dividing into the external and internal digital arteries.

The anterior tibial artery gives off the following branches.

(a) *The Articular Artery* comes off from the anterior tibial at the upper border of the popliteus. It passes forwards and upwards to supply the structures surrounding the knee joint.

(b) *Muscular Arteries.*—These are three in number, and arise from the parent trunk under cover of the popliteus muscle. They pass transversely forwards in the interval between the tibia and fibula, and gaining the front of the leg, are distributed to the muscles of that region, and more especially to the tibialis anticus and extensor digitorum. One of these branches inosculates with the anterior tibial after the latter has pierced the interosseous membrane.

In one specimen of *Aptenodytes* one of these muscular arteries was of large size, and extended as far as the cleft between the two outer toes, where it took the place of the external digital artery. In others the arrangement was similar to that described in *Eudyptes chrysocome.*

(c) *The Internal Digital Artery,* after separating from the anterior tibial, passes together with the anterior tibial nerve and the tendon of the tibialis anticus beneath the anterior annular ligament of the ankle, and having passed to the upper end of the metatarsus, divides into two branches. Of these one, which may be named the perforating artery, passes from front to back of the leg by means of a foramen between the middle and inner metatarsal bones, while the other continues along the front of the metatarsus, as far as the base of the toes, where it divides into two branches for the supply of the contiguous sides of the middle and inner toes.

(d) *The External Digital Artery* passes downwards in front of the metatarsus, lying to the outer side of the anterior annular ligament, and opposite the head of that bone divides, like the internal digital artery, into two branches. Of these one (the perforating) passes through a foramen between the middle and outer metatarsal bones to the back of the leg, while the other continues its course along the front of the metatarsus to the base of the digits, where it divides into two branches for the supply of the contiguous sides of the middle and outer toes.

Comparative Remarks.

Having now completed the description of the arterial system of the Penguins, it may be well in a few words to compare it with that of other birds.

The arrangement of the carotid arteries of birds has formed the subject of special essays by Bauer,[1] Meckel,[2] Nitzsch,[3] and Barkow,[4] all of whom have directed attention to a number of variations in respect of the arrangement and distribution of these trunks in different species. Among these various observations, Meckel[5] directs attention to the fact that in the genus *Aptenodytes* (species not mentioned) the two common carotids are of equal size, and that they are symmetrically arranged, and come off from the innominate arteries of opposite sides. Since that observation, I cannot ascertain that anything definite has been put on record with regard to the arterial system of the Penguins, until the late Professor Garrod,[6] in his paper "On the carotid arteries of birds," extended the observations of Meckel, and showed that in *Spheniscus demersus*, *Spheniscus humboldti*, and *Aptenodytes pennantii*, the common carotid arteries are of equal size. These observations I have now been able to confirm, and to show that they apply to every species of Penguin which I have had an opportunity of examining.

If now we look to the arrangement of the other arteries in the Spheniscidæ, we find that every member of the group is farther characterised by the possession of two arterial arrangements, which, taken together, appear to be characteristic of the group as a whole. I refer to the distribution of the arteries of the anterior and posterior extremities. In respect of the latter, as already noticed, the principal artery of the limb is not, as is usually the case in birds, the sciatic, but the crural trunk. Indeed, so far as I could ascertain after careful dissection of every species at my disposal, the sciatic artery is absent, except in *Spheniscus mendiculus*, in which I found a very minute twig derived from the abdominal aorta, accompanying the sciatic nerve. With this single exception, the crural artery entirely replaces the sciatic, and supplies those branches which in the majority of birds are supplied partly by the femoral, but chiefly by the sciatic artery. As before observed, Mr. Forbes informs me that he has discovered a similar arrangement in certain other birds, but in none "that can at all be considered as allied to the Penguins."[7]

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[1] Disquis. circa nonnullarum Avium systema arteriosum, Berolini, 1825.

[2] Beitrag zur Geschichte des Gefässystem der Vögel, Meckel's Archiv, 1826, pp. 19 and 157.

[3] Observationes de Avium arteria carotide communi, Halle, 1829.

[4] Anatomisch-physiologische Untersuchungen über das Schlagadersystem der Vögel, Meckel's Archiv, 1829, p. 305.

[5] Anatomie Comparée, vol. ix. p. 363.

[6] Proc. Zool. Soc., 1873, p. 457.

[7] Letter to the author.

The arrangement of the arteries of the anterior extremity of the Penguins is even more exceptional, and indeed, so far as I can ascertain, is altogether confined to members of the group of Spheniscidæ. The existence of retia mirabilia in various species of mammals is well known, and in birds they have been described in connection with the orbital and anterior tibial arteries. I cannot, however, ascertain that anything at all resembling the perfect arterial rete, above described in the Penguins, has hitherto been observed in any other bird. A venous rete has been described by Van der Kolk[1] in the wing of the Condor, but an alar arterial rete appears to occur in the wing of the different members of the group of Spheniscidæ, and in them alone. The occurrence of this arterial rete in birds which spend a large portion of their existence beneath the surface of the water, is of interest in connection with the occurrence of large retia in the truly aquatic mammalia, such as the Cetacea. In the Penguins, as in the Cetacea, the physiological *raison d'être* is far from apparent.

The characteristics of the group of the Spheniscidæ, so far as the arterial system is concerned, may be summed up shortly as follows:—*Firstly*, The possession of two common carotid arteries of equal size, symmetrically placed with reference to the middle line of the neck, and furnishing branches which are symmetrically distributed in the regions of the head and neck. *Secondly*, The entire absence or marked degeneration of the sciatic artery, and the substitution for it of a branch of the crural artery. *Thirdly*, The existence of an arterial rete mirabile in the region of the humerus and forearm.

VENOUS SYSTEM.

Pulmonary Veins.

Of these there are two—a right and a left. Each is formed by the junction of two branches, and passes transversely inwards above the corresponding innominate vein, to open close to its fellow into the cavity of the left auricle. The pulmonary veins are situated above (dorsad of) the other constituents of the root of the lung.

Systemic Veins.

The Jugular Veins.

The jugular veins (Pl. XI. fig. 1) of the two sides are of equal size. Each is formed by the union of a number of branches in the region of the head. These branches may be divided into two sets—a superficial and a deep. The superficial branches are three in number.

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[1] Annales des Sciences Naturelles, sér. iv., tom. v. p. 141, pl. iv.

Of these, one (the external facial vein of Neugebauer[1]) passes backwards parallel with the zygoma, and crosses the superficial surface of the digastric muscle to unite behind the articulation of the lower jaw bone with the second branch. The second vein (the occipital of Neugebauer) arises among the muscles of the neck, close to the occiput. It passes downwards along the posterior border of the digastric muscle to unite with the first branch. The large vein thus formed is joined by a third branch, which carries off the blood from the deep muscles in the occipital region, after which it unites in the basilar region with the deep veins of the head to form the commencement of the jugular vein.

The venous trunk formed by the union of the superficial veins unites immediately behind the os quadratum with the deep branch (the internal facial of Neugebauer) of the jugular vein. The deep branches of the two jugulars of opposite sides unite across the middle line to form a venous arch, the convexity of which is directed forwards. This arch rests against the palatal surface of the pterygoid muscles, and receives numerous small branches from the base of the skull and from the palatal region. Each extremity of the arch is prolonged backwards to unite with the common trunk formed by the superficial veins of the head, and the two together form the commencement of the jugular vein. From the point of origin the jugular vein passes backwards along the neck, in company with the vagus nerve and subcutaneous cervical artery and under cover of the panniculus carnosus muscle as far as the root of the neck. Here it enters the thorax, and crossing the dorsal surface of the subclavian artery, unites with the subclavian to form the innominate vein. In consequence of the transposition of the trachea and œsophagus to the right of the middle line, the jugular vein of the right side is likewise displaced from the front of the vertebral column, and lies altogether to its right side and in contact with the posterior surface of the œsophagus. At the root of the neck, however, like these structures, the jugular vein regains its normal relation to the cervical column. Each jugular vein receives numerous branches from the trachea, œsophagus, and panniculus carnosus muscle. One of larger size than the others arises among the extensor muscles of the neck, and joins the jugular vein about the middle in length of the cervical region.

The Humeral Vein.

The veins of the wing in the Penguins do not accompany, nor do they correspond with, the arteries. They are for the most part of small size, and pass from both surfaces of the wing towards its posterior margin, where they terminate in a single trunk of large size. This, the basilic vein of Neugebauer (Pl. XI. fig. 4), commences close to the tip of the wing and passes upwards, lying in close relation to the posterior border of that organ as high as the axilla. Having reached the axilla, it passes between the serratus

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[1] Systema venosum Avium, Nova Acta Acad. Nat. Curios, tom. xxi.

anticus minor and pectoralis minor muscles, and unites with the large anterior thoracic vein from the pectoralis major to form the subclavian. As the humeral vein passes upwards it receives a branch of large size opposite the elbow joint. This branch is formed by the union of several small branches, which arise near the tip of the dorsal surface of the wing, and, after passing from the dorsal to the ventral or concave surface of the organ, through the interosseous space between the radius and ulna, where it receives some small twigs from the extremity of the concave surface of the wing, ascends to open into the trunk of the humeral vein opposite the elbow joint.

The Subclavian Vein

Is formed by the junction of the humeral and anterior thoracic veins, close to the axillary border of the scapula. After entering the thorax, it lies parallel with and above the artery of the same name, and terminates by uniting with the jugular to form the innominate vein. The subclavian vein, before entering the thorax, receives a large branch from the scapular region. This branch lies between the scapula and the wall of the chest. Within the cavity of the chest the subclavian vein receives branches corresponding to those of the companion artery. The *vertebral* vein, which closely accompanies the vertebral artery, opens into the angle of junction of the subclavian and jugular veins. In some species (*Pygosceles*) the vertebral vein joins the subclavian, while in others (*Spheniscus demersus* and *Spheniscus minor*) it pours its blood into the jugular vein. In either case the termination of the vertebral is close to the point of junction of the great veins of the head and wing.

There is not the slightest appearance in the wing of the Penguin of a venous rete mirabile, comparable to that already described in connection with the humeral artery.

The Innominate Vein.

Formed by the junction of the jugular and subclavian veins, the innominate vein (Pl. XI. fig. 1) passes backwards, and crossing below the pulmonary and above the innominate artery of the same side, opens into the cavity of the right auricle in the usual manner. The position of the orifices of the innominate veins is described in connection with the heart. Their cardiac extremities, as well as that of the inferior vena cava, are much enlarged, and recal to mind the appearance of the corresponding dilatation of the inferior vena cava of the Seals.

The Crural Vein

Is formed behind the knee joint by the union of branches which correspond to those of the crural artery. It travels upwards along with that artery to the upper border of the adductor magnus, over which it passes to reach the inner side of the thigh. From the inner side of the thigh the crural vein passes into the cavity of the pelvis along with, but separated from the artery by the pectineus muscle. Having reached the pelvic cavity it terminates as follows:—So soon as the crural vein enters the pelvic cavity, it divides into four branches (Pl. XII. fig. 7), two of which pass backwards and two forwards. Of the two former, one, which may be named the superficial branch, lies on the lower surface of the posterior lobe of the kidney, and passes backwards as far as the posterior extremity of that lobe, where it unites with the second or deep retrocurrent branch. The second or deep branch follows a parallel course, but instead of lying in contact with the lower surface of the kidney, is placed between the upper surface of that organ and the upper wall of the pelvis. It extends backwards as far as the posterior extremity of the kidney, where it inosculates with the superficial branch of the same side, as well as with the trunk formed by the union of the superficial and deep branches of the opposite side. By means of the last-named inosculation a venous arch is formed, the summit of which is directed backwards. This arch lies in contact with the posterior extremities of the kidneys, and is crossed by the ureters. It receives five or six separate branches (hypogastric), which take their rise in the inferior caudal region. From the most projecting point of the arch a single large mesial vein arises and passes forwards between the layers of the meso-rectum. This trunk (the coccygo-mesenteric of Neugebauer[1]) forms the commencement of the portal vein, which in the Penguins, as in other birds,[2] communicates freely with the veins of the legs.

Of the two branches derived from the crural vein which pass forwards, one is considerably smaller than the other. It passes forwards, lying in contact with the lower surface of the anterior renal lobe, and close to the anterior extremity of the latter unites with the second of the anterior branches. The latter vein likewise passes forwards in contact with the lower surface of the anterior lobe of the kidney, but lies internal to the first branch. Opposite the anterior border of the kidney these two branches unite to form a single trunk, which almost at once unites in the middle line with its fellow of the opposite side of the body to form the vena cava inferior. Both the anterior and posterior branches of the crural vein receive numerous branches from the substance of the kidney.

The Inferior Vena Cava.

This vein, formed as above described, passes forwards in company with the aorta as far as the right lobe of the liver, through the substance of which it passes. After receiving the hepatic veins, the vena cava emerges from the apex of the right hepatic lobe, and almost at once enters the right auricle of the heart.

The Hepatic Veins open into the vena cava inferior before that trunk escapes from the apex of the right hepatic lobe.

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[1] Systema venosum Avium, Nova Acta Acad. Nat. Curios, tom. xxi.

[2] Nicolai, Isis, 1826, p. 414.

The Portal Vein

Is of large size. The large trunk (coccygo-mesenteric, Pl. XII. fig. 7) which forms its commencement passes off from the summit of the arch formed by the union of the retrocurrent branches of the crural veins of opposite sides. After leaving this arch, the portal vein travels forwards, lying between the layers of the meso-rectum as far as the posterior surface of the liver. Immediately behind that organ, the portal vein receives numerous tributary branches from the stomach, intestine, spleen, and pancreas, and thereafter divides into two branches, which enter the liver above the bile ducts. Of the two terminal branches, one passes to the right and the other to the left lobe of the liver. At its entrance into the liver the hepatic artery lies below both the portal vein and the bile ducts.

Comparative Remarks.

From the preceding description it will be seen that the venous system of the Penguins does not present any very striking peculiarities, as compared with that of other birds. Barkow[1] has pointed out that the jugular veins in birds are subject to three different arrangements. In some birds the jugular veins are of equal size, and symmetrically disposed on either side of the middle line of the neck. In others the jugular vein of one side exceeds in size that of its fellow, while in a third group the jugular vein of one side only is present, and carries off the blood from both sides of the head.

In every species of Penguin the two veins are of equal size, and are symmetrically disposed on either side of the cervical middle line.

In birds in general, according to the observations of Hunter[2] and Neugebauer,[3] the portal vein consists of two distinct trunks—a right and a left. The right portal vein is formed chiefly by the junction of the coccygo-mesenteric with the anterior mesenteric veins, while the left portal vein is formed by the union of branches derived from the stomach.

In every species of Penguin the whole of these veins unite to form a single trunk, which only divides, as in the mammal, into two branches immediately before these enter the substance of the liver.

LYMPHATIC SYSTEM.

With respect to the detailed anatomy of the lymphatic system in the Penguins, I regret that I am able to give but little information, the state of the parts in the majority of the species examined preventing me from making the necessary injections.

Reid[4] states that in the Patagonian Penguin "The absorbent system is more perfect

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[1] Untersuchungen über das Schlagadersystem der Vögel, Meckel's Archiv für Anatomie, 1829, p. 496.

[2] Catalogue of Mus. of Roy. Coll. of Surgeons, tom. ii. pl. xxv. fig. 1.

[3] Systema venosum Avium, Nova Acta Acad. Nat. Curios. vol. xxi.

[4] Proc. Zool. Soc., 1835, p. 147.

than in most birds. Of the thoracic ducts the left is the largest. There are a femoral and two axillary glands; also an extra pair of bronchial glands more than in the Loon or Gull." I must content myself with adding, by way of comment on this passage, that although carefully looked for, I was unable to recognise the presence of either axillary or femoral lymphatic glands in any species of Penguin which I had an opportunity of dissecting.

V.—NEUROLOGY.

THE BRAIN AND SPINAL CORD.

The brain (Pl. XII. figs. 1, 2, 3) and spinal cord of every species of Penguin closely resemble those of other birds. The somewhat unsatisfactory state of preservation of the brain prevented me making a minute examination of the organ. I have, however, appended accurate drawings of the exterior of the brain in one species of each of the genera which I had an opportunity of dissecting.[1]

The cranial nerves of the Penguins in respect of their distribution closely resemble those of the Duck or Goose, and the latter being well known, I feel it unnecessary farther to allude to them.

The spinal cord in the Penguins, as in other birds, develops a large rhomboidal sinus.

SPINAL NERVES.

Of the spinal nerves, in accordance with the number of intervertebral foramina, there are forty-two pairs in every species of Penguin. At the same time it is right to state that in the coccygeal region of *Eudyptes chrysocome* I could only distinguish four instead of seven pairs. The small size of the posterior nerves doubtless prevented me from recognising them in the midst of tissue so hardened by the preservative employed as to render the recognition of minute structures extremely difficult.

As usual, each of the spinal nerves divides into two branches, a dorsal and a ventral. The dorsal branches are distributed to the dorsal spinal muscles, as well as to the skin of the back. The ventral branches present the arrangement described below.

Cervical Nerves.

The cervical nerves are fourteen in number. The anterior divisions of the upper twelve appear in the dissection of the neck after passing from between the lateral and inferior cervical muscles. They do not unite to form a plexus, but after supplying numerous branches to the spinal muscles, reach the panniculus carnosus, which, together

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[1] For the brain of *Aptenodytes* I am indebted to the kindness of Mr. Forbes, prosector to the Zoological Society, who kindly removed it from a specimen which died in the menagerie of that society. The other drawings are from Challenger specimens.

with the skin, they supply. The anterior divisions of the last two cervical nerves pass backwards, and unite with the first dorsal to form the single cord which in the Penguins represents the brachial plexus.

The Brachial Plexus.

The brachial plexus (fig. 1) is formed by the union of the anterior branches of the last two cervical and first dorsal[1] nerves, and receives a communicating twig from the second dorsal nerve.[2] These nerves pass out from the intervertebral foramina lying between the scalenus muscle above and the lateral muscles of the root of the neck below. They unite together to form a single cord, which escapes from the thorax along with the subclavian artery by passing over the second rib to reach the axilla. As it passes from the thorax, the single cord lies between the supra- and infra-spinatus muscles above, and the pectoralis minor below, and between these muscles it breaks up into branches for the supply of the wing.

Previously to its union with the other nerves which form the single cord of the brachial plexus, the second last cervical nerve gives off certain branches. They are arranged as follows:—

(*a*) The nerve to the *rhomboid*, *trapezius*, and *levator scapulæ* (1)[3] winds upwards between the shoulder girdle and the wall of the chest, to reach the deeper surface of the rhomboid muscle, where it divides into three branches, which are distributed to the three muscles above named.

(*b*) The nerve to the *pectoralis medius* (2) passes downwards through the foramen situated on the inner side of the upper extremity of the coracoid bone, and enters the deeper surface of the muscle which it supplies. A subordinate twig is given off from this nerve to supply the coraco-brachialis.

From the single large cord which represents the brachial plexus, the following branches are derived:—

(*a*) The nerve to the *pectoralis major* (3), which passes downwards, and enters the deeper surface of that muscle. From this nerve a subordinate branch is supplied to the "muscle des parures," and another to the pectoralis minor.

(*b*) The nerve to the *serratus anticus major* and *serratus anticus minor* (4). This nerve arises from the plexus, above the origin of the nerve to the pectoralis major. It pierces the serratus anticus minor, and after giving off branches to that muscle, terminates in the serratus anticus major.

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[1] By first dorsal nerve I mean that nerve which lies in the intercostal space which is bounded in front by the first or rudimental rib, and behind by the second rib. The designation of this nerve is dependent on the view held regarding the nature of the first or rudimental rib. By some anatomists it is considered to be the moveably articulated transverse process of the last cervical vertebra, while by others it is regarded as the costal element of the first dorsal vertebra. I have adopted the latter view, and consequently enumerate the nerve in question among those of the dorsal region.

[2] The communicating branch from the second dorsal nerve is absent in *Eudyptes chrysolophus* and in *Spheniscus mendiculus*.

[3] The figures in brackets refer to the annexed diagram of the plexus.

(c) Two branches also pass off to supply the first and second heads of the *triceps brachii* (5).

After giving off the nerve to the pectoralis major, the large cord of the plexus divides into two branches, of which one is distributed to the palmar or concave, and the other to the dorsal or convex surface of the wing.

The Palmar Branch.

The branch to the concave surface of the wing (6) accompanies the arterial rete mirabile across the internal surface of the humerus, and divides about the middle in length of that bone into two branches, which may be named the radial and ulnar.

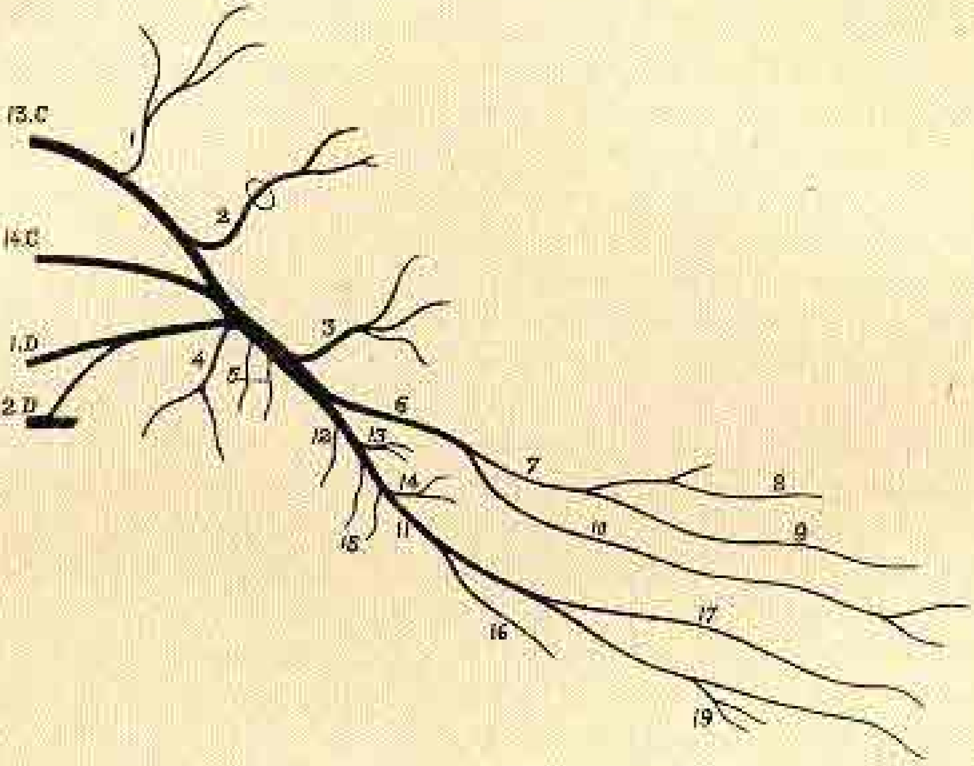

Fig. 1.—Diagram of the Brachial Plexus of *Eudyptes chrysocome.*

(A) *The Radial Nerve* (7) passes as far as the elbow, where it divides into two branches.

(i.) The first of these (8) extends downwards along the anterior border of the radius as far as the wrist joint, beyond which I could not trace it, but apparently it becomes cutaneous in that region. From this branch a twig is given off to supply the brachialis internus muscle.

(ii.) The second branch of the radial nerve (9) extends along the concave surface of the wing, lying in the interval between the radius and ulna, and in close relation to the muscles occupying that space. It crosses the wrist joint, and extends as far as the radial metacarpal bone, where it is distributed to the skin.

(B) *The Ulnar Nerve* (10) extends along the inner surface of the humerus, and crossing the elbow joint in company with the humeral vein, passes along the ulnar margin of the wing as far as the middle in length of the metacarpal bones, where it divides into two branches.

(i.) The first of these passes round the anterior margin of the wing to reach the dorsal surface of that organ, where it is distributed to the skin.

(ii.) The other is distributed to the cutaneous structures on the concave surface of the wing, as far down as the first phalanx.

The Dorsal Branch or Musculo-Spiral Nerve.

The second branch, derived from the single cord of the brachial plexus, passes backwards, to be distributed on the dorsal surface of the wing. From its course, with reference to the humerus, it may be named the musculo-spiral nerve.

Leaving the cord of the brachial plexus, the musculo-spiral nerve (11) passes backwards over the posterior margin of the humerus under cover of the scapular heads of the triceps. Having reached the dorsal surface of the wing, it crosses the elbow joint and passes downwards, lying in the interval between the radius and ulna, under cover of the extensor carpi radialis brevis, as far as the wrist joint, beyond which it can be traced as far as the distal end of the metacarpal bone.

The musculo-spiral nerve gives off the following branches.

(*a*) A branch to the *tensor patagii longus* muscle (12) winds round the inner side of the neck of the humerus, and enters the posterior border of that muscle. This branch closely resembles the circumflex nerve of the mammal.

(*b*) A branch to the *latissimus dorsi* (13) passes upwards and backwards round the axillary margin of the scapula to reach the lower border of the latissimus dorsi, where it divides into two twigs, one of which is distributed to each of the two portions of that muscle.

(*c*) A branch (14) which supplies the *dorsal scapular muscles* winds round the axillary border of the scapula, and divides into two twigs, one of which supplies the supra- and the other the infra-spinatus muscle.

(*d*) Another branch (15) passes to the *triceps*, and supplies both the humeral heads of that muscle.

(*e*) A *cutaneous branch* (16) is given off by the musculo-spiral nerve opposite the middle in length of the humerus. It reaches the outer side of the elbow joint, and supplies the skin of that region.

(*f*) A *second cutaneous* branch (17) leaves the trunk of the nerve opposite the elbow joint. It passes along the anterior margin of the radius as far as the wrist joint, beyond which it could not be traced. It was apparently distributed to the skin.

(*g*) Small branches (19) are given off to supply the radial extensors of the wrist.

DORSAL NERVES.

Intercostal Nerves.—The anterior branches of the dorsal nerves are nine in number. Of these the first emerges from the intervertebral foramen corresponding to the intercostal space, which is bounded in front by the first or rudimental, and behind by the second, while the ninth nerve lies behind the ninth vertebral rib. The anterior division of the first dorsal nerve unites with those of the last two cervical nerves to form the large cord of the brachial plexus, along with which it is more particularly described. It furnishes no branch to the first intercostal space.

All the other intercostal nerves, with the exception of the last, pass outwards, lying on the internal intercostal muscles as far as the middle in length of the vertebral segments of the ribs. Here they pierce the intercostal muscles, and extending downwards under cover of the skin, terminate by supplying branches to the lateral and inferior thoracic walls, nearly as far as the inferior middle line of the body. The intercostal nerves, therefore, do not lie between the sternal segments of the ribs, but escape from the intercostal spaces before reaching them. As the nerves extend downwards they give branches to the intercostal muscles, as well as to the muscles of the abdominal wall.

The second intercostal nerve furnishes a branch to the brachial plexus.

The anterior branch of the last dorsal nerve extends downwards behind the ninth vertebral rib, and, after supplying a branch to the obliquus internus abdominis, terminates by being distributed to the other muscles of the abdominal wall. None of the intercostals give off lateral cutaneous branches as in the mammal, the place of these being taken by irregular branches supplied by the intercostal nerves, after they have escaped from the intercostal spaces.

LUMBO-SACRAL NERVES.

To avoid ambiguity, I include all the spinal nerves between the last dorsal and the first coccygeal in the category of lumbo-sacral nerves. Although not forgetful of the work of Gegenbaur and others in the determination of the exact limitation of the lumbar, sacral, and coccygeal portions of the avian vertebral column, yet so many difficulties are met with in regard to this limitation, whether the attempt be founded on a consideration of the arrangement of the spinal nerves, or on that of the relation which a variable number of vertebræ in different species bear to the pelvic bones, that it appears to me that it will conduce to the intelligibility of my description if I simply include the spinal nerves lying between the last dorsal vertebra and the first moveable coccygeal under the name of lumbo-sacral. By adopting this plan, first suggested by Mivart,[1] I shall avoid the adoption of any morphological views which, while they may

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[1] Trans. Zool. Soc., vol. viii. pt. 7, 1874.

prove acceptable to some, would probably be objected to by other anatomists. The facts being stated, such views may be based upon them as may occur to different morphologists.

Thus defined the lumbo-sacral nerves are thirteen in number.

The anterior division of the first lumbo-sacral nerve, in respect of its distribution, closely resembles the last dorsal nerve. It extends downwards, parallel to the anterior division of the last dorsal nerve, and breaks up into branches which supply the muscles and skin of the anterior abdominal wall. This nerve has no connection with either the last dorsal or the second lumbar nerve in any species except *Eudyptes chrysocome* from Tristan, and hence takes no share in the formation of the crural plexus.

The second lumbo-sacral nerve gives off a branch which passes downwards, parallel to the first lumbo-sacral nerve, which it closely resembles in its course and distribution. It is distributed to the muscles of the abdominal wall. Having given off this branch, the second lumbar nerve unites with the anterior division of the third and a portion of the fourth lumbar nerve to form the crural plexus.

The Crural Plexus.

The crural plexus (fig. 2) is formed by the union of a portion of the second with the whole of the third and one-half of the fourth of the anterior divisions of the lumbo-sacral nerves. These nerves unite to form a plexiform arrangement, from which two large nerves—the crural and obturator—are derived.

The Crural Nerve.

The crural nerve (1)[1] is formed by the union of branches from the second, third, and fourth lumbar nerves. It passes from the pelvic cavity in company with the crural artery and vein, and, having reached the inner side of the thigh, at once breaks up into a number of branches, which are distributed as follows:—

(*a*) A branch (2) enters the posterior border of the *sartorius* and supplies that muscle.

(*b*) Three branches (3, 4, and 5) are given off close together from the crural nerve, immediately after the latter has escaped from the pelvic cavity. They pass to the *rectus femoris*, *gluteus medius*, and *gluteus minimus* respectively, and enter the deeper surfaces of these muscles. The branch to the rectus femoris also supplies the tensor fasciæ femoris.

(*c*) Three or four twigs derived from the crural nerve (6) are distributed to the *extensor cruris* muscle, and along with these two branches pass off for the supply of the *gracilis* (7) and *ambiens* (8) muscles.

(*d*) The crural nerve also supplies a branch to the *pectineus*.

(*e*) A large *cutaneous* nerve (9), derived from the crural trunk, in addition to the

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[1] The figures in brackets refer to the annexed diagram of the crural and sciatic plexus.

branches above mentioned, comes off from the crural nerve so soon as it has reached the inner side of the thigh. It passes downwards, and coming into relation with the terminal portion of the femoral artery, opposite the inner side of the knee joint, is distributed to the skin of the inner side of the leg as low as the ankle joint. This branch closely resembles the saphenous nerve of the mammal.

(*f*) A second *cutaneous* branch (10), derived from the crural trunk, winds forwards in front of the extensor cruris muscle, to reach the outer side of the thigh, where it becomes cutaneous by passing between the sartorius and extensor cruris muscles. Having reached the skin, this branch divides into two parts, both of which extend downwards as far as the calf of the leg, supplying in their course branches to the skin covering the outer side of the thigh and the outer head of the gastrocnemius.

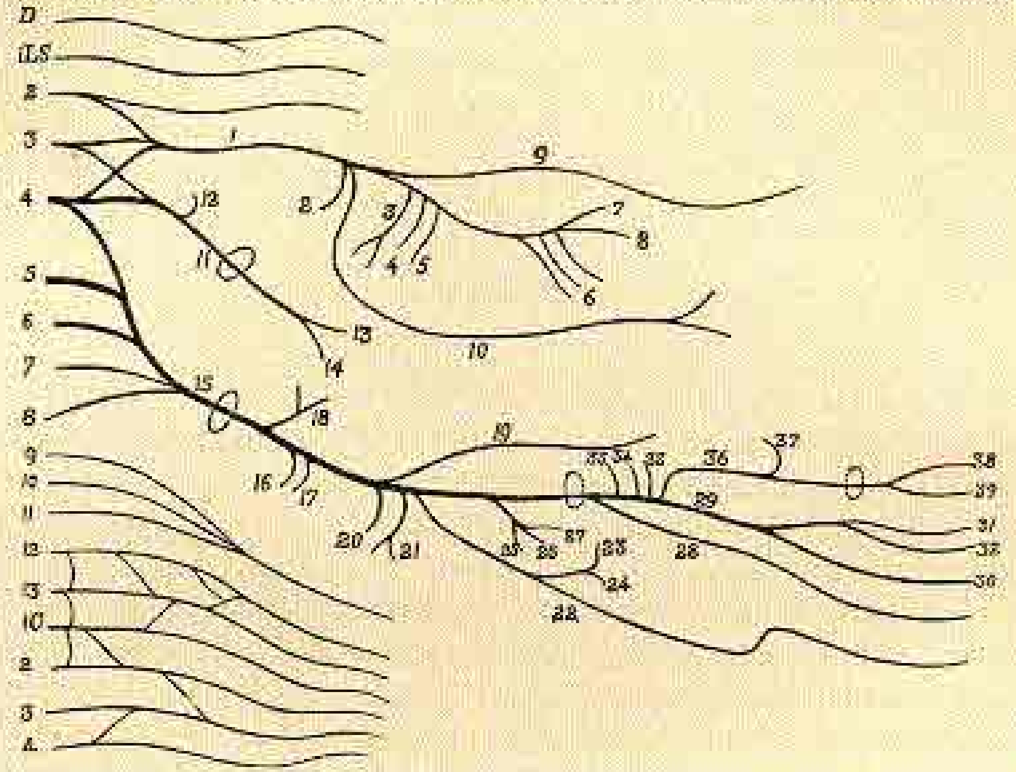

Fig. 2.—Diagram showing the distribution of the Lumbo-Sacral and Coccygeal Nerves of *Eudyptes chrysocome* from Kerguelen.

The Obturator Nerve.

The obturator nerve (11) is formed by the union of branches from the third and fourth lumbar nerves. It passes obliquely backwards, and escapes from the pelvis along with the tendon of the obturator internus muscle, by passing through the foramen ovale. Before leaving the pelvic cavity, the obturator nerve gives a branch to the obturator internus (12), and, having reached the thigh, it supplies the adductor magnus (13) and the obturator externus (14) muscles.

Variations in Crural Plexus.—In none of the birds which I have dissected, with the single exception of *Eudyptes chrysocome* from Tristan, does the first lumbo-sacral nerve contribute in any way to the formation of the crural plexus.

In *Spheniscus minor* the crural plexus is formed by the second and third lumbo-sacral nerves alone. The fourth nerve, which in all the other species forms part of the crural, in this species joins the sciatic plexus.

In *Aptenodytes* the branch to the abdominal muscles, which is derived from the second lumbo-sacral nerve, and is usually distributed separately, unites with the first lumbo-sacral nerve and forms a portion of the latter.

The Sciatic Plexus.

The anterior division of the fifth lumbo-sacral nerve (fig. 2), so soon as it passes from the intervertebral foramen, receives a large communicating branch from the fourth, and then unites with the sixth, seventh, and eighth lumbo-sacral nerves to form the sciatic plexus.

Thus formed the sciatic plexus gives origin to the sciatic nerve.

The Sciatic Nerve.

The sciatic nerve (15) is formed by the union of a portion of the fourth with the whole of the fifth, sixth, seventh, and eighth lumbar nerves. It escapes from the pelvic cavity through the sciatic foramen. Having reached the thigh, the nerve divides into two parts—a superficial and a deep. The superficial portion lies between the biceps and the adductor longus, the deep between the latter and the adductor magnus muscles. The deep portion at once breaks up into branches for the supply of the semi-membranosus (16) and adductor longus (17) muscles.

(A) *The superficial portion* of the sciatic nerve, after giving off a number of twigs for the supply of the biceps femoris (18), breaks up into the following branches:—

(*a*) A *cutaneous* branch (19) which extends downwards along the back of the calf of the leg, as low as the sole of the foot. It gives off branches to the skin as it descends.

(*b*) A branch of supply to the outer head of the *gastrocnemius* (20).

(*c*) A branch to the superficial portion of the *flexor perforatus digitorum* and *plantaris* (21).

(*d*) A long slender branch (22) which extends downwards along the whole length of the calf, lying between the flexor perforatus and the inner head of the gastrocnemius. Immediately above the ankle joint this nerve passes forwards beneath the tendon of insertion common to the anterior and inner heads of the gastrocnemius, and having gained the front of the metatarsus, descends as far as the sole of the foot, to be distributed to the skin in that region. About the middle in length of the tibial segment of the limb this nerve gives off a branch which passes transversely forwards between the flexor perforatus and the inner head of the gastrocnemius. It terminates by supplying branches to the anterior head of the gastrocnemius (23), and to the flexor perforans digitorum (24).

(*e*) The next branch derived from the sciatic nerve supplies the inner head of the gastrocnemius (25), the flexor perforans digitorum (26), and the popliteus (27).

Having given off these branches, the sciatic nerve divides into two parts, a large and a small, both of which pass through the fibrous pulley of the biceps muscle.

(*f*) The smaller of the two terminal branches (28), after passing through the fibrous pulley of the biceps muscle, runs downwards along the outer side of the leg, under cover of the superficial origin of the flexor perforatus as far as the ankle joint, where it breaks up into branches for the supply of the skin covering the outer side of that articulation.

In *Aptenodytes* there are two cutaneous branches, which follow a similar course, and are similarly distributed, except that the second one does not pass through the pulley of the biceps.

(*g*) The larger terminal branch of the sciatic nerve (29) also passes through the pulley of the biceps muscle, and descending along the outer border of the fibula, under cover of the peroneus longus and outer head of the gastrocnemius, as far as the ankle joint, gives off a digital branch (30) to the outer side of the external toe. The nerve then passes downwards as far as the cleft of the toes, where it divides into two digital branches (31, 32) for the supply of the contiguous sides of the middle and outer toes. It moreover gives a twig to the sole of the foot, which passes through a foramen between the middle and outer metatarsal bones. Immediately below the knee joint the main trunk gives off branches of supply to the tibialis anticus (33), extensor longus digitorum (34), and peroneus longus (35), and a branch of considerable size (36), which, winding round the outer side of the fibula, reaches the front of the leg, where it lies in contact with the fibula, under cover of the tibialis anticus, and supplies a branch to the peroneus brevis (37). Extending downwards, this nerve passes along with the tendon of the tibialis anticus beneath the anterior annular ligament, and reaching the cleft of the toes divides into two digital branches (38, 39) for the supply of the contiguous sides of the middle and inner toes. It moreover supplies a branch to the posterior or rudimental toe.

The remaining lumbo-sacral nerves, namely, the ninth to the thirteenth inclusive, pass obliquely backwards and outwards. The ninth, tenth, and eleventh run close together, and terminate by supplying the lateral muscles of the tail and the skin in the neighbourhood of the anus. From one of these nerves a branch is given to supply the crurococcygeus muscle. The twelfth and thirteenth lumbo-sacral accompany the coccygeal nerves, with which they are distributed. The thirteenth lumbo-sacral nerve passes out between the first moveable coccygeal vertebra and the last bone of the lumbo-sacral mass.

Variations in the Sciatic Plexus.—In all the species examined, with the exceptions of *Eudyptes chrysocome* from Tristan, *Spheniscus minor*, and *Aptenodytes longirostris*, the ninth, tenth, and eleventh lumbo-sacral nerves pass outwards together, and have no connection with the sciatic plexus. In *Eudyptes chrysocome* from Tristan, however, the ninth nerve unites with the preceding nerves to form the sciatic plexus. In *Aptenodytes*, again, only a portion of the ninth nerve enters the sciatic plexus, the remaining portion being distributed along with the tenth and eleventh nerves. In *Spheniscus minor* a portion of the eighth nerve also enters the sciatic plexus, its remaining portion and the whole of the ninth being distributed along with the tenth and eleventh lumbo-sacral nerves.

COCCYGEAL NERVES.

The coccygeal nerves escape from the spinal canal between the moveable coccygeal vertebræ. Of them I could only distinguish four, although, seeing that the moveable coccygeal vertebræ are eight in number, it appears probable that there may have been seven coccygeal nerves. However this may be, the coccygeal, together with the twelfth and thirteenth lumbo-sacral nerves, form long slender branches, which pass backwards parallel to one another, and freely communicate by means of numerous cross branches. In this way a sort of plexus is formed, which, occupying the inferior surface of the caudal vertebræ, is for the most part concealed by the depressor caudæ muscle of the same side. Escaping along the outer border of the depressor caudæ muscle, the slender trunks of these nerves pass backwards to be distributed partly to the muscles of the tail, and partly to the skin of that region.

In *Spheniscus minor* I was able to distinguish five separate coccygeal nerves.

THE SYMPATHETIC NERVE

The principal cord of the sympathetic system of nerves is arranged in the Penguins as in other birds. In the neck it accompanies the vertebral artery through the osseous canal formed by the perforated transverse processes of the cervical vertebræ. The ramifications of this system of nerves I was unable to trace.

ORGANS OF SENSE.

THE EYE AND ITS APPENDAGES.

The Muscles of the Eye-lids.—Both eyelids of the Penguins are provided with muscles, by the joint action of which the aperture between them is enlarged.

The *elevator of the upper eyelid* consists of a broad, flat, but very thin plate of muscular fibres which arise from the fascia covering the orbital surface of the insertion of the ocular muscles. The fibres pass transversely outwards, and are inserted into the deeper surface of the upper eyelid. By the contraction of these fibres the upper eyelid is raised.

The *depressor of the lower eyelid* is a powerful muscular band, the origin of which is situated on the floor of the orbit, under cover of the Harderian gland. The muscle arises from the basi-sphenoid bone opposite the orbital process of the os quadratum. Its fibres pass obliquely forwards and outwards, to be inserted into the lower eyelid, as well as into the conjunctival membrane behind it. The origin of this muscle lies between the Harderian gland and the pterygoid muscle. It acts as a depressor of the lower eyelid.

The *muscles of the third eyelid* or membrana nictitans are arranged exactly as in other birds.

Such is also the case as regards the *ocular muscles*, the two oblique muscles arising together from the anterior and internal wall of the orbital cavity, while the recti muscles at their origin surround the optic foramen.

The lachrymal gland in *Eudyptes chrysocome* is of a somewhat oval form, and rather smaller than a garden pea. It lies in contact with the eyeball, under cover of the post-orbital process. From it a single duct passes off which extends downwards and forwards, to open upon the surface of the palpebral conjunctiva immediately behind the posterior commissure of the eyelids.

The Harderian gland is extremely large. It occupies the entire floor of the orbital cavity, resting upon the upper surface of the palate bone and pterygoid muscle. Its upper surface is in contact with the globe of the eye. The duct passes off from the anterior extremity of the gland, and, winding round the inner side of the eyeball, opens upon the conjunctival membrane covering the ocular surface of the membrana nictitans, opposite the anterior commissure of the eyelids. Thus, in the Penguins as in other birds, there are two glands in connection with the orbit, the duct of one of which opens behind and the other in front of the eyeball. The secretion of both is carried off by means of the lachrymal duct.

The lachrymal duct is single throughout. It commences at an orifice situated on the anterior commissure of the eyelids, and passes obliquely forwards and downwards to gain the nasal fossa, where it terminates close to the orifice of the duct of the nasal gland. These two ducts pass forwards parallel with one another, but while the duct of the nasal gland is deeply situated, and perforates the anterior margin of the orbit before opening into the nasal fossa, the lachrymal duct is superficially placed, and lies immediately under cover of the skin.

According to Owen,[1] the lachrymal duct in birds commences by two apertures at the nasal canthus. Such is not the case in any species of Penguin.

The nasal gland in the Penguins is of very large size. It occupies the deep crescentic groove situated on the upper surface of the skull, close to the margin of the orbit. Widest behind, the nasal gland diminishes to a point anteriorly, and from this extremity of the gland the duct arises. The duct passes forwards and downwards, lying in a

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[1] Anatomy of Vertebrates, vol. ii. p. 144.

bony canal, close to the anterior margin of the orbit. By means of this canal the duct of the nasal gland is conducted to the nasal fossa, into which it opens close to the orifice of the lachrymal duct. In *Aptenodytes* the nasal orifices of these two ducts are situated one inch in front of the anterior margin of the orbital cavity. According to Owen,[1] the nasal gland in the Albatross and Penguin is provided with two or three ducts. So far as the Penguins are concerned, I have only been able to find a single duct to the nasal gland in every species which I have examined.

The Eyeball.—As regards the *eyeball* itself, it may be observed that the sclerotic coat in all the Penguins is provided with well-developed ossified plates, and that the choroidal pecten is of large size, conical in form, and provided with numerous plications.

VI.—SPLANCHNOLOGY.

Before proceeding to describe the viscera, it may be as well to sketch the position which they occupy in the cavity of the thorax and abdomen. On opening these cavities, and without farther dissection, the viscera are seen to be arranged as follows (Pl. XVI. fig. 9). In the middle line is the heart, covered by the pericardium, the apex of the organ being accommodated in a depression bounded on either side by the apical portion of each hepatic lobe. In front of the heart are the terminal portions of the trachea and œsophagus, and on either side of the viscus are the right and left lungs. Behind the heart and lungs is the liver, which occupies the entire breadth of the abdominal cavity. Posterior to the left hepatic lobe is the stomach, and behind the right are a number of the coils of the small intestine. Lying in the interval between the intestinal coils on the right and the stomach on the left, is the elongated gall bladder, which in the Penguins reaches nearly as far as the cloaca. The posterior extremity of the abdominal cavity is occupied by the large globular cloaca and by the anal passage.

The urinary and genital organs have their usual position immediately below, and in contact with the vertebral column.

DIGESTIVE ORGANS.

The digestive organs of one or other species of Penguin have been described by Reid[2] in the case of *Aptenodytes patachonica*, Forst., and by Garnot[3] in that of *Aptenodytes demersa*. Meckel,[4] moreover, refers to these organs in certain members of the group, but omits to particularise the species which he examined. Consequently, his observations,

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[1] Anatomy of Vertebrates, vol. ii. p. 144.

[2] Proc. Zool. Soc., 1835, pt. iii. p. 147.

[3] Remarques sur la zoologie des îles Malouines, Annales des Sciences Naturelles, Zoologie, 1826, tom. vii. p. 53.

[4] Anatomie Comparée, vol. viii.

from a comparative point of view, are of but little value. The descriptions indeed of all the authors mentioned, are so meagre and unsatisfactory, that I have felt justified in giving a more minute account of these organs than would otherwise have been necessary. For the sake of accurate comparison, I have selected *Eudyptes chrysocome* from Tristan d'Acunha as a type, and having in the first place described at length each portion of the alimentary canal of that bird, I have thereafter added comparative remarks on the anatomy of the other species which I have dissected.

THE MOUTH.

The tongue of *Eudyptes chrysocome* from Tristan d'Acunha, is elongated and somewhat rounded at its free extremity. It measures 1⅝th inches in length and ⅝ths of an inch in greatest breadth. Its upper surface is covered by a series of stout conical papillæ, the free extremities of which are directed backwards towards the throat. The papillæ are arranged in nine longitudinal rows, one of which occupies the middle line of the tongue, while four others are arranged symmetrically on either side of the middle line. The papillæ composing the central rows are of larger size than those situated externally. The latter diminish in size from the middle line to the lateral margins of the tongue. The base of the tongue is separated from the rest of the organ by a groove, which is most clearly defined when the point of the tongue is depressed. The basal portion so separated is triangular in form, the apex of the triangle being directed forwards. It, like the rest of the organ, is invested by recurved papillæ.

The superior laryngeal aperture is placed immediately behind the root of the tongue, and presents the form of an elongated slit, bounded on either side by an elevated portion of the mucous membrane, which, for convenience of description, may be named the "laryngeal pads." These pads (Pl. XIII. fig. 1) together are of an oval form, and measure ¾ths of an inch in length, and ½ an inch in greatest breadth. They are slightly raised above the level of the adjacent mucous membrane. Like the tongue, they are covered with conical recurved papillæ, which, however, are of smaller size and more sparsely and irregularly distributed than on the dorsum linguæ. The papillæ are of larger size at the margins of the laryngeal slit than at the external margins of the pads. The laryngeal aperture has the form of an elongated slit, which at first sight apparently corresponds in length to that of the laryngeal pads. Upon closer examination, however, the aperture is seen to correspond only to the anterior half of the antero-posterior diameter of the pads, the posterior segment of the apparent aperture being merely a superficial groove between the pads of opposite sides. To their outer side the mucous membrane of the mouth is smooth and devoid of papillæ, presenting only the apertures of several buccal glands, the ducts of which open into the mouth in this region.

The floor of the mouth below the tongue is formed by a triangular portion of mucous membrane, which fills up the angle bounded by the two halves of the lower jaw bone. The margins of this portion of mucous membrane are serrated, and form a double line of stunted papillæ, which project upwards and rest against the lateral margins of the tongue. On each side of the floor of the mouth, immediately in front of the gape, is a circumscribed group of conical papillæ, the apices of which are directed backwards. This group, for purposes of description, may be termed the buccal group.

The roof of the mouth or palate (Pl. XIII. fig. 2), like the tongue, is covered by a series of stout recurved conical papillæ. These are arranged in six longitudinal rows, to which, however, opposite the angle of the mouth, two others are added. There are therefore eight rows in all, but only six of them extend the whole length of the palate. These rows are arranged symmetrically—four on either side of the middle line. As on the tongue, so on the palate, the largest papillæ are met with in the central rows, those forming the lateral rows diminishing gradually in size. In front the roof of the mouth is completed by two elongated hardened plates, which fill up the angle formed by the junction of the two superior maxillary bones of opposite sides. These plates are smooth and altogether devoid of papillæ.

Salivary Glands.—The salivary or buccal glands consist of a number of secretory follicles, which, in accordance with their position, may be divided into three groups.

The first or parotid group is situated immediately behind the angle of the mouth. The glands themselves lie immediately beneath the mucous membrane of the cheek, and their ducts open by means of a linear series of apertures immediately behind the gape.

The second or palatal group is met with beneath the mucous membrane of the palate. The glands composing it are somewhat irregularly distributed, but are met with in greatest numbers along a transverse line joining the two angles of the mouth.

The third or lingual series consists of a quantity of isolated follicles situated on the outer side of each of the laryngeal pads. The openings of their ducts are clearly distinguishable on the mucous membrane of this region.

Variations in respect of the Mouth.

In *Eudyptes chrysocome* from Kerguelen (Pl. XIII. fig. 1) the papillæ covering the dorsum linguæ are arranged in seven instead of nine rows, as in *Eudyptes chrysocome* from Tristan d'Acunha. Of these rows one corresponds to the middle line of the tongue, while the others are placed three on either side of the middle line.

In *Eudyptes chrysocome* from the Falkland Islands, the laryngeal pads together measure $\frac{3}{4}$ths of an inch in length and $\frac{5}{8}$ths in greatest breadth. The papillæ covering them are of smaller size and less numerous than in the specimens of this species from Tristan d'Acunha and from Kerguelen. Indeed the laryngeal pads of this species may be said to be almost smooth.

In *Eudyptes chrysolophus* (Pl. XIV. fig. 1) the tongue measures 2 inches in length and ⅓rd of an inch in greatest breadth. It resembles in form that of *Eudyptes chrysocome*, but differs in respect of the number of papillæ with which its surface is covered. The papillæ at the tip of the tongue are arranged in three rows, between which, when traced backwards, others are gradually interpolated, so that close to the base of the tongue there are observable no fewer than eight distinct lines of longitudinally arranged papillæ. As in *Eudyptes chrysocome*, they are recurved, and increase in size from the apex to the base of the tongue. The laryngeal pads together measure 1 inch in length and ½ an inch in greatest breadth. The papillæ covering them are of small size. They are arranged in three irregular rows on either side of the laryngeal aperture, but become irregularly arranged, and of smaller size towards the external and posterior margins of the pads.

The buccal group of papillæ is of relatively larger size than in *Eudyptes chrysocome*. The papillæ composing it are also stouter than in that species.

The palate of *Eudyptes chrysolophus* (Pl. XIV. fig. 2), immediately behind the smooth quadrilateral plate which fills up the angle of the jaw, presents three rows of papillæ on either side of the middle line. The rows, as such, are traceable as far back as the gape, opposite which their number is increased to six. Behind the gape the papillæ again decrease in number as well as in size, and disappear entirely opposite the articulation of the lower jaw bone.

The floor of the mouth and the salivary follicles of *Eudyptes chrysolophus* resemble those of *Eudyptes chrysocome*.

In every species of *Spheniscus* which I have examined, the tongue differs from that of *Eudyptes*, inasmuch as it is of relatively smaller size. This difference in size of the tongue is most observable when the length of the organ is compared with that of the lower jaw (compare figs. 1 and 3, Pl. XIV.). In *Eudyptes* the tongue extends forwards almost to the symphysis of the lower jaw, whereas in every species of *Spheniscus* the free extremity of the tongue fails to reach that point. Accordingly in *Spheniscus*, the tongue instead of covering the entire floor of the mouth, as in *Eudyptes*, leaves a considerable portion of it (about an inch in *Spheniscus demersus*) exposed to view. The tongue of *Spheniscus*, moreover, differs from that of *Eudyptes* in respect of its form. In the former the tongue is of an elongated triangular form, and diminishes in breadth from base to apex, while in the latter the organ is of nearly uniform breadth throughout. Lastly, in *Spheniscus* the oral papillæ are of considerably smaller size than in *Eudyptes*, and in every species of *Spheniscus* the buccal group of papillæ is of smaller size than in any species of *Eudyptes*.

In *Spheniscus demersus* (Pl. XIV. fig. 5) the tongue measures 1¾ inches in length and ⅝ths of an inch in breadth at the base. The lingual papillæ are arranged in five rows. One of these occupies the middle line of the tongue, and the others are placed two on either side of it. As in *Eudyptes*, the papillæ of the central row are the largest. The laryngeal pads together measure 1 inch in length and ⅝ths of an inch in greatest breadth, and are sparsely covered by conical papillæ, which are of small size and irregularly distributed. The mucous membrane of the floor of the mouth is provided with a V-shaped fringe of delicate bayonet-shaped papillæ, the bases of which are coalescent. The free portion of the tongue rests on the space bounded by this fringe. The palatal papillæ (Pl. XIV. fig. 6) are arranged in six rows—three on either side of the middle line. Posteriorly they lose their linear distribution, and form, together with those of the opposite side, an irregular patch, which corresponds to the laryngeal pads behind the tongue. The buccal group of papillæ is of smaller size than in *Eudyptes*, and the papillæ composing it are more diminutive and scattered than in that genus. In front the palate is completed by a single smooth plate, which, in accordance with the interspace between the superior maxillary bones of opposite sides, is much more elongated and slender than in *Eudyptes* (compare figs. 2 and 4, Pl. XIV.).

The anatomy of the mouth of *Spheniscus magellanicus* (Pl. XIV. figs. 3 and 4) agrees in all respects with that of *Spheniscus demersus*, and therefore lends no support to the view that the birds so named are specifically distinct.

In *Spheniscus mendiculus* (Pl. XIV. fig. 7) the tongue resembles in form that of *Spheniscus demersus* and *Spheniscus magellanicus*. It measures 1⅛ inches in length and ⅝ths of an inch in breadth at the base. The lingual papillæ at the apex of the organ are arranged in three rows, to which farther back two others are added. The base of the tongue, therefore, immediately in front of the laryngeal pads, presents no fewer than five separate rows of papillæ. One of these corresponds to the middle line of the tongue, and two are placed on either side. The papillæ themselves are of nearly uniform size throughout. The laryngeal pads together measure ¾ths of an inch in length and ½ an inch in greatest breadth. On these pads the papillæ are arranged in two distinct rows—one on either side of the laryngeal aperture. To the outer side of them, however, there is a number of smaller papillæ, which are irregularly distributed on the surface of each of the pads.

The floor of the mouth resembles that of *Spheniscus demersus*, as does also the buccal group of papillæ. The palatal papillæ (Pl. XIV. fig. 8) are arranged in four rows anteriorly, two on either side of the middle line, but opposite the gape two other rows make their appearance, so that at this point there are six separate rows of these structures. Each of the two external rows consists of only six or seven papillæ, of considerably smaller size than those composing the central rows. Behind the gape these structures diminish in size, and form, along with the continuation of the central rows, an irregular patch, in which the linear arrangement is no longer recognisable. This patch, as in *Spheniscus demersus*, corresponds to the laryngeal pads on the floor of the mouth. In front the palate is completed by a smooth horny plate, which resembles in form the corresponding structure in *Spheniscus demersus*.

In *Spheniscus mendiculus* I failed to recognise the lingual group of salivary follicles met with in other species.

In *Spheniscus minor* the tongue is of the same form as in other species of the genus. It measures 1 inch in length and ¼th of an inch in breadth at the base. Its surface is invested by five longitudinal rows of papillæ, one mesially placed and two on either side. The papillæ increase slightly in size from apex to base of the tongue. The laryngeal pads together measure ⅝ths of an inch in length and ⅜ths in greatest breadth. They are covered by a number of irregularly arranged papillæ, of smaller size than those which cover the dorsum linguæ. The floor of the mouth of *Spheniscus minor* differs from that of other species of the genus, inasmuch as it presents no trace of the marginal bayonet-shaped papillæ met with in the latter. The buccal group of papillæ is extremely small, and the papillæ composing it quite rudimentary. They resemble in their arrangement the corresponding structures in the other species of *Spheniscus*. The palate is provided with six rows of recurved papillæ, three on either side of the middle line. These rows extend backwards as far as the gape, behind which they dwindle in size, lose their linear arrangement, and form two irregular groups, one on either side of the middle line, much as in the other species already described. The lingual group of salivary follicles is indistinguishable in *Spheniscus minor*.

In *Pygosceles tæniatus* (Pl. XV. fig. 1) the tongue, which measures 2¾ inches in length and ⅝ths of an inch in breadth at the base, presents a form intermediate between that of *Eudyptes* and of *Spheniscus*. It agrees with that of *Eudyptes*, inasmuch as its tip nearly reaches the symphysis of the lower jaw, but its form as a whole more closely resembles that of *Spheniscus*. Its upper surface is covered by five longitudinal rows of recurved papillæ. Those composing the central row are of larger size than those nearer the margins of the tongue. All the lingual papillæ increase in size from apex to base of the tongue, with the exception of those situated immediately in front of the laryngeal pads, which are of somewhat smaller size than those covering the greater part of the organ. The laryngeal pads together measure 1¼ inches in length and ¾ths of an inch in greatest breadth. They are covered by a number of much smaller papillæ, which are arranged in three rows on each side of the larnygeal slit, but externally are irregularly distributed. The floor of the mouth is elongated, triangular in form, provided on either side of the middle line with a single row of bayonet-shaped papillæ. These rows extend forwards from the gape, and meet in front so as to enclose a triangular space, on which the tongue rests. The mucous membrane between these papillar lines is thrown into straight longitudinal rugæ. The buccal group of papillæ is arranged much as in *Spheniscus*, but the papillæ composing it are of much larger size than in any species of that genus.

The palate of *Pygosceles* (Pl. XV. fig. 2) is covered with stout recurved papillæ, which, an inch behind the union of the superior maxillary bones, are arranged in four rows—two on either side of the middle line. Passing backwards, these papillæ increase in size as well as in number, until opposite the gape in one specimen, there were five longitudinal rows on either side of the middle line, while in a second specimen of the same species there were no fewer than six, making twelve rows of palatal papillæ in all. Posterior to the gape, the palatal papillæ dwindle in size, and form an elongated oval patch on either side of the posterior narial aperture. These papillæ disappear entirely at the entrance of the œsophagus. Instead of being completed anteriorly by means of a perfectly smooth horny plate, as in *Eudyptes*, *Spheniscus*, and *Aptenodytes*, that portion of the palate of *Pygosceles tæniatus* is provided with two rows of well-defined papillæ. The lingual group of salivary follicles in *Pygosceles* is of relatively smaller size than in *Eudyptes chrysocome*.

In *Aptenodytes longirostris* (Pl. XV. fig. 3) the tongue, which measures 2¼ inches in length and ⅝ths of an inch in greatest breadth, more closely resembles that of *Spheniscus* than of *Eudyptes*, both in respect of size and form. In both *Aptenodytes* and *Spheniscus* the tongue narrows gradually from base to apex, and in both there is a considerable interval between the point of the tongue and the symphysis of the lower jaw bone. The papillæ covering the dorsum linguæ are recurved, and are of nearly uniform size throughout. These papillæ are arranged in five longitudinal rows, of which one occupies the middle line of the tongue and two are placed on either side. There is no diminution in size of these papillæ immediately in front of the laryngeal pads, and consequently there is an absence in *Aptenodytes* of the special papillar patch which occupies that position in *Pygosceles*. The laryngeal pads together measure 1¼ inches in length and ⅞ths of an inch in greatest breadth. Each is covered by a series of papillæ of much smaller size than those which cover the tongue. They are arranged in four somewhat irregular rows on either side of the laryngeal slit, and disappear entirely at the entrance of the œsophagus. The floor of the mouth (Pl. XV. fig. 5) is bounded laterally by two rows of papillæ. One of these, the external, extends from the gape forwards to the symphysis of the lower jaw, and consists of bayonet-shaped papillæ, which at some places are ranged in single file, while at others they are placed two or three abreast. The second or inner row is situated ¼th of an inch to the inner side of the outer range. It corresponds only to the middle third of the latter, and consists likewise of a series of bayonet-shaped papillæ, which, however, are of smaller size than those which constitute the outer row. The lower surface of the tongue occupies the interval between the two inner rows. Internal to the second is a third row of very minute papillæ, which, commencing at the gape, extends forwards for a very short distance, and does not meet its fellow of the opposite side behind the symphysis of the jaw. The buccal group of papillæ is more largely developed in *Aptenodytes* than in any species of Penguin which I have examined. It consists of a large group of much elongated conical papillæ, the apices of which are directed backwards and come into contact with the lateral margin of the tongue.

The palate of *Aptenodytes* (Pl. XV. fig. 4) is covered by elongated recurved papillæ, which are more slender than the corresponding structures in *Pygoscelis*. They are arranged in eight longitudinal rows, four on either side of the middle line. The papillæ of the central are larger than those composing the lateral rows. Behind the gape the papillæ are of much smaller size, but are still arranged in parallel rows, of which six or seven may be counted on either side of the middle line. These together form an elongated patch, which corresponds in position to that of the laryngeal pads on the floor of the mouth. The papillæ disappear entirely at the commencement of the œsophagus. The palate is completed in front by an elongated oval plate, the anterior extremity of which is prolonged forwards as a narrow spine, which to some extent fills up the interval between the superior maxillary bones of opposite sides. This plate is perfectly smooth and devoid of papillæ. In this respect *Aptenodytes* differs from *Pygoscelis*, while it agrees with both *Eudyptes* and *Spheniscus*. The palatal and parotid groups of salivary follicles are well defined, but the lingual group can scarcely be said to exist.[1] The latter consists of only a few isolated follicles, the openings of which are scattered irregularly over the floor of the mouth, instead of forming a well-defined patch on either side of the laryngeal pads, as in *Eudyptes*.

THE ŒSOPHAGUS.

By the term œsophagus I understand that portion of the alimentary canal which extends from the cavity of the mouth backwards to the anterior border of the glandular portion of the stomach, the so-called proventriculus of some authors. The description of the proventriculus will be incorporated along with that of the stomach.

The œsophagus, thus defined, measures in *Eudyptes chrysocome* from Tristan d'Acunha, 9 inches in length. As it passes backwards from the mouth it occupies the middle line of the neck, having the trachea below it. At the posterior part of the cervical region, however, in consequence of the great projection forwards of that portion of the vertebral column, which, as previously noticed, actually comes in contact with the furcular angle, the œsophagus is displaced to the right, and at this spot rests against the right side of the spine, lying between the latter and the right limb of the furculum (see Pl. VIII.). Having reached the aperture of the thorax, the œsophagus regains the middle line of the neck, where it is crossed superficially by the bifurcation of the trachea. Beyond this point it deviates to the left, and comes into contact with the posterior surface of the left lobe of the liver, opposite the upper border of which it becomes continuous with the stomach. The transition from the œsophagus to the stomach is so gradual, that it is impossible from an inspection of the exterior of the organs to determine where the one ends and the other begins. On opening the tube,

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[1] According to Reid, Proc. Zool. Soc., 1835, p. 147, *Aptenodytes patachonica* possesses only one pair of salivary glands—the submaxillary.

however, the anterior border of the gastric glandular patch accurately defines the junction of the œsophagus with the stomach.

The walls of the œsophagus are exceptionally thick. This is due partly to the large development of the muscular coat, which consists of two layers, an external and an internal, but chiefly to the exceptional thickness of the mucous membrane, which is extremely dense and very elastic. Owing to the elasticity of its lining membrane, the œsophagus is capable of enormous dilatation. So much is this the case, that in many specimens of Penguin which had been killed after taking a meal, I found the lower portion of the œsophagus distended with food to such an extent that its diameter almost equalled that of the stomach. On the other hand, when the stomach is empty, the œsophagus, by virtue of the elasticity of its mucous lining, contracts so that its lumen is almost obliterated, and the lining membrane is thrown into the well-defined longitudinal rugæ represented in Pl. XIII. fig. 4.

Variations in respect of the Œsophagus.

In all the Penguins which I have examined, the structure and relations of the œsophagus are similar to those above described in *Eudyptes chrysocome* from Tristan d'Acunha.[1] The length of the tube, however, varies in different species. The accompanying table shows the length of the œsophagus in the different species examined, in inches.

LENGTH OF ŒSOPHAGUS FROM POSTERIOR BORDER OF LARYNGEAL PADS TO ANTERIOR BORDER OF PROVENTRICULAR GLAND.

Eudyptes chrysocome, from Tristan,	9
Eudyptes chrysocome, from the Falklands,	10½
Eudyptes chrysocome, from Kerguelen,	8½
Eudyptes chrysolophus,	11½
Spheniscus demersus,	12
Spheniscus magellanicus,	14½
Do. do. second specimen,	13½
Spheniscus mendiculus,	9½
Spheniscus minor,	6½
Pygoscelis tæniatus,	13½
Aptenodytes longirostris,[2]	20
Do. do. second specimen,	18½

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[1] According to Reid (Proc. Zool. Soc., 1835, p. 147), the œsophagus of *Aptenodytes patachonica* is provided with a "gular pouch." There was no appearance of any such pouch in any species of Penguin which I examined. I am therefore inclined to consider the "gular pouch" of Reid as nothing else than the upper portion of the œsophagus, which at certain times is found to be packed with undigested food, and thus performs a function similar to that of the "crop" of some birds, at least in so far as it is the receptacle of a quantity of food, which is gradually thereafter transferred to the stomach to undergo digestion.

[2] In *Aptenodytes patachonica* the œsophagus measures 20 inches in length—Reid, Proc. Zool. Soc., 1835, p. 147.

THE STOMACH.

As already remarked, it is impossible, owing to the gradual transition from the œsophagus to the stomach, to decide, on the strength of a merely external examination, where the former ends and the latter begins. An inspection of the interior of these organs, however, enables us to fix the position of the anterior border of the proventricular glandular patch, and this border sufficiently indicates the separation between these two portions of the alimentary canal. This border corresponds pretty closely on the exterior of the viscus to the posterior border of the left lobe of the liver. From it to the posterior extremity the stomach measures 4 inches in length. The transverse diameter of the glandular portion of the stomach, measured externally, is 1½ inches, and that of the muscular portion, both in respect of longitudinal and transverse measurements, is the same. The stomach extends from the posterior border of the left hepatic lobe obliquely backwards and to the right, its posterior extremity occupying the middle line of the abdominal cavity immediately in front of the globular cloaca (Pl. XVI. fig. 9). To the right of the stomach are the coils of the small intestine, as well as the gall bladder, while on the left the stomach lies in contact with the abdominal wall. The stomach is cylindrical in form, except at its posterior extremity, where it is somewhat flattened from above downwards, and is attached to the vertebral column by a double fold of peritonæum or meso-gastrium. Externally it is divisible into two portions, (Pl. XIII. fig. 3), an anterior, ovoid in form, which, from the fact that it contains the proventricular gland may be named the *glandular* portion, and a posterior of much smaller size, which presents on either surface a slight indication of a central tendon, from which the muscular fibres composing its walls radiate as from a central point. The latter corresponds to the gizzard of other birds, and may be termed the *muscular* portion of the stomach. These two portions when the viscus is empty are separated externally by a well-defined constriction. Immediately behind the pyloric orifice the muscular portion of the stomach dilates into a small pouch-like diverticulum, which lies to the right side of the viscus.

On opening the stomach by means of a longitudinal incision carried along its left margin, its two portions (Pl. XIII. fig. 4) are seen to present very different characters. The anterior or glandular compartment is lined by a soft succulent mucous membrane, which on the right side of the stomach is raised above the surrounding level through the presence of a well-defined patch of subjacent proventricular glands. This patch does not form a continuous belt of uniform breadth, as in the majority of aquatic birds, but is triangular in form, and is confined to the right wall of the stomach. The base of the glandular patch corresponds on the inside of the stomach to the constriction which externally separates the glandular and muscular portions of the organ, while its apex is directed forwards towards the mouth. From base to apex the proventricular gland measures 1½ inches in length, and its breadth at the base is the same. Its basal angles are separated from one another on the left wall of the tube by an interval of ¾ths of an inch. Along this interval, the œsophageal rugæ, which elsewhere cease at the anterior border of the proventricular gland, extend backwards and become continuous with the rugæ lining the muscular portion of the stomach. Each of the orifices of the proventricular glands is placed on the summit of a little elevation of the mucous membrane covering the glandular patch, and here and there elevated ridges of the mucous membrane are seen to separate these orifices from one another.

The muscular portion of the stomach, from the posterior border of the proventricular gland backwards, measures 2 inches in length. It is lined by a thick but soft mucous membrane, which, when the stomach is empty, is thrown into rugæ. These for the most part are longitudinally arranged, but communicate freely with one another by means of short, more or less obliquely placed, mucous folds. The mucous membrane thus presents an irregularly convoluted appearance, which somewhat resembles that of the gyri of the cerebrum. The pyloric aperture is considerably smaller than the lumen of the intestine. It is defended by three small projections, which appear to be nothing else than the free ends of the longitudinal rugæ which line the muscular portion of the stomach.

Contents of Stomach.—In the stomach of one specimen of *Eudyptes chrysocome* from Tristan d'Acunha, I found a small number of the horny mandibles of cephalopods. With the exception of these the stomach was empty. It was observed that there was no trace of the small stones and grit, which in several other species constitute so remarkable an element of the gastric contents.

Variations in respect of the Stomach.

In *Eudyptes chrysocome* from the Falkland Islands, the stomach, in respect of size and form, agrees with that of *Eudyptes chrysocome* from Tristan d'Acunha. The proventricular gland is confined to the right wall of the viscus, and is crescentic rather than triangular in form. The horns of the crescent are directed backwards. The glandular patch, measured transversely to the long axis of the œsophagus, is 3½ inches in length and 1½ inches in greatest breadth. The left wall of the stomach is devoid of glands, the interspace between the two horns of the crescent measuring 1½ inches in breadth.

In one specimen of *Eudyptes chrysocome* from the Falklands, the stomach was perfectly empty, while in another it was filled to distension with a dark pulpy mass, which careful examination proved to be composed of minute, half-digested portions of small crustacea. In both these stomachs there was a total absence of either fish bones or gravel.

In *Eudyptes chrysocome* from Kerguelen (Pl. XIII. fig. 3) the stomach measured in one specimen 6½ inches in breadth, and in another 5 inches. When distended with food there is scarcely any indication externally of the constriction which separates the glandular and muscular portions of the organ. The former measured 2 and the latter 2¼ inches in transverse diameter. The proventricular gland occupies (Pl. XIII. fig. 4) the right wall of the stomach, and in the distended condition of the viscus is, as above described in one of the specimens of *Eudyptes chrysocome* from the Falkland Islands, crescentic in form. When, on the other hand, the stomach is contracted, the patch assumes a triangular form similar to that above described of *Eudyptes chrysocome* from Tristan d'Acunha. In one specimen the proventricular gland measured 3 inches in length from right to left of the œsophagus, and 2 inches in greatest breadth from before backwards, while in a second specimen these measurements were 2½ and 1½ inches respectively. Between the basal angles of the triangular patch, in both specimens, there was a portion of the left wall of the stomach altogether devoid of glands. This space in both specimens measured 1½ inches in breadth, and here the œsophageal rugæ, which elsewhere cease abruptly at the anterior margin of the glandular patch, extend backwards to become continuous with the longitudinal folds of the muscular portion of the stomach.

The pyloric orifice is situated ¾ths of an inch in front of the posterior extremity of the stomach. The mucous membrane of the muscular portion of the stomach is thrown into longitudinal rugæ, which converge toward the commencement of the gut.

In one specimen of this species the stomach was quite empty. In another, not only the stomach but the lower end of the œsophagus was distended with a large quantity of pulpy matter consisting of partly digested crustacea. As in *Eudyptes chrysocome* from Tristan d'Acunha, there was no trace either of gravel or of fish bones among the gastric contents.

The stomach of *Eudyptes chrysolophus* (Pl. XVI. fig. 1) measures 7½ inches in length. The greatest transverse diameter of the glandular portion of the viscus is 2¼, and that of the muscular portion 2½ inches. The line of junction of these two portions of the viscus is indicated on the exterior of the organ by a slight constriction. As in other species, the duodenum comes off from the anterior (inferior) wall of the stomach. The proventricular gland closely resembles that of *Eudyptes chrysocome* from Kerguelen. As in that species, it occupies the right wall of the stomach, and does not form a complete belt. The glandular patch is triangular in form, its apex being directed forwards towards the mouth, while the base corresponds to the junction of the glandular and muscular portions of the stomach. It measures 2 inches in breadth from base to apex, and 2½ inches in breadth from right to left of the stomach. The basal angles of the triangle are separated on the left wall of the stomach by an interval which is altogether devoid of glands. This interval is 1½ inches in breadth, and here the œsophageal rugæ are prolonged backwards, to become continuous with those of the mucous lining of the gizzard. The mucous membrane of the latter is thrown into well-defined rugæ, which for the most part are longitudinal in direction, but communicate freely with one another by means of short oblique folds. The pyloric orifice is provided with two prominent projections of the mucous membrane, which may to some extent serve the purpose of a pyloric valve.

In one specimen dissected the stomach was empty. In another the stomach contained a quantity of dark-coloured pulp, the nature of which to a large extent could not be determined, but appeared to consist of partially digested fish. In corroboration of this opinion, it may be mentioned that numerous scales and bones of fish were extracted from the mass. There was not the slightest trace of gravel in the stomach of either of the specimens examined.

In *Spheniscus demersus*[1] (Pl. XVI. fig. 2) the stomach externally measures 6½ inches in length, and 3 inches in diameter at its widest or glandular portion. In one specimen the stomach was distended with food to such an extent that there was no trace of the external constriction which usually separates its glandular and muscular parts. In a second specimen, however, this constriction was well defined. In it the glandular portion measured 2 inches in diameter, while that of the gizzard amounted to 1½ inches. In the first of these specimens the stomach occupied the greater part of the abdominal cavity, and completely concealed the coils of the small intestine. In the second the gastric relations were similar to those above described in *Eudyptes*. The duodenum comes off from the anterior wall of the gizzard. The proventricular gland is triangular in form with rounded angles, and occupies the right wall of the viscus, but does not form a complete belt. Its base corresponds to the line of junction of the glandular and gizzard portions of the stomach, while the apex is directed forwards towards the mouth. The gland measures 2 inches in length from base to apex, and 2½ inches in breadth at the base. Between the basal angles on the left side of the viscus is a space measuring 1½ inches in breadth, which is altogether devoid of glands. The glandular follicles are more closely aggregated at the margins than at the centre of the patch, and in one of the specimens examined this arrangement was so pronounced as to give rise to the appearance of two distinct patches of follicles. Closer examination showed, however, that the apparent line of separation was likewise, but to a much less extent, provided with glandular follicles. The muscular portion of the stomach does not differ, except in size, from the corresponding part in *Eudyptes*.

In one specimen of *Spheniscus demersus* the stomach was empty, while in another not only both portions of the stomach, but also the œsophagus was crammed with the remains of fish, including a large quantity of bones. Among these contents I failed to recognise any crustacean remains, neither was there any trace of gravel among them.

In *Spheniscus magellanicus* (Pl. XVI. fig. 3) the stomach measured 6½ inches in

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[1] According to Garnot (Annales des Sciences Naturelles, 1826, p. 53), the stomach of *Spheniscus demersus* when empty, measures 4 inches in length.

length in one specimen, and 7½ in another. In the latter the greatest diameter of the glandular portion of the stomach measured 2¼ inches, while the gizzard measured 1⅛ inches from before backwards, and 1 inch from side to side. The external constriction between the glandular and muscular portions of the stomach was well defined in both specimens, the stomach externally closely resembling in form that of *Eudyptes chrysocome* (Pl. XIII. fig. 3). The duodenum comes off from the anterior wall of the gizzard. In one of the specimens examined, there was a small cæcal pouch, which projected to the right immediately above the pyloric aperture. This pouch, which admitted the point of the finger, was not recognisable in the other specimen of *Spheniscus magellanicus*, nor indeed in any other species which I examined. Probably, therefore, it was an individual peculiarity. The proventricular gland in one specimen formed almost a complete belt, which on the right wall of the viscus measured 3 inches, while on the left wall it did not exceed 2 inches in breadth. Between the two extremities of the band was a space measuring ¼th of an inch in breadth, which, however, was not, as in *Spheniscus demersus*, entirely devoid of glands. Here the two extremities of the proventricular gland were united by means of a small number of glandular follicles, which were irregularly disposed, and placed at a greater distance from one another than is the case with those which form the greater portion of the patch. In a second specimen the proventricular gland on the right wall of the stomach measured 3 inches, while on the left it measured only 1 inch in breadth. In this specimen the gland formed a complete belt, which completely surrounded the gastric cavity. The posterior border of the gland in both specimens was straight, the diminution in its breadth on the left wall of the stomach taking place at the expense of the anterior border, which sloped obliquely from before backwards, and from right to left. In the second specimen, as in the first, the glandular follicles were not so closely aggregated on the left as on the right wall of the stomach. In this specimen the difference in the aggregation of the follicles was less observable than in the first, and hence in it, as above remarked, the proventricular gland really presented a completely zonular character. The pyloric orifice is defended by several folds of mucous membrane. In other respects the organ agrees with that of *Eudyptes*.

That the gastric gland of *Spheniscus magellanicus* really differs in form from that of *Spheniscus demersus*, I have convinced myself by the examination of several additional specimens of both species. In the one it is triangular in form, and does not form a complete zone, while in the other the belt of follicles is complete. Whether, however, this character is of sufficient weight to justify us in regarding these birds as specifically distinct, seems to me doubtful, and I shall devote a few lines to the discussion of this question in a future paragraph. (See p. 228.)

In one specimen of *Spheniscus magellanicus*, the stomach was filled with a grey pulpy mass, the composition of which it was impossible to determine. In a second the stomach contained a small quantity of a green alga, intermixed with about forty cuttle-fish beaks of small size. There was also a number of lenses, which may have belonged either to fish or to cuttles. In none of the specimens examined did the stomach contain any gravel.

In *Spheniscus mendiculus* (Pl. XVI. fig. 4) the stomach measures externally 6 inches in length. In neither of the specimens which I examined did it present any trace of the external constriction, which in other species indicates the separation of the glandular and muscular portions of the viscus. The greatest transverse diameter of the glandular portion of the stomach measured 2¼ inches, whilst that of the gizzard amounted to 2¾ inches. The form of the exterior of the stomach, as a whole, apart from the absence of the constriction just referred to, closely resembles that of *Eudyptes chrysocome* (Pl. XIII. fig. 3). The proventricular gland does not form a complete belt, but is crescentic in form, the broadest part of the gland occupying the right wall of the stomach, while the horns of the crescent extend towards the left. The posterior or concave margin of the glandular patch corresponds to the line of junction of the glandular and muscular portions of the stomach, while its convex margin is directed forwards. The gland measures 1¾ inches in greatest breadth on the right wall of the viscus. The horns of the crescent are separated from one another on the left, by an interspace which measures ¾ths of an inch in breadth. This portion of the gastric wall, unlike that of *Spheniscus magellanicus*, is entirely devoid of glandular follicles, and here the longitudinal rugæ of the œsophagus, which elsewhere cease at the anterior border of the proventricular gland, extend backwards, to become continuous with those which line the gizzard. The lining membrane of the latter agrees in all respects with that of other species above described, being thrown into well-defined longitudinal rugæ, which converge towards the pylorus. These rugæ communicate with one another by means of short oblique folds. The pyloric orifice is situated 2 inches in front of the posterior extremity of the stomach, and is defended by a well-defined circular valve-like fold of mucous membrane.

The contents of the stomach of one specimen of *Spheniscus mendiculus* consisted of a quantity of fish bones and scales. In another the stomach was filled to repletion with a soft pulpy mass intermixed with a large quantity of fish bones. The exact nature of the pulp I could not determine, beyond the recognition of several fragments of small crustaceans. In neither of the specimens at my disposal did the stomach contain any trace of gravel.

In *Spheniscus minor* (Pl. XII. fig. 4) the stomach measures 3¾ inches in length. The glandular and muscular portions of the viscus are of equal diameter, and measure 1 inch in breadth. When distended there is a well-defined external constriction, indicating the junction of the glandular and muscular portions of the organ.

The proventricular gland may be said to be zonular in character, and closely resembles the corresponding structure in *Spheniscus magellanicus*, and differs from that of *Sphen-*

iscus demersus and of *Spheniscus mendiculus*. The posterior border of the gland is almost straight, and coincides with the line of junction of the glandular stomach and gizzard. Its anterior border, on the other hand, is much curved, and extends forwards on the right wall of the stomach to a rounded point, whence it slopes obliquely backwards and to the left. In consequence of this arrangement, the proventricular gland on the right wall of the stomach measures 1¾ inches in breadth, while on the left it diminishes to 1¼th inches. The larger portion of the gland consists of closely aggregated glandular follicles, but on the left gastric wall there is an interspace between its extremities, which measures ¼th of an inch in breadth. This interval is not, however, devoid of glands, but here they are much more sparsely distributed than elsewhere. Thus the gastric gland of *Spheniscus minor* may be regarded as zonular in character, using the term in the same sense as it has been employed when describing the corresponding organ of *Spheniscus magellanicus*, and remembering that on the left wall of the stomach the glands are fewer in number in a given space than on the right wall. The interior of the gizzard does not differ, except in size, from that of *Eudyptes chrysocome*. The pyloric aperture is situated on the right margin and anterior surface of the gizzard, 1 inch in front of its posterior extremity. It is provided with a single valve-like fold of mucous membrane.

The stomach of the single specimen of *Spheniscus minor* which I dissected was empty, with the exception of a few fragments of cuttle-fish beaks of small size. It contained no gravel.

In *Pygosceles tæniatus* (Pl. XVII. fig. 1) the stomach resembles in form that of *Eudyptes chrysocome* (Pl. XIII. fig. 3). In one specimen it measured 7, and in another 9 inches in length. When distended the glandular and muscular portions are separated externally by a slight constriction. The former measures 2¾ inches in diameter, and the latter in one specimen measured 2, and in another 2¾ inches. On opening the stomach, the proventricular gland is seen to form a complete belt, which entirely surrounds the gastric cavity. The posterior border of the glandular belt is almost straight. Its anterior border, on the other hand, is much curved. That portion of the gland which lies in relation to the right wall of the stomach is considerably broader than that which is situated on the left, and consequently the anterior border of the gland on the right wall of the stomach is prolonged forwards to form a rounded angle which constitutes its highest point. From this point the anterior border of the gland slopes obliquely backwards and to the left, so that the left half of the glandular belt is considerably narrower than the right. On the right gastric wall the glandular patch, in one specimen, measured 4 inches in breadth, and in another 3 inches, while on the left it measured 2 and 1½ inches respectively. As already remarked, the proventricular gland of *Pygosceles* forms a complete zone, and differs in this respect from that of every other species of Penguin which I have examined. A close approach to this arrangement is met with in the stomachs of *Sphen-*

iscus magellanicus and *Spheniscus minor*, but in both of these, as above noticed, the glandular follicles are not so closely aggregated on the left wall of the stomach as elsewhere. In these species, therefore, the gland shows a tendency to lose the completely zonular character, and to approach that of other species in which the gland assumes a less regular form. In *Pygosceles*, on the other hand, the gland follicles are as closely aggregated on the left as on the right gastric wall, and hence every portion of the belt presents a similar structure. The interior of the gizzard resembles that of *Eudyptes chrysocome*, the mucous membrane forming well-marked rugæ, which communicate freely with one another. The pylorus occupies the usual position on the anterior gastric wall. It is defended by two nodular, valve-like folds of mucous membrane.

The stomach and œsophagus in one specimen of *Pygosceles* was distended with a soft pulpy mass, intermixed with which was an immense quantity of small fish bones. Several fragments of Annelids were distinguished amid the pulp. The stomach, moreover, contained about thirty small stones, varying in size from ½ an inch in diameter to that of small gravel particles. In a second specimen of the same species, the stomach contained a quantity of isopodous crustacea, amongst which fragments of *Oniscus* were distinguishable. About fifty small stones were also extracted from among the gastric contents. The stones varied in size from that of a coffee bean to that of sand particles.

In *Aptenodytes longirostris*[1] (Pl. XVII. fig. 2) the stomach measures 8 inches in length. The line of junction of its glandular and muscular portions is indicated externally by a well-marked constriction. The glandular portion measures 2¾ inches, and the muscular portion 3 inches in diameter. As a whole, the external form of the stomach closely resembles that of *Eudyptes chrysocome*. In three of the four specimens of *Aptenodytes* which I examined, the proventricular gland was of an irregularly oval form, the long axis of the oval being placed transversely to that of the œsophagus. In them the glandular patch occupied the right wall of the stomach, and measured 2¾ inches in greatest breadth, and 3½ inches in length from side to side of the stomach. In each of these specimens there was an interval on the left gastric wall which was altogether devoid of glandular follicles, and in this interval the œsophageal rugæ were prolonged to become continuous with those of the gizzard. In the fourth specimen of *Aptenodytes* the proventricular gland formed a complete zone, much as in *Pygosceles*. In it the broadest part of the belt was situated on the right wall of the stomach, and measured 4 inches in breadth, while on the left gastric wall it did not exceed 2 inches in breadth. The occurrence in two specimens of one and the same species of *Aptenodytes* of a proventricular gland of different form is difficult to explain. In every other species of Penguin which I have examined I have found the proventricular gland similar in form in every specimen of the same species, and, taking into consideration the fact

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[1] In *Aptenodytes patachonica* the stomach measures 4 inches in length and 2¼ in breadth.—Reid, Proc. Zool. Soc., 1835, p. 147.

that in three out of four specimens of *Aptenodytes longirostris*, the proventricular gland presented precisely the same form, it seems to me that the presence in the fourth specimen of a proventricular gland of a different form must be regarded as an individual peculiarity. The muscular portion of the stomach of *Aptenodytes*, except in size, agrees with that of *Eudyptes chrysocome*. The intestine comes off from the right margin of the viscus, its commencement being defended by a valve-like fold of mucous membrane.

In one specimen of *Aptenodytes longirostris* the stomach contained a quantity of spines belonging to a species of *Spatangus*, together with a number of small stones. In a second specimen the stomach was filled with a pulpy mass, through which a number of small stones were distributed. The largest of these stones measured $\frac{1}{2}$ an inch in diameter, but did not exceed $\frac{1}{16}$th of an inch in thickness. A large number of lenses, which may have belonged either to fish or to cephalopods, was also extracted from the pulp.

The Small Intestine.

The small intestine in every species of Penguin which I have dissected comes off from the anterior (ventral) surface of the muscular portion of the stomach. It is arranged in two groups of concentric coils. Of these the larger group (Pl. XVI. fig. 9) is superficially placed, and comes into view immediately on opening the cavity of the abdomen. It occupies the right half of that cavity, and lies between the posterior surface of the right lobe of the liver in front and the right margin of the stomach behind and to the left. The second or smaller group is not exposed until after the removal of the stomach, above which it lies. It occupies the middle portion of the abdominal cavity, and lies between the vertebral column above and the upper surface of the stomach below. The intestinal coils composing it are concentrically arranged, the group presenting an appearance as of a watch spring coiled upon itself.

The small intestine terminates posteriorly below the sacrum by becoming continuous with the great gut. The duodenal curve in the Penguins is not so well defined as in the majority of birds. In the latter it usually forms a well-marked curve, within the cavity of which the pancreas is accommodated. In the Penguins, on the other hand, the duodenum, except in so far as it constitutes the first portion of the gut, is indistinguishable from the rest of the small intestine. In them the duodenal curve does not differ either in size or form from the other coils of the small gut. Neither is the pancreas limited to the first of these coils, as in the majority of birds, but extends for a variable distance in different species along the gut, and in every species comes into relation with two or more of the intestinal coils. The hepatic and pancreatic ducts open into the upper portion of the small intestine, at a variable distance from the pylorus in different species. The exact position of the extremities of these ducts, with reference to the intestine, will be found in the description of the glands to which they belong.

The mucous membrane of the small intestine is beset throughout with villi, which are mostly conical in form.

The subjoined table shows the length of the small intestine in the different species of Penguin which I have dissected.

LENGTH OF SMALL INTESTINE FROM PYLORUS TO JUNCTION OF CÆCA WITH INTESTINE.

Eudyptes chrysocome, from Tristan d'Acunha.

No. 1. 11 feet 8 inches.
No. 2. 14 feet 8 inches.

Eudyptes chrysocome, from the Falkland Islands.

No. 1. 16 feet.
No. 2 (immature). 18 feet 2 inches.

Eudyptes chrysocome, from Kerguelen Island.

No. 1. 21 feet 7 inches.
No. 2. 23 feet.

Eudyptes chrysolophus.

No. 1. 21 feet 3 inches.
No. 2. 21 feet 4 inches.
No. 3. 20 feet.

Spheniscus demersus.[1]

No. 1. 24 feet 6 inches.
No. 2. 20 feet 8 inches.
No. 3 (immature). 13 feet 1 inch.

Spheniscus magellanicus.

No. 1. 30 feet 6 inches.
No. 2. 27 feet 5 inches.
No. 3. 19 feet 6 inches.[2]

Spheniscus mendiculus.

No. 1. 10 feet 7 inches.
No. 2. 13 feet.

Spheniscus minor.

No. 1. 6 feet 9 inches.

Pygosceles tæniatus.

No. 1. 11 feet.
No. 2. 10 feet.
No. 3. 11 feet 6 inches.

Aptenodytes longirostris.

No. 1. 21 feet 8 inches.
No. 2. 25 feet 3 inches.
No. 3. 17 feet 10 inches.
No. 4. 19 feet 8 inches.

Aptenodytes patachonica,[3] Forst.

No. 1. 22 feet 6 inches.

From this table it appears that the length of the small intestine is extremely variable in different individuals belonging to one and the same species, this difference varying in amount from 2 feet in different specimens of *Eudyptes chrysocome*, to as much as 8 feet in different specimens of *Aptenodytes longirostris*. It seems, therefore, that the length of the alimentary canal in these birds is a factor of very small value in the determination of different species. The difference in length most probably depends on the more or less nutritive quality of the food at the disposal of the various individuals which compose a species. It seems not unreasonable to suppose that, just as in the herbivorous mammal

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[1] In the specimen examined by Garnot the small intestine measured 6·2 metres in length.

[2] For this specimen, which died in the Menagerie of the Zoological Society of London, I am indebted to the kindness of P. L. Sclater, Esq.

[3] Reid, Proc. Zool. Soc., 1835, p. 143.

the intestine is of greater length than in the carnivorous, so in the case of different specimens of one and the same species of Penguin, the length of the gut may vary in accordance with the more or less nutritive quality of the food at the disposal of different specimens of one and the same species inhabiting different localities. In support of this view, I may refer to the difference in length of the intestine in two specimens of *Eudyptes chrysocome*. In one of these from Tristan d'Acunha, the gut measured 11 feet 8 inches in length, while in another specimen from Kerguelen the intestine was 23 feet in length. Both of these birds are considered by ornithologists to belong to one and the same species, and yet the length of the intestine of the one is nearly double that of the other. This difference, as well as the smaller differences in the length of the alimentary canal in various specimens of the same species which inhabit approximately the same locality, appears to me to be only explicable on the supposition above enunciated. Be this as it may, difference in length of the alimentary canal cannot *per se* be considered a reliable factor in the determination of species.

The Large Intestine.

The large intestine (Pl. XIII. fig. 6 and Pl. XVII. figs. 5, 6, 7, 8) includes the cæca, rectum, cloaca, and anal passage.

In *Eudyptes chrysocome* from Tristan d'Acunha, each of the cæca measures ½ an inch in length, and is somewhat dilated at its blind extremity. They are closely applied to one another in front of (below) the termination of the small intestine, the gut passing backwards above them.[1] Their apertures of communication with the great gut are free and unprovided with any valve. Their mucous membrane presents a reticulated appearance, and, unlike that of the small intestine, is altogether devoid of villi.

The rectum, from the cæcal apertures to its opening into the cloaca, measures 1 inch in length. Its calibre is of uniform size throughout, and does not exceed that of the small intestine. Its mucous membrane is provided with villi, which, however, are less numerous and more sparsely distributed than in the small gut.

The cloacal chamber is globular in form, and when distended measures 1½ inches in diameter. When opened, its mucous membrane is seen to be thrown into slightly marked longitudinal rugæ, which are most abundant in the neighbourhood of the rectal aperture. Its surface otherwise is smooth, and presents no trace of villi. On the upper wall of the cloaca there is a well-defined transverse fold of mucous membrane, the posterior border of which is free. This fold indicates the separation of the cloacal chamber into two parts, an anterior larger, and a posterior smaller, which, however,

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[1] Both Garnot (Annales des Sciences Nat., Zoologie, 1826, p. 53) and Meckel (Anatomie Comparée, vol. viii. p. 214) note the close adhesion of the cæca to one another in the Penguins examined by them. Meckel, moreover, states that the cæcal cavities communicate directly with one another. Such was not the case in any species which I have examined. In all, the cæcal cavities communicated only with the rectum, each by means of a separate aperture.

communicate freely with one another. The anterior compartment is continuous with the rectum, and receives the fæces, while the posterior compartment, separated from the anterior by the fold above described, forms a sort of transversely elongated diverticulum or *cul-de-sac*, into the blind extremity of which open the ducts of the urinary and genital organs. The apertures of all these ducts in the male (Pl. XVII. fig. 7) are situated on the extremities of nipple-shaped eminences. In the female (Pl. XVII. fig. 8), on the other hand, these eminences are only three in number, and of these two are of larger size than the third. The two larger correspond, as in the male, to the openings of the ureters, while the smaller papilla, which is not provided with any aperture, indicates the position of the extremity of the right or aborted oviduct. The oviduct of the left side communicates by means of a narrow aperture with the uro-genital *cul-de-sac*, and is not provided with any papillary eminence.

Behind the globular cloaca the gut diminishes in size, to form the anal passage, which opens externally at the anus. The mucous membrane of this portion of the gut is thrown into longitudinally arranged rugæ. Between the cloaca and the anal passage is a transversely placed fold of mucous membrane, which is limited to the upper wall of the passage. This fold separates the apertures of the urinary and genital ducts in front from that of the bursa fabricii behind. The modifications presented by the bursa fabricii in different species I shall describe presently. Meanwhile, I may observe that its aperture of communication with the anal passage presents the form of a transversely elongated slit, and is not defended by any valve.

The description above given of the interior of the cloaca, shows that the Penguins agree with the majority of birds in so far as the structure of this portion of the gut is concerned. Mr. W. Forbes,[1] in an instructive paper on the bursa fabricii in birds, shows that in the great majority (excepting the Struthionidæ) the cloaca is divisible into three distinct chambers, which correspond respectively to the rectal, urino-genital, and anal passages above described. The position of the terminations of the urinary and genital ducts, as well as of the aperture of the bursa fabricii, he found to be similar in the very numerous species which he examined. The accuracy of these observations I have now been able to confirm in respect of every species of Penguin which I have examined.

The anal passage is provided with three muscles, two levatores and a sphincter.

The levatores ani (Pl. XVII. fig. 6) are two riband-like muscular bands, described by Gervais and Alix[2] under the name of "releveurs de l'anus." Each *arises* from the posterior border of the ischium, close to the posterior or free extremity of the pubic bone, and passes backwards to be inserted into the lateral surface of the anal passage, and to a small extent into the posterior wall of the globular cloaca. Each of these muscles,

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[1] On the Bursa Fabricii in Birds, Proc. Zool. Soc. Lond., 1877, p. 304.

[2] Ostéologie et Myologie des Manchots, p. 16.

as it passes backwards to its insertion, lies along the outer side of the corresponding ureter, and nearly in contact with the depressor coccygis muscle. In action it would appear that they draw forwards the posterior extremity of the gut, and probably assist in everting the cloaca during copulation and defæcation.

The sphincter ani consists of a stout bundle of muscular fibres, which surrounds the anus and the posterior extremity of the anal passage.

Bursa fabricii.[1]—The bursa fabricii varies much in size and structure in different specimens of one and the same species. Its size does not appear to be in any way dependent on sex, but rather on functional requirements which influence both sexes alike at various periods. What the nature of these functional requirements really is, I am unable to say. That they are not confined to one sex is abundantly proved by the fact that in some individuals, both male and female, the bursa presents the appearance reproduced in Pl. XVII. fig. 5, where it assumes the form of a relatively small pyriform sac, the blind extremity of which does not extend farther forwards than the middle in length of the globular cloaca. In other specimens, again, the bursa fabricii, when distended, equals, or even exceeds in size the cloaca itself (Pl. XVII. fig. 6).

In those specimens in which the bursa was of small size, whether male or female, I found its lining membrane to be uniformly smooth, thin, and delicate, while in those in which it presented the larger size represented in Pl. XVII. fig. 6 the lining membrane of the bursa appeared to have become hypertrophied, and presented a soft, spongy, and succulent character. In the latter the succulent mucous membrane was thrown into well-defined rugæ, which for the most part were longitudinal in direction, but communicated freely with one another by means of short, more or less transversely placed folds (Pl. XVII. fig. 6). The difference in size and structure of the bursa in different specimens of one and the same species is difficult to account for. According to Mr. Forbes,[2] the bursa fabricii is of larger size in the young bird, and undergoes a process of atrophy as maturity or old age is reached. It is possible that this observation may hold good in the case of the Penguins, as in that of the birds which he examined. At the same time it appears to me to be exceedingly doubtful. The majority of the Penguins at my disposal, as proved by an examination of their skeletons, were certainly adult specimens, and yet the bursa presented the very remarkable variations, both in size and structure, above referred to. In none have I seen it of smaller size than in that delineated on Pl. XVII. fig. 5. It seems, therefore, more likely that the variations in size and structure of the bursa fabricii of the Penguin are associated with certain periodic requirements experienced by both sexes, with the exact nature of which, we are still

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[1] Professor Owen in his paper "On the morbid appearances observed in the dissection of *Aptenodytes forsteri*," Proc. Zool. Soc., 1865, p. 439, directs attention to the large size of the "urinary bladder," by which I understand he means the bursa fabricii in that bird, and remarks that it constitutes one of the peculiarities in the anatomy of the Penguins as compared with other birds.

[2] Proc. Zool. Soc., 1877, p. 304.

unacquainted. In every specimen of Penguin which I examined the bursa was perfectly empty. The subjoined table[1] gives the dimensions of the various portions of the great intestine and bursa fabricii of different species in English inches.

Specimen.	Length of cæca.	Length of great intestine from junction of cæca to anus.	Length of rectum.	Diameter of cloaca.	Bursa fabricii.
Eudyptes chrysocome, from Tristan d'Acunha.					
No. 1 ♀	1½	3	1	1½	Two-thirds the length of cloaca. Broadly pyriform. Mucous membrane thick, spongy, and rugose.
No. 2 ♂	1½	3	1	½	Half the length of the cloaca. Pyriform. Mucous membrane smooth, thin, and without rugæ.
Eudyptes chrysocome, from the Falkland Islands.					
No. 1 ♂	½	3½	1½	1½	Equal in length to the cloaca. ¼ of an inch in diameter throughout. Mucous membrane thick but smooth, and devoid of rugæ. Presents apertures of numerous glandular follicles.
Eudyptes chrysocome, from Kerguelen Island.					
No. 1 ♂	½	2½	½	1¼	Small and of equal diameter throughout. Half the length of the cloaca. Mucous membrane perfectly smooth, thin, and devoid of any appearance of glands.
No. 2 ♀	¾	3	1½	¾	Equal in length to the cloaca. ¼ of an inch in diameter throughout. Mucous membrane perfectly smooth, thin, and not glandular.

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[1] In this table the length of the anal passage is omitted, as being unimportant. Its dimensions can be readily ascertained in each case by deducting the length of the rectum, *plus* the diameter of the cloaca, from the length of the great intestine, measured from the point of junction of the cæca to the anus.

Specimen.	Length of cæca.	Length of great intestine from junction of cæca to anus.	Length of rectum.	Diameter of cloaca.	Bursa fabricii.
Eudyptes chrysolophus.					
No. 1 ♀	¾	3½	1¼	1½	Equal in length to the cloaca. ¼ of an inch in greatest width. Pyriform. Mucous membrane smooth, thin, and not glandular.
No. 2 ♀	¾	3½	1¼	1½	Three-fourths the length of the cloaca. Narrow and pyriform. Mucous membrane smooth, thin, and not glandular.
No. 3 ♂	1	3	1	2	Three-fourths the length of the cloaca. Narrow, pyriform. Mucous membrane thin, smooth, and not glandular.
Spheniscus demersus.					
No. 1 ♂	1	3½	...	1	Equal in length to the cloaca. ¼ of an inch in diameter at widest part. Pyriform in shape. Mucous membrane thin, smooth, and not glandular.
No. 2 ♂	1	4	1¾	1½	Half the length of the cloaca. ½ of an inch in diameter at widest part. Pyriform in shape. Mucous membrane thin, smooth, and not glandular.
No. 3[1] ♂ immature.	1	3½	...	...	As large as cloaca. Globular in form. Mucous membrane thick, spongy, and glandular.
Spheniscus magellanicus.					
No. 1 ♂	1½	4	...	...	½ of an inch in length. Pyriform in shape.
No. 2 ♀	1½	3	1	1½	Equal in length to the cloaca. Pyriform. ¼ of an inch in diameter throughout. Mucous membrane smooth, thin, and not glandular.

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[1] For this specimen I am indebted to the kindness of Mr. W. Forbes, prosector to the Zoological Society of London. The large size of the bursa fabricii in this immature specimen bears out the views of Mr. Forbes in the paper above referred to.

Specimen.	Length of cæca.	Length of great intestine from junction of cæca to anus.	Length of rectum.	Diameter of cloaca.	Bursa fabricii.
Spheniscus mendiculus.					
No. 1 ♂	⅝	3	1½	1	Two-thirds the length of the cloaca. Mucous membrane smooth, thin, and not glandular. On either side of the aperture of the bursa is a small recess, studded with numerous glandular apertures.
No. 2 ♂	¾	2½	...	1½	Half the length of the cloaca. Mucous membrane smooth, thin, and not glandular.
Spheniscus minor.					
No. 1 ♂	¾	1¾	¾	¾	Half the length of the cloaca. Pyriform in shape. Mucous membrane smooth, thin, and not glandular.
Pygosceles tæniatus.					
No. 1 sex?	2	4½	2	2	Enormous. Pyriform in shape. Exceeds the cloaca in length. 2¼ inches long, 1¾ inches in greatest breadth. Mucous membrane very thick, rugose, and glandular.
No. 2 ♀	1¼	4½	2¼	1½	Narrow and pyriform. 1½ inches in length, ¼ of an inch in greatest breadth. Mucous membrane thin, devoid of rugæ, and not glandular.
No. 3 sex?	1½	5	2¼	1½	Equal in length to the cloaca. Mucous membrane thick, rugose, and glandular as in No. 1.

Specimen.	Length of cæca.	Length of great intestine from junction of cæca to anus.	Length of rectum.	Diameter of cloaca.	Bursa fabricii.
		Aptenodytes longirostris.			
No. 1 ♀	1½	4½	...	...	2½ inches in length 1¼ inches in greatest breadth. Larger than cloaca. Mucous membrane thick, rugose, and glandular.
No. 2 ♂	...	4	...	2	Larger than the cloaca. Mucous membrane thick, rugose, and glandular. Form of bursa resembles that figured in Pl. XVII. fig. 6.
No. 3 ♀	1½	4	...	...	Larger than the cloaca. Mucous membrane thick, rugose, and glandular.
No. 4 ♂	1½	5½	...	...	Pyriform in shape. Equal in length to the cloaca. ¾ of an inch in greatest breadth. Mucous membrane thick, rugose, and glandular; not as thick as in the other specimens examined.
		Aptenodytes patachonica[1] (Forst.).			
No. 1 ♂	1¼	6	...	...	...

The Liver.

The liver of *Eudyptes chrysocome* (Pl. XIII. fig. 5) occupies the entire breadth of the anterior portion of the abdominal cavity. It consists of two lobes, a right and a left, of which the former is about one-third larger and heavier than the latter. Each lobe resembles in form a three-sided pyramid, the hollowed base of which is directed backwards, the apex forwards. The outer side is convex, and is adapted to the inner surfaces of the ribs, while the inner side is concave, and when the lobes are *in situ* bound a V-shaped space, in which the ventricular portion of the heart is lodged. The upper or vertebral border of each lobe is thick, rounded, and united with the corresponding border of the opposite lobe, while the lower or abdominal border is thin, sharp, and nearly in contact with its fellow. The great mass of the intestinal coils rests against the base

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[1] These measurements are extracted from Reid's paper on the Patagonian Penguin in the Proc. Zool. Soc., 1835, p. 148.

of the right hepatic lobe, while the termination of the œsophagus, and the glandular portion of the stomach, have a similar relation to the left lobes of the liver. The anterior portion of the vertebral border of each hepatic lobe lies in contact with the posterior border of the corresponding lung. The vena cava inferior pierces the right lobe of the liver before opening into the right auricle of the heart.

The hepatic ducts are two in number, one belonging to each lobe. Each measures about 3 inches in length, and opens separately into the small intestine. The right hepatic duct is provided with an enormous diverticulum or gall bladder[1] (Pl. XIII. fig. 5), while the left is destitute of any such appendage. The gall bladder is cylindrical in form, and measures 3½ inches in length. Its calibre diminishes slightly from behind forwards, the narrowest part of the sac corresponding to the point of junction of the gall bladder with the right hepatic duct. The junction takes place 1 inch from the commencement of the latter. The gall bladder extends as far back as the constriction which indicates the junction of the glandular and muscular portions of the stomach. It is superficially placed, lying immediately under cover of the abdominal muscles, and rests upon the coils of the small intestine, between the latter and the right margin of the stomach. The mucous lining of the gall bladder is perfectly smooth, and destitute of the reticulated arrangement met with in the mammal. The right hepatic duct, after its junction with the gall bladder, passes backwards, in front of the coils of the intestine, and, sinking into the interval between these and the right margin of the stomach, opens into the small intestine 4 inches from the pylorus.

The left hepatic duct of *Eudyptes chrysocome* is derived exclusively from the left lobe of the liver. It passes off from the posterior surface of the liver close to the junction of the right and left lobes. It follows a course parallel to that of the duct of the right side, and opens into the small intestine 2 inches from the pyloric orifice. Both hepatic ducts pass very obliquely through the intestinal wall.

Variations in respect of the Liver.

The deviations presented by the liver in the different species of Penguin from that above described in *Eudyptes chrysocome*, except in respect of size, are few and unimportant. As already observed, in *Eudyptes chrysocome* the left hepatic lobe is about one-third smaller than the right lobe. This holds good of every Penguin which I have dissected, with the exceptions of *Eudyptes chrysolophus* and *Spheniscus demersus*, in both of which the left hepatic lobe, although of slightly smaller size than the right, was relatively larger than in the other species.

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[1] According to Reid (Proc. Zool. Soc., 1835, p. 147), in *Aptenodytes patachonica* the gall bladder "is inserted into the intestine without the intervention of any duct." Such is not the case in any species of Penguin which I have examined.

As in *Eudyptes chrysocome* from Tristan d'Acunha, so in the majority of the Penguins, neither of the hepatic lobes presents any trace of subdivision. In one specimen of *Eudyptes chrysocome* from Kerguelen, however, the left lobe of the liver presented close to its posterior free margin a slight fissure. This occurrence ought probably to be regarded as an individual peculiarity, as the fissure in question was absent in every other specimen of the same species which I had an opportunity of examining. In both specimens of *Pygosceles tæniatus* which I examined, the left hepatic lobe was divided into two parts by means of a well-marked fissure, situated on the inner or cardiac surface of that lobe. This fissure separated the inner third of the lobe from the rest of the hepatic substance, but did not extend to the outer surface of the lobe. This fissure is absent in every other species of Penguin.

The right and left hepatic ducts in *Eudyptes chrysocome* are exclusively derived from the corresponding lobes. Such is likewise the case in every other species, with the exception of *Spheniscus magellanicus* and *Pygosceles tæniatus*, in both of which the left hepatic duct is not exclusively derived from the left lobe of the liver, but receives a tributary duct from the right lobe. In every species the left hepatic duct enters the intestine nearer the pylorus than the right duct. The only exception to this rule which I met with, occurred in the case of a single specimen of *Eudyptes chrysolophus*, in which the right duct entered the gut nearer to the pylorus than the left. Other specimens of the same bird, however, presented the normal arrangement, hence it seems likely that the unusual arrangement in the single case referred to was an individual peculiarity.

The accompanying table shows the dimensions, in inches, of the gall bladder, hepatic ducts, &c., in different species of Penguin.

Specimen.	Length of left hepatic duct.	Distance from pylorus of point of entrance into intestine of left hepatic duct.	Length of right hepatic duct.	Distance from pylorus of point of entrance into intestine of right hepatic duct.	Length of gall bladder.
Eudyptes chrysocome, from Tristan d'Acunha.					
No. 1	3	2	3	4	3½
No. 2	3	1¾	3	5	3½
Eudyptes chrysocome, from the Falkland Islands.					
No. 1	3	1	3	7	3½

Specimen.	Length of left hepatic duct.	Distance from pylorus of point of entrance into intestine of left hepatic duct.	Length of right hepatic duct.	Distance from pylorus of point of entrance into intestine of right hepatic duct.	Length of gall bladder.
Eudyptes chrysocome, from Kerguelen.					
No. 1	$3\frac{3}{4}$	4	4	11	$3\frac{1}{2}$
No. 2	$2\frac{3}{4}$	$3\frac{3}{4}$	3	8	3
Eudyptes chrysolophus.					
No. 1	3	13	4	9	$4\frac{1}{2}$
No. 2	3	3	4	8	$4\frac{1}{2}$
Spheniscus demersus.					
No. 1	$3\frac{1}{2}$	14	4	21	4
No. 2	$3\frac{3}{4}$	9	$4\frac{1}{4}$	15	...
No. 3 immature.	...	8	...	$11\frac{1}{2}$	...
Spheniscus magellanicus.					
No. 1	5	13	7	26	$5\frac{1}{2}$
No. 2	5	13	$5\frac{1}{2}$	25	...
Spheniscus mendiculus.					
No. 1	3	$5\frac{1}{4}$	3	$7\frac{1}{2}$	3
Spheniscus minor.					
No. 1	...	$2\frac{1}{2}$	...	$4\frac{3}{4}$	$2\frac{1}{4}$

Specimen.	Length of left hepatic duct.	Distance from pylorus of point of entrance into intestine of left hepatic duct.	Length of right hepatic duct.	Distance from pylorus of point of entrance into intestine of right hepatic duct.	Length of gall bladder.
Pygoscelis tæniatus.					
No. 1	...	10	...	13	...
No. 2	...	10½	...	12	4½
Aptenodytes longirostris.					
No. 1	...	25	...	37	6
No. 2	...	30	...	37	7

THE PANCREAS.

The pancreas of *Eudyptes chrysocome* from Tristan d'Acunha (Pl. XIII. fig. 5) consists of an elongated glandular mass, measuring 6 inches in length. The upper end or head is triangular in form, and lies in contact with the commencement of the intestine, being wedged in between the latter and the right margin of the muscular portion of the stomach. The remainder of the gland consists of a narrow flattened band, having an average breadth of ¼th of an inch. It lies in contact but is not continuous with the enlarged portion or head, and is situated between the two layers of the mesentery, close to the wall of the intestine. In a second specimen of *Eudyptes chrysocome* from Tristan, this segment of the gland was divided into two distinct portions, which, however, were in close contact with one another. In this specimen, each of these portions possessed a duct which opened directly into the intestine. The number of pancreatic ducts apparently varies not only in different species but in different specimens of one and the same species. In one specimen of *Eudyptes chrysocome* from Tristan I found two, and in another three separate pancreatic ducts. In both cases the upper pancreatic duct carried off the secretion from the upper portion or head of the gland, while the remaining elongated riband-like portion was provided in one specimen with a single, and in another with two ducts. The points of entrance of these ducts into the intestine varied in different species as well as in different specimens of the same species. These variations are indicated in the subjoined table.

Variations in respect of the Pancreas.

The pancreas presents essentially a similar appearance in every species of Penguin, and differs only in size and in the fact that in some species, *e.g.*, *Eudyptes chrysocome*,[1] the gland which is usually single is divided into two or more separate parts, which, however, are closely in contact with one another. With regard to the position of the points of entrance of the hepatic and pancreatic ducts into the intestine, it may be stated that, as a rule, the left bile duct opens into the gut next the stomach, and is followed by one, or it may be by two pancreatic ducts, then by the right bile duct, and lastly by the lowest pancreatic duct. This rule is not, however, without exception. It may farther be observed, that when only two pancreatic ducts are present, that which arises from the head of the gland usually opens into the intestine below that which carries off the secretion from the lower portion of the viscus.

It ought to be noticed that the pancreas of several of the birds dissected had to some extent undergone decomposition, and that the exact determination of the number of the pancreatic ducts was thereby rendered difficult. The results of my dissections, however, are given in the accompanying table.

TABLE showing the relative positions of the Intestinal Extremities of the Hepatic and Pancreatic Ducts in different Species of Penguin. The figures indicate in inches the distance from the pylorus of the point of entrance into the intestine of each of the ducts.[2]

Specimen.	Left hepatic duct.	Upper pancreatic duct.	Middle pancreatic duct.	Lower pancreatic duct.	Right hepatic duct.
Eudyptes chrysocome, from Tristan d'Acunha.					
No. 1	2	4¼	absent.	3	4
No. 2	1¾	2¼	2½	7	5
Eudyptes chrysocome, from Kerguelen.					
No. 1	3¾	4	5½	absent.	8
No. 2	4	4¼	5¼	9	11

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[1] In *Spheniscus demersus*, Garnot (Annales des Sciences Naturelles, 1826, p. 53) found the pancreas divided into two distinct portions.

[2] In this table I have omitted all mention of the pancreatic ducts in *Eudyptes chrysocome* from the Falkland Islands. The reason is, that in both specimens examined the pancreas was so far decomposed as to render the determination of the number of pancreatic ducts impossible.

Specimen.	Left hepatic duct.	Upper pancreatic duct.	Middle pancreatic duct.	Lower pancreatic duct.	Right hepatic duct.
Eudyptes chrysocophus.					
No. 1	13	4	absent.	5	9
No. 2	3	3½	absent.	3½	8
Spheniscus demersus.					
No. 1	14	18	absent.	absent.	21
No. 2	9	9¼	12	24	15
Spheniscus magellanicus.					
No. 1	13	absent	absent.	34½	26
No. 2	13	16	absent.	32	25
Spheniscus mendiculus.					
No. 1	5¼	6½	absent.	14	7½
Spheniscus minor.					
No. 1	2½	2¼	absent.	3¼	4¾
Pygosceles tæniatus.					
No. 1	10	19	absent.	absent.	13
No. 2	10½	11	absent.	absent.	12
Aptenodytes longirostris.[1]					
No. 1	25	30	absent.	absent.	37

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[1] In *Aptenodytes patachonica*, according to Reid (Proc. Zool. Soc., 1835, p. 147) "the biliary and pancreatic ducts enter the intestine about 3½ inches from its commencement."

THE SPLEEN.

The spleen of *Eudyptes chrysocome* (Pl. XVI. fig. 5) from Tristan d'Acunha, as well as in specimens from the Falklands and Kerguelen Island, is of a reddish purple colour, and presents the form of a flattened oval cake, measuring 1 inch in length, ½ an inch in greatest breadth, and ¼ of an inch in thickness. It lies to the right side of, and behind the termination of the œsophagus, being situated in front of the upper end of the left kidney, and in close relation to the under surface of the liver. In the female it lies in front of the ovary. It is supplied with blood by a branch from the cœliac axis. The veins carrying back the blood to the heart open into the portal vein.

Variations in respect of the Spleen.

The spleen, as might be expected, varies much in size, not only in different species, but in different specimens of the same species. In one specimen of *Eudyptes chrysolophus* (Pl. XVI. fig. 6) the organ presented the form of an oval flattened cake, measuring 1 inch in length and ½ an inch in greatest breadth, while in another specimen it was oblong in form, and measured 1 inch in length, ¼ of an inch in breadth, and the same in thickness. In *Spheniscus demersus* the spleen is proportionally larger than in *Eudyptes*. In one specimen it measured 1½ inches in length, 1 inch in breadth, and ¼th of an inch in thickness, and presented an irregular outline; while in a second specimen (Pl. XVI. fig. 7) the viscus was of an elongated oval form, the extremities of the oval being pointed. In this specimen the spleen measured 2¼ inches in length and ¾ of an inch in greatest breadth.

In *Spheniscus magellanicus* (Pl. XVI. fig. 8) the spleen measured 2 inches in length, ¾ of an inch in breadth, and ⅛th of an inch in thickness. In *Spheniscus mendiculus*, unfortunately, I failed to note the dimensions of the organ. In *Spheniscus minor* (Pl. XII. fig. 5) the spleen is kidney-shaped, and measures ¾ of an inch in length and ¼ of an inch in breadth. The spleen in one specimen of *Pygosceles tæniatus* was circular in form, and of the size of a farthing, while in a second specimen (Pl. XVII. fig. 3) it measured 2 inches in length and ½ an inch in greatest breadth. In form the spleen of the second specimen was somewhat crescentic, the convex margin being directed toward the right side of the bird. Lastly, in *Aptenodytes longirostris* (Pl. XVII. fig. 4) the spleen presents the form of an almost circular flattened cake, measuring 1 inch in diameter and ½ an inch in thickness.

In every species in which the spleen presents an elongated form, the long axis of the viscus in the natural position of the organ coincides with that of the body of the bird.

RESPIRATORY ORGANS.

The Upper Larynx.

The framework of the upper larynx of every species of Penguin presents the same form, and consists of four separate cartilages—the thyroid, cricoid, and two arytenoids.

The Thyroid Cartilage (Pl. XVIII. figs. 1, 2) is usually extensively ossified, and somewhat resembles in form that of a shoe. Its lower surface is convex from side to side, and is covered by the thyro-hyoid muscles, while the upper or laryngeal surface is deeply concave. The lateral portions of the cartilage are prolonged backwards in the form of two processes or horns, the posterior extremities of which come into relation to, and articulate with, the lateral borders of the intermediate cricoid cartilage. The anterior extremity of the thyroid cartilage is somewhat pointed and convex. The posterior margin, on the other hand, is uniformly concave, with the exception of a small projecting nodule which occupies the middle line of the cartilage and projects horizontally backwards. The concavity itself is adapted to the reception of the anterior tracheal rings, which are incomplete, and limited to the lower aspect of the windpipe. From the middle line of the upper or laryngeal surface of the thyroid cartilage there projects upwards a vertical plate, which equals in length the cartilage itself. This forms an incomplete septum laryngis, which, projecting into the box of the larynx, divides the latter incompletely into two lateral compartments, each of which is bounded externally by the arytenoid cartilage and internally by the septum in question. The arytenoid cartilages are connected by means of ligament to the upper border of the thyroid cartilage, but nowhere directly articulate with it.

The Cricoid Cartilage (Pl. XVIII. fig. 2), or rather bone, for it is usually entirely ossified, completes the laryngeal box posteriorly, being wedged in between the extremities of the cornua of the thyroid cartilage. Its form is somewhat irregular, but two surfaces and two lateral margins may be distinguished. The anterior surface is smooth and covered by the laryngeal mucous membrane, while the posterior surface, deeply hollowed, affords attachment to the sphincter-like muscles of the upper larynx. The lateral margins are deeply concave, the concavity being due to the presence of a concave articular surface adapted to the reception of the posterior extremity of the corresponding thyroid cornu, which thus articulates directly with the cricoid cartilage. Each of the upper and lateral angles of the cricoid cartilage is, moreover, furnished with a deeply concave articular surface, with which the posterior extremity of the corresponding arytenoid cartilage directly articulates.

The Arytenoid Cartilages.—Each of these cartilages (Pl. XVIII. fig. 2) is of an elongated oval form, the anterior extremity of which is narrow and pointed, while the posterior is rounded and convex. Its outer surface is hollowed to accommodate the apertor muscle of the upper larynx, while the inner or laryngeal surface is flat, smooth, and covered by the laryngeal mucous membrane. The upper or free border of the cartilage is thin and sharp, and is covered by the dense mucous membrane forming the "laryngeal pads." Connected with the posterior part of this border is a small pointed piece of cartilage, which in some species is quite distinct from, although connected with, the arytenoid cartilage, while in others it is quite continuous with the latter. The lower border of each arytenoid affords attachment to the thyro-arytenoid ligament. The anterior pointed extremity of the arytenoid projects beyond that of the thyroid cartilage, and does not articulate with its fellow, although it is connected with it as well as with the basi-hyal bone, by means of the central thyro-hyoid ligament. The posterior rounded extremity of the arytenoid is provided with a convex articular surface, by means of which it articulates with the upper lateral facet on the cricoid cartilage.

The Ligaments of the Larynx consist of two thyro-arytenoid ligaments, by means of which the bases of the arytenoid cartilages are attached to the upper border of the thyroid. The anterior extremities of the arytenoid cartilages are, moreover, connected with one another by means of the central thyro-hyoid ligament, the principal function of which is to attach the anterior pointed extremity of the thyroid cartilage to the basi-hyal bone. The posterior extremities of the arytenoids, as well as the extremities of the thyroid cornua, articulate directly with the cricoid cartilage, the articulation of each being surrounded by a delicate fibrous capsule.

The Intrinsic Muscles of the upper larynx are two in number, a sphincter and apertor.

The Sphincter Laryngis (Pl. XVIII. fig. 4) is symmetrically disposed on either side of the laryngeal aperture, and is situated immediately beneath the laryngeal pads. The muscular fibres *arise* on either side of the middle line, from the posterior extremity and posterior half of the outer surface of each thyroid cornu, the origin of the muscle corresponding closely to the insertion of the claviculo-thyroid muscle. The fibres pass obliquely forwards and inwards toward the middle line, and are *inserted* into the anterior half of the outer surface of each arytenoid cartilage. The external fibres of opposite muscles become continuous with one another in front of the arytenoid cartilages, and thus complete the sphincter arrangement. The sphincter laryngis apparently closes the aperture of the larynx by approximating the arytenoid cartilages.

The Apertor Laryngis (Pl. XVIII. figs. 4, 5) consists of two lateral halves, which come into contact posteriorly, and thus form a single muscular mass which separates the origins of the two halves of the sphincter laryngis. The muscle of each side *arises* in front from the anterior three-fourths of the upper margin of the thyroid cartilage. It passes obliquely backwards and inwards, and is *inserted* into the posterior half of the outer surface of the arytenoid cartilage, as also into the posterior hollowed surface of the cricoid cartilage, where the fibres of opposite muscles become almost continuous with one another. The greater portion of this muscle is concealed by the sphincter laryngis. The action of this muscle is apparently that of a dilator of the laryngeal aperture. This is accomplished by the muscle taking its fixed point externally, and acting upon the readily moveable arytenoid cartilages.

The upper larynx in every species of Penguin agrees, except in size, with that above described in *Eudyptes chrysocome* from Tristan d'Acunha.

The Trachea.

The trachea of *Eudyptes chrysocome* from Tristan d'Acunha (Pl. VIII.) measures 7 inches in length. In its course along the neck it lies at first in front of the vertebral column, but like the œsophagus, becomes displaced, so as to lie to the right of the posterior cervical vertebræ. This displacement is due to the fact that the posterior cervical vertebræ project forwards to such an extent that they come into contact with the furcular angle, and consequently the trachea and œsophagus are displaced to the right before passing into the thorax. After entering the thorax, the trachea regains the middle line, and almost at once divides into the two bronchial tubes. The thoracic portion of the trachea lies in front of the œsophagus, and occupies the fork formed by the two innominate arteries. The tube is flattened from above downwards, and presents externally a slight trace of a longitudinal mesial groove, which indicates the position of a septum, which in the majority of the Penguins divides the tracheal tube more or less completely into two distinct compartments. The structure of the trachea in the Penguins does not differ from that of other birds. The tracheal rings, which in birds in general are cartilaginous, are prone to ossify in the Penguins. In *Eudyptes chrysocome* from Tristan, these rings are 107 in number. They are freely moveable upon one another in the region of the neck, and accommodate the trachea to the varying flexures of that portion of the vertebral column. In the thorax, on the other hand, they are much less mobile, and give to the thoracic portion of the tube a rigidity which is wanting in the cervical segment of the tube. The thoracic portion of the trachea as a whole is much less flexible than the cervical, still a certain amount of movement is permitted between the rings composing it, with the exception of the last nine, which, although not actually soldered together, are so arranged as to prevent the possibility of any bending of that portion of the trachea of which they are component elements.

The most striking peculiarity of the trachea in the Penguins lies in the presence of a mesial tracheal septum, which extends from the point of bifurcation forwards, to a greater or less extent in different species. This septum divides the lumen of the trachea more or less completely into two lateral channels. In *Eudyptes chrysocome* from Tristan, it is more limited in extent than in any other species which I have examined. Indeed in one specimen, the trachea presented not the slightest trace of a septum, while in another the septum did not extend more than ⅛th of an inch in front of the bifurcation. The tracheal septum varies in length in different species, but it appears to bear no relation whatever to sex. This is shown in the subjoined table. With regard to structure, the septum tracheæ resembles that of the tracheal walls in the possession of cartilaginous bars which are continuous with the rings of the trachea. These bars are included within a double fold of the tracheal mucous membrane, which, together with the cartilaginous elements, completes the septum. The posterior extremity of the septum tracheæ is attached to the point of bifurcation of the two bronchial tubes, while its anterior extremity invariably presents a hollowed, concave, sharp margin in front of which the tracheal tube is single and undivided. The appearance of cartilaginous bars in the septum seems to show that in the Penguins this septum tracheæ presents a persistent condition of that stage of development of the early embryo of the chick, in which the two diverticula which ultimately form the lungs and bronchial tubes open separately into the œsophagus. In the chick, these diverticula having developed to form the lungs, communicate with the œsophagus by means of a tube (the trachea) which is single throughout, whereas in the Penguins it would appear that the septum, which originally separates the two diverticula persists throughout life to a greater or less extent in different species. In *Eudyptes chrysocome* from Tristan, the last four tracheal rings are welded together to form a single immoveable mass, to which the bronchial tubes are attached.

THE SYRINX.

The framework of the lower larynx of *Eudyptes chrysocome* from Tristan d'Acunha consists of the last four tracheal rings. Of these the last three, being situated behind the point of bifurcation, in reality belong rather to the bronchial tubes than to the trachea. In as much as they are inseparably united with the last tracheal ring, however, it is more convenient to enumerate them as structurally connected with the larger tube. The last tracheal ring proper is provided with a mesial process, or pessulus, which lies in the bronchial fork and adapts the posterior extremity of the trachea to the commencement of the bronchial tubes. To this the following three rings on either side are immoveably united to form a single osseous mass. Between the last of these rings and the first bronchial bar proper there exists on the ventral surface of the bronchus an elliptical space, which is filled by an elastic membrane. The dorsal surface of the syrinx on either side of the middle line is completed by means of a broad, elastic membrane, which extends along the whole length of the corresponding bronchial tube, and forms the dorsal wall of the latter. This is apparently the essential part of the organ of voice, as apart from it and the elliptical membrane on the ventral surface of the bronchus the larynx possesses no vibrating structure. The lower larynx is entirely devoid of intrinsic muscles, and only in certain species does the contractor tracheæ extend so far back as to come into relation with, and have any effect upon the organ of voice. This probably explains the persistently braying character of the voice of the Penguins, which all who have listened to these birds in their native haunts describe as being uniform in tone, and capable of but little modulation.

The Bronchial Tubes.—Each of the bronchial tubes, from the point of bifurcation of the trachea to the corresponding lung, measures in *Eudyptes chrysocome* from Tristan d'Acunha 1 inch in length. Each diminishes in diameter from its commencement to its termination. The bronchial rings, exclusive of those which enter into the formation of the syrinx, are twelve in number, and, unlike those which form the trachea, are incomplete, and form a series of cartilaginous bars which are confined to the inferior or ventral surface of the bronchial tube. The bronchial bars are soft and flexible, and therefore differ from those met with in the trachea, which are rigid and osseous in character. The bronchial bars diminish rapidly in length from before backwards. The dorsal wall of each bronchus is entirely membranous from end to end, this membrane constituting the vibrating plate already described in connection with the lower larynx.

In both specimens of *Eudyptes chrysocome* from Tristan d'Acunha, which I examined, a peculiar dense fibrous pad (Pl. XIX. fig. 1) was closely adherent to this membrane. The exact nature or function of this body is difficult to determine, but that it forms no essential part of the laryngeal or bronchial apparatus is shown by the fact that it is absent in every other species of Penguin which I have dissected. This remark holds good, not only of other species, but also of specimens of *Eudyptes chrysocome* from the Falkland Isles (Pl. XIX. fig. 3) and from Kerguelen, and were it not for the fact that it was observed in two specimens of *Eudyptes chrysocome* from Tristan, I should certainly have regarded it as an individual and possibly pathological occurrence. In view of the fact stated, however, its occurrence ought probably to be regarded as a distinctive peculiarity of a local form of one species of *Eudyptes.* Further research, however, is necessary to decide this point. The terminal portion of each bronchus is entirely membranous and altogether devoid of cartilaginous bars.

Muscles of the Trachea and Bronchi.

1. *Cleido-thyroid muscle.*

Sterno-thyroïdien, Vicq d'Azyr, 1773, p. 581, No. 1.
Gabelknochen-Luftröhren-Muskel, Tiedemann, Bd. i. p. 667, No. 2.
Ypsilo-trachéus, Cuvier, vol. iv. p. 466.
Ypsilo-trachéalis, Meckel, vol. x. p. 340.
Cleido-trachéen, Gervais and Alix, p. 17.

Attachments.—The cleido-thyroid muscle (Pl. VIII.) *arises* from the anterior border of the clavicle, about $\frac{1}{2}$ an inch from its junction with the bone of the opposite side. The two muscles pass forwards, and converging come into contact about the middle in length of the neck. From this point forwards they diverge, and each (after winding round the lateral surface of the trachea) is *inserted* into the superior and lateral surfaces of the thyroid cartilage close to its posterior border.

Action.—This muscle retracts the thyroid cartilage, and indirectly the hyoid bone, and approximates them to the clavicle.

Relations.—The muscles at their origin are almost inseparable from the superjacent fibres of the cutaneous muscle of the neck. In the terminal part of their course the muscles lie in contact with the trachea.

Nerve supply (?)

Variations.—In three species of *Spheniscus*, namely—*Spheniscus magellanicus*, *Spheniscus demersus*, and *Spheniscus mendiculus*, I found this muscle prolonged forwards to the great cornu of the hyoid bone, to the apohyal element of which it took a distinct attachment. Neither in *Spheniscus minor* nor in any species of the other genera which I dissected was this the case.

2. *Sterno-trachealis muscle.*

Les laringiens inférieurs et externes, Vicq d'Azyr, 1773, p. 581, No. 3.
Brustbein-Luftröhren Muskel, Tiedemann, p. 666, No. 1.
Sterno-trachéens, Cuvier, vol. iv. p. 466.
Sterno-trachealis, Meckel, vol. x. p. 340.
Sterno-trachéen, Gervais and Alix, p. 17.

Attachments.—The sterno-tracheal muscle *arises* from the deeper or thoracic surface of the costal process of the sternum. The fibres form a riband-like muscle, which passing forwards, gains the lateral aspect of the trachea 1¼ inches in front of the bifurcation of that tube. Its anterior fibres are *inserted* directly into the trachea, while the posterior become continuous with those of the contractor tracheæ.

Action.—This muscle retracts the posterior extremity of the trachea within the thorax.

Relations.—The sterno-trachealis arises close to the origin of the triangularis sterni.

Nerve supply (?)

Variations.—The point at which the sterno-tracheal muscle applies itself to the side of the trachea varies in different species. In *Eudyptes chrysocome* from the Falklands, it reaches the trachea 1¼ inches, in *Eudyptes chrysocome* from Kerguelen 1 inch, in *Eudyptes chrysolophus* 1½ inches, in *Spheniscus magellanicus* 2 inches, in *Spheniscus demersus* 1¾ inches, in *Spheniscus mendiculus* 1½ inches, in *Spheniscus minor* ¾ of an inch, in *Pygosceles tæniatus* 1¾ inches, and in *Aptenodytes longirostris* 1⅔ inches in front of the point of bifurcation of that tube.

Remarks.—By Cuvier, Tiedemann, and Meckel, the sterno-tracheal muscle is described as being inserted into the thyroid cartilage. I regard that insertion as belonging to the contractor tracheæ rather than to the sterno-trachealis. At the same time, in as much as some of the fibres composing the sterno-trachealis are directly continuous with those of the contractor tracheæ, the former muscle may not improperly be described as being inserted into the thyroid cartilage, although its principal and direct insertion is undoubtedly, as above described, into the tube of the trachea.

3. *Contractor tracheæ.*

Broncho-trachealis, Owen, Anatomy of Vertebrates, vol. ii. p. 223.

Attachments.—The muscle so named by Macgillivray (History of British Birds, vol. ii. p. 25) *arises* from the posterior border of the inferior surface of the thyroid cartilage, and may be considered as a prolongation backwards of the thyro-hyoid muscle, with which it is almost continuous. From this origin it extends along the lateral border of the trachea, and terminates in a pointed extremity which is *inserted* into the lateral surface of that tube, ½ an inch in front of its bifurcation. As the muscle passes backwards its fibres are attached to each of the tracheal rings. Its posterior extremity extends beyond the insertion of the sterno-tracheal muscle, with which some of its fibres are continuous, and although it does not reach the syrinx, it evidently represents the single muscle (broncho-trachealis) with which, according to Cuvier (vol. iv. p. 473), that organ is provided in the genera *Falco*, *Larus*, *Phalacrocorax*, &c.

Action.—This muscle when contracting approximates the tracheal rings to one another and shortens the tube.

Relations.—The origin of this muscle is situated below (in front of) the insertion of the cleido-trachealis, and corresponds to the origin of the thyro-hyoid muscle. Between the muscles of opposite sides there is an interval free of muscle fibres, both on the superior and inferior surfaces of the trachea, in which the rings of the trachea are seen uncovered by muscle.

Nerve supply (?)

Variations.—(Pl. XIX.)—In *Eudyptes chrysocome* from Kerguelen, the two muscles of opposite sides are in contact along the upper surface of the trachea for the posterior half of that tube. There is thus no interval between the two as in *Eudyptes chrysocome* from Tristan d'Acunha. In *Eudyptes chrysocome* from the Falklands, the insertion of the contractores tracheæ is situated ¾ of an inch in front of the tracheal bifurcation.

In *Eudyptes chrysolophus*, in which the trachea is larger than in *Eudyptes chrysocome*, the contractor tracheæ is likewise inserted ¾ of an inch in front of the bifurcation. Consequently, the muscle in this species is relatively to the trachea longer than in *Eudyptes chrysocome*.

In *Spheniscus demersus*, *Spheniscus magellanicus*, and *Spheniscus minor*, the insertion of the contractores extends farther back than in *Eudyptes*, and reaches a point exactly opposite the tracheal bifurcation. In the two former, as in *Eudyptes chrysocome* from Kerguelen, the two muscles of opposite sides are in contact along the upper surface of the trachea for the posterior half of that tube. Such is not the case in *Spheniscus minor*. In *Spheniscus mendiculus* the insertion of the contractor falls short of the bifurcation by ½ an inch.

In *Pygoscelis tæniatus* the contractores are inserted ¾ of an inch in front of the bifurcation, and, as in *Spheniscus demersus* and *Spheniscus magellanicus*, the muscles of opposite sides are in contact along the upper surface of the trachea for the posterior three-fourths of the tube.

Lastly, in *Aptenodytes* (Pl. XVIII. figs. 8 and 9), the insertions of the contractores reach a point exactly opposite the bifurcation of the trachea. In this species the muscles are relatively more powerful than in any other, the two muscles being in contact both above and below the trachea, so that they form a muscular sheath which entirely envelopes the posterior two-thirds of that tube.

If now we compare the different genera in respect of the insertion of this muscle, it appears that *Aptenodytes* agrees with *Spheniscus* (with the exception of *Spheniscus mendiculus*), in as much as the contractores extend as far back as the tracheal bifurcation. *Pygoscelis*, on the other hand, agrees with *Eudyptes*, in as much as the insertion of the contractores is situated from ½ to ¾ of an inch in front of the bifurcation. *Spheniscus mendiculus* agrees with *Eudyptes* rather than with the other species of its own genus, but it is possible that the point of insertion of these muscles in the single specimen examined may not prove constant in other specimens of the same species.

Variations in respect of the Trachea and Bronchi.

The variations in respect of the trachea and bronchi in various species of Penguin from the arrangement above described in *Eudyptes chrysocome* from Tristan are referrible to three points. *Firstly*, the relation of the posterior extremities of the contractores tracheæ to the lower larynx; *secondly*, the number of rings, tracheal and bronchial, which participate in the formation of the syrinx; and *thirdly*, the extent of the septum tracheæ.

With regard to the first of these points, it will have been observed that, as shown above, in certain species, *e.g.*, the various species of *Eudyptes*, in *Pygoscelis*, and in *Spheniscus mendiculus*, the contractores tracheæ fall short of the tracheal bifurcation, while in others, such as *Aptenodytes* and the remaining species of *Spheniscus*, the contractores extend as far back as that point. In the former group, therefore, the lower larynx is altogether destitute of muscles, while in the latter it is provided with a single pair, to wit, the posterior extremities of the contractores. That a generic distinction cannot, however, be founded on this fact is shown by the occurrence in *Spheniscus mendi-*

culus of contractores which do not reach the syrinx, although undoubtedly on other grounds that species must be grouped along with others as members of the genus *Spheniscus*.

With regard to the second point—the number of rings forming the syrinx—it is necessary to state that I experienced considerable difficulty in determining the exact number of these in different species. This difficulty arose from the fact that in some genera, for instance *Eudyptes* and *Spheniscus*, the lower tracheal and upper bronchial rings are so closely welded together as to render it almost impossible to estimate the number of rings forming the syrinx, while in others, such as *Pygosceles* and *Aptenodytes*, the rings forming the syrinx are scarcely more closely approximated than those which enter into the formation of the trachea and bronchi, and are scarcely less moveable upon one another than these. Hence in the last-named genera it is difficult to determine where the syringeal rings terminate and the tracheal or bronchial rings proper begin. I have therefore been compelled to estimate the number of syringeal rings in these genera solely in accordance with the fact that certain of them in the region of the lower larynx are relatively less moveable upon one another than in the region either above or below, but do not profess to have estimated their number with absolute certainty. The succeeding table (pp. 211–213) gives the results of my observations, whatever their value may be.

In respect of the position of the interbronchial segment or pessulus of the last tracheal ring, I have noticed what I consider to be a generic characteristic. In the genus *Eudyptes* the position of the interbronchial segment of that ring nearly corresponds to, or in other words is parallel with, the long axis of the trachea, while in *Spheniscus* it forms an angle with the axis of that tube. In *Pygosceles*, again, the pessulus maintains an intermediate position between that of *Eudyptes* and of *Spheniscus*, while in *Aptenodytes* the interbronchial segment of the last ring of the trachea more closely resembles that of *Spheniscus* than of *Eudyptes*. It may farther be observed, that while in *Eudyptes* and *Spheniscus* all the tracheal rings are to a greater or less extent ossified, and form rigid structures, in *Aptenodytes* and *Pygosceles*, on the other hand, none of the tracheal or bronchial rings ever undergo ossification, and hence in these genera the windpipe is much more flattened and compressible than in the others above referred to.

With reference to the third point, the extent of the septum tracheæ, the table on pp. 211–213 shows *firstly*, that in the genus *Aptenodytes* the septum tracheæ relatively to the trachea is of larger size than in the other genera, with the exception of *Spheniscus*; *secondly*, that in *Pygosceles* the septum relatively to the trachea is of smaller size than in *Aptenodytes*; and *thirdly*, that *Eudyptes* as a genus possesses the smallest septum. The genus *Spheniscus* differs from the others, in as much as the species composing it vary to a greater extent, in so far as the tracheal septum is concerned, than do the species of other genera. In *Spheniscus demersus* the tracheal septum relatively to the trachea is of nearly the same magnitude as in *Aptenodytes*, in *Spheniscus mendiculus* the tracheal septum resembles that of *Pygosceles*, while in *Spheniscus minor* the complete absence of a septum tracheæ is paralleled by the case of one specimen of *Eudyptes chrysocome* from Tristan d'Acunha.

A reference to the table on pp. 211–213 shows, moreover, that the dimensions of the tracheal septum do not constitute a generic distinction, that they are not constant in different specimens of one and the same species, and that they are not in any way characteristic of sex.

Remarks.—So far as I can ascertain, the discovery of the presence of a tracheal septum in the Penguins is due to Jæger,[1] who in a paper in Meckel's Archives described the tracheal septum as it occurs in *Aptenodytes demersa*. In a footnote he likewise refers to the occurrence in *Procellaria* of a corresponding subdivision of the windpipe by means of a longitudinal septum, and observes that in that genus the septum is more limited than in *Aptenodytes*. Jæger's observations have since been copied into nearly every text-book of comparative anatomy, but I cannot find that they have been extended to other species. At least neither Reid,[2] in his communication on the anatomy of *Aptenodytes patachonica*, nor Garnot,[3] in his anatomical account of *Aptenodytes demersa*, refers to the peculiarity in question.[4]

Specimen.[5]	Length of trachea.	Number of tracheal rings.	Length of bronchus.	Number of bronchial rings.	Length of septum tracheæ from bifurcation of trachea.	Number of tracheal and bronchial rings forming the syrinx.
			Eudyptes chrysocome, from Tristan d'Acunha.			
No. 1 ♀	7	107	1	12	absent.	4
No. 2 ♂	...	...	...	...	$\frac{1}{8}$	...
			Eudyptes chrysocome, from the Falkland Islands.			
No. 1 ♂	8	...	...	...	2	...
No. 2 ♂	$7\frac{3}{4}$	110	$1\frac{1}{4}$	15	$1\frac{3}{4}$	5

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[1] Theilung der Luftröhre durch eine Scheidewand bei der Fettgans, *Aptenodytes demersa*, Meckel's Archiv für Anat. und Physiol., 1832, p. 48.

[2] Proc. Zool. Soc. Lond., 1835, p. 132.

[3] Anatomical account of *Aptenodytes demersa* in "Remarques sur la Zoologie des Îles Malouines," par M. P. Garnot in Annales des Sciences Naturelles, Zoologie, 1826, tom. vii. p. 53.

[4] Since this paragraph was written, Mr. W. Forbes has published his observations on the anatomy of the Petrels, and has pointed out in several of these birds the existence of a tracheal septum similar to that described above in the Penguins.—Challenger Reports, Zoology, vol. iv., p. 32.

[5] In this table the dimensions of the trachea, &c., are given in English inches.

Specimen.	Length of trachea.	Number of tracheal rings.	Length of bronchus.	Number of bronchial rings.	Length of septum tracheæ from bifurcation of trachea.	Number of tracheal and bronchial rings forming the syrinx.
		Eudyptes chrysocome, from Kerguelen.				
No. 1 ♀	6¼	101	1¼	15	3	5
No. 2 sex?	6	...	...	...	2¼	...
		Eudyptes chrysolophus.				
No. 1 ♂	9	112	1	10	1½	8
No. 2 ♀	...	...	...	...	1½	...
		Spheniscus demersus.				
No. 1 ♂	9	109	1½	14	8	6
No. 2 ♂	...	...	...	...	7	...
No. 3 ♂	9½	...	...	...	8½	...
		Spheniscus magellanicus.				
No. 1 ♂	10	117	1½	17	7¾	5
No. 2 ♂	9½	...	...	...	8¾	...
[1] No. 3 ♂	9½	...	...	...	9	...
		Spheniscus mendiculus.				
No. 1 ♂	9¼	110	1¼	13	6¾	5
No. 2 ♂	9	...	...	...	7½	...

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[1] For this specimen I am indebted to the kindness of P. L. Sclater, Esq., F.R.S.

Specimen.	Length of trachea.	Number of tracheal rings.	Length of bronchus.	Number of bronchial rings.	Length of septum tracheæ from bifurcation of trachea.	Number of tracheal and bronchial rings forming the syrinx.
			Spheniscus minor.			
No. 1 ♂	6	104	1½	15	absent.	7
			Pygoscelis tæniatus.			
No. 1 ♀	10½	84	2½	20	3¼	4
No. 2 ♂	10½	—	—	—	7	—
No. 3 ♀	—	—	—	—	7	—
No. 4 ♀	—	—	—	—	7	—
			Aptenodytes longirostris.			
No. 1 ♂	14½	125	2½	19	12	11
No. 2 ♀	13	—	—	—	10½	—
No. 3 sex?	—	—	—	—	11	—
No. 4 ♂	—	—	—	—	11	—

THE LUNGS.

The lung of *Eudyptes chrysocome* from Tristan (Pl. XII. fig. 6) is triangular in form. Its external surface is uniformly convex and smooth, with the exception of six fissures, which extend from the upper border of the organ obliquely backwards and downwards towards the inferior margin. These fissures correspond in position to the seven anterior vertebral ribs, which in the Penguins, as in other birds, indent the lung substance. The inner surface of the lung is slightly concave, and receives the vessels and nerves which constitute its root. These enter the lung midway between its apex and base, and occupy a similar position with reference to the superior and inferior borders of the organ. On this surface of the lung there are four separate apertures, by means of which certain of the air-cells, to be presently described, are supplied with air during the process of inspiration. Of these apertures, one is situated about half-an-inch in front of the point of entrance of the bronchus, a second is placed close to and in front of that tube, the third is situated behind the point of entrance of the bronchus, and the fourth is placed on the inferior border of the lung. By means of the first of these air is transmitted from the lung to the cervical, by means of the third to the inter-clavicular, and by means of the fourth to the hepatic air sac. The superior border of the lung is almost straight. It is thick and rounded, and is marked by six oblique fissures, which, as above observed, are likewise visible on the external surface of the organ, and indicate the position of the six anterior ribs. The inferior border is thin, sharp, and convex, from before backwards. It comes into relation with, and overlaps the lateral surface of the liver, heart, and pericardium. Behind it is continuous with, and forms an angle with the posterior margin of the lung, which rests against the anterior border of the kidney. About the middle of the posterior border of the lung there is a single oval aperture. By means of this, the fifth orifice, the largest or abdominal air sac is brought into communication with the bronchial tube, through which it is supplied with air. The apex or anterior extremity of the lung is pointed, and rests against the lower surface of the first rib.

The accompanying table shows the measurements of the lung of different species in inches:—

Species.	Length.	Greatest breadth.
Eudyptes chrysocome, from Tristan d'Acunha, . . .	4½	2
Eudyptes chrysocome, from the Falkland Islands, . . .	4	2
Eudyptes chrysocome, from Kerguelen, ...	4	2
Eudyptes chrysolophus, ...	5	2½
Spheniscus demersus, ...	5	2
Spheniscus magellanicus, ...	5	2
Spheniscus mendiculus, ...	3½	2
Spheniscus minor, ...	3	1½
Pygoscelis tæniatus, ...	6	2¾
Aptenodytes longirostris, ...	6½	3

Variations.—Except in respect of size, the lung of every species of Penguin agrees with that described above of *Eudyptes chrysocome*.

THE AIR SACS.

The air sacs in every species of Penguin which I have examined are nine in number. Of these four pairs are placed symmetrically on either side of the middle line, while the ninth is single and occupies the middle line of the body. The first four pairs, from their relations to neighbouring organs, may be named the hepatic, the pericardiac, the abdominal, and the cervical, while the ninth or azygos air cell may be termed the interclavicular.

The following description is drawn up from a special dissection of *Eudyptes chrysocome*, but apart from dimensions, is equally applicable to the other species examined :—

The first, or hepatic air sac, extends from the axilla, where it is bounded in front by the subclavian artery, backwards as far as midway between the last rib and the anus. On the outer side it is in contact with the ribs and intercostal muscles, while on the inner side it is bounded from before backwards by the heart and pericardium, by the outer side of the liver, and by the transversalis abdominis muscle. The wall of this sac is attached to the whole length of the thoracic surface of the sternum internal to the sternal notch. The sac itself is divided incompletely into two parts by means of a transversely-disposed septum. This septum is situated opposite the posterior border of the lung. The hepatic air sac derives its air directly from the lung, by means of an aperture which is situated on the inner surface of the lung, close to the inferior border of that organ behind the septum above described. The posterior extremity of this sac intervenes between the obliquus externus and transversalis abdominis muscles.

The second, or pericardiac sac, lies below the pericardium. It is bounded below by the anterior half of the thoracic surface of the sternum, and above by the heart and pericardium, while on the inner side it is in contact with its fellow of the opposite side. It does not communicate directly with the lung, but receives its air through the intervention of the hepatic sac, by means of an aperture which, in *Aptenodytes*, is of sufficient size to admit of the passage of two fingers.[1] This aperture of communication is situated directly above the external or costal process of the sternum. Thus the pericardiac sac only communicates indirectly with the bronchial tubes.

The third and largest of the air sacs is the abdominal. It extends from the posterior

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[1] According to Milne-Edwards (Leçons sur Physiologie et l'Anatomie Comparée, vol. ii. p. 353,) the pericardiac air sac (le réservoir diaphragmatique antérieur of that author) receives its air directly from the lung in the majority of birds. Such, so far as I could ascertain, is not the case in any species of Penguin. At the same time it is right to observe that in the majority of the birds dissected the means used in preserving the specimens occasioned considerable difficulty in the recognition of the various apertures of communication between the lungs and the air sacs. The existence of five distinct apertures in the lung of most of the species examined certainly leads to the conclusion that in the Penguins, as in other birds, each of the air sacs communicates with the lung by means of a separate aperture.

In the work quoted will be found a very complete list of authors who have directed their attention to the respiratory organs of birds. That list I do not think it necessary to repeat here.

border of the lung backwards along the superior abdominal wall, where it lies in relation with the ventral surface of the corresponding kidney as far as the cloaca. It is bounded below and internally by the hepatic lobe of the same side, by the mesentery, and by the coils of the intestine, while externally, it is in contact in front with the hepatic air sac, and behind with the transversalis abdominis muscle, which here intervenes between the hepatic and abdominal air sacs. This sac receives its air directly from the lung by means of an aperture which is situated on the posterior border of the lung.

The fourth or cervical sac is of an elongated oval form, and extends forwards to the root of the neck. It lies above and to the outer side of the inter-clavicular sac, with the posterior wall of which it is united. To its inner side are the trachea and œsophagus. Above it is bounded by the vertebral column, and below it is crossed from without inwards by the carotid artery. It extends from the cavity of the thorax forwards for 3 inches into the root of the neck. The cervical sac communicates directly with the lung by means of an aperture which is situated on the inner surface of the latter, half an inch in front of the point of entrance of the bronchial tube.

The fifth, or inter-clavicular air sac, differs from those above described in being single. It is situated between the limbs of the clavicle, and extends forwards to the root of the neck and backwards to the cavity of the thorax. It is bounded below by the clavicle and by the inner surface of the strong coraco-clavicular membrane, to which it is closely adherent. Opposite the bases of the coracoid bones, the inter-clavicular sac divides into two parts, which are symmetrically disposed on either side of the middle line. Each of them extends as far back as the incomplete septum which is met with in the interior of the hepatic air sac. Externally the inter-clavicular sac reaches the axilla in front, and comes into contact with the hepatic sac behind. Above it touches the trachea, œsophagus, and carotid arteries, while below and in front it is bounded by the great skin muscle of the neck, and behind by the thoracic surface of the sternum. This sac communicates directly with the lung by means of an aperture situated on the inner surface of the latter, behind the point of entrance of the bronchial tube. It therefore receives its air directly from the intra-pulmonic bronchial tubes.

As is well known,[1] the bones of the Penguins do not admit of the passage of air into their interior, as do those of the majority of birds.

URINARY ORGANS.

The kidneys of *Eudyptes chrysocome* from Tristan d'Acunha (Pl. XVII. figs. 7, 8) occupy the usual position, being wedged into the hollowed irregular surface of the lower aspect of the lumbo-sacral portion of the vertebral column. In the male, the testicle of either side is

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[1] Jaquemin, Nova Acta Acad. Nat. Curios, tom. xix. p. 318; and Owen, Art. "Aves," Cyclopædia of Anatomy and Physiology, tom. i. p. 343

situated in front of the upper extremity of the corresponding kidney, while in the female the unilateral ovary lies in front of the upper end of the left kidney. Each kidney is divided into two lobes by means of an oblique fissure, which passes from the outer margin of the organ obliquely forwards and inwards. In this respect all the Penguins differ from the majority of birds, in which the kidney is divided into three lobes. Of the two lobes, the anterior is the larger and more expanded, while the posterior is narrow and elongated. The two kidneys together, therefore, present a form somewhat resembling that of a violin. The upper surface of each is convex and irregular, and corresponds with the lower surface of the vertebral column, against which it rests. The lower surface, on the other hand, is nearly flat and uniformly smooth. Each kidney measures 2½ inches in length and ¾ of an inch in greatest breadth. Its posterior lobe has an average breadth of ½ an inch.

The ureter commences close to the anterior border of the kidney, and passes backwards, being at times visible on the lower surface of the organ, at times embedded in the renal substance. Having escaped from the posterior extremity of the kidney, it passes backwards, lying in contact with the superior abdominal wall, and terminates on the summit of a nipple-shaped papilla, situated on the upper wall of the posterior compartment of the cloaca. In its course between the kidney and cloaca, the ureter lies along the inner side of the corresponding genital duct. At their entrance into the cloaca, the orifices of the ureters lie internal to and separate those of the ducts of the reproductive glands. The ureter, from the posterior border of the kidney to its entrance into the cloaca, measures 1¾ inches in length.

Variations in respect of the Kidney.

The only exception to the description above given of the kidney occurs in the case of *Spheniscus minor*. In that species I found the posterior lobes of opposite kidneys completely fused along their inner margins, so that here the two kidneys formed a single continuous mass of renal tissue. The anterior lobes, on the other hand, are quite distinct as in other species. In *Spheniscus minor*, moreover, the posterior extremity of each kidney displays an emarginate notch, from which the ureter passes off. This notch is seen in no other species which I have examined. In all the other birds which I examined the kidney differs from that of *Eudyptes chrysocome* only in size.

The subjoined table shows in inches the dimensions of the kidney and ureter in the various species examined.

TABLE SHOWING THE SIZE OF THE RENAL ORGANS IN VARIOUS SPECIES OF PENGUIN IN INCHES.

Species.	Length of kidney.	Greatest breadth of kidney.	Length of ureter.
Eudyptes chrysocome, from Tristan d'Acunha,	2½	¾	1¾
Eudyptes chrysocome, from the Falkland Islands,	2½	¾	1¾
Eudyptes chrysocome, from Kerguelen,	3	1	2¼
Eudyptes chrysolophus,	3¾	1¼	4
Spheniscus demersus,	3½	1¼	3
Spheniscus magellanicus,	3½	1¾	4
Spheniscus mendiculus,	3	¾	2
Spheniscus minor,	2½	¾	1½
Pygoscelis tæniatus,	4½	1½	3½
Aptenodytes longirostris,	4	1½	5

GENERATIVE ORGANS.

MALE ORGANS.

The Testicles (Pl. XVII. fig. 7) in every species of Penguin are arranged as in other birds. Each is situated on the under surface and close to the anterior border of the corresponding kidney. In *Eudyptes chrysocome* each measures ½ an inch in length and ¼ of an inch in breadth. The testicle is of a dark purple colour, elongated oval in form, and somewhat laterally compressed. The vas deferens comes off from the posterior border of the testicle and passes horizontally backwards, lying at first in contact with the lower surface of the kidney, and afterwards with the superior abdominal wall. As it passes backwards, the vas deferens lies along the outer side of the corresponding ureter, and terminates by opening upon the upper wall of the posterior compartment of the cloaca. The cloacal orifice of each vas is situated on the extremity of a nipple-shaped projection of somewhat smaller size and situated to the inner side of that on which the ureter opens.

Variations.—The male generative organs do not present any variations from the arrangement above described in *Eudyptes chrysocome*. It may be of interest to state that in nearly every specimen examined the testicle of the left side was considerably larger than that of the right, which suggests the question whether there may not be a tendency on the part of the male gland of the right side to undergo a process of atrophy similar in character to that undergone by the homologous female gland of the same side.

FEMALE ORGANS.

The Ovary (Pl. XVII. fig. 8).—As is the case in the majority of birds, the right ovary in the Penguins is entirely absent. That on the left side, on the other hand, is well developed. In *Eudyptes chrysocome* it measures 1 inch in length, and ½ an inch in greatest breadth. It lies in contact with the lower surface of the left kidney, and to some extent overlaps the anterior margin of that organ. The ovary in its immature condition consists of a mass of capsules, which vary in size from that of a pin-head to that of a small garden pea. In the ovary of one specimen of *Eudyptes chrysocome* I counted 120 of these capsules. The ovary is covered on its lower surface by a layer of peritoneum, and lies in contact with the dilated extremity of the left oviduct.

The Oviduct of the right side, like the corresponding ovary, is functionally useless. In several species of Penguin, however, I was able to corroborate the observation of Stannius,[1] that in the Penguins, as in certain other birds, a portion at least of the right oviduct persists throughout life.

The extent to which atrophy takes place appears to vary in different species. In *Eudyptes chrysocome* I failed to distinguish the slightest trace of the right oviduct, while in *Eudyptes chrysolophus* that structure was represented by a fibrous cord, which extended from the cloaca forwards, as far as the posterior border of the kidney. In *Aptenodytes longirostris*, again, the right oviduct was represented by a slender fibrous cord, which was traceable from the cloaca to midway between the cloaca and the posterior border of the kidney. It would appear, therefore, that in the Penguins, as in other birds, the oviduct of the right side, although present in a fully-developed condition in the embryo, becomes gradually atrophied, and that this atrophy takes place from before backwards. This opinion is confirmed by the fact that in the female of every species of Penguin the place of entrance of the right oviduct into the cloaca is represented by a well-defined but small nipple-shaped papilla, which occupies a position in the cloaca similar to that occupied in the male by the vas deferens of the same side.

The left, or functionally active oviduct (Pl. XVII. fig. 8), lies in contact with the lower surface of the left kidney, to which, as well as to the superior abdominal wall, it is attached by means of a double fold of peritoneum. In the mesentery I failed to find any trace of muscular fibres.[2] In addition to this membranous fold, the anterior extremity of the oviduct is connected by means of a fibrous band or ligament to the connective tissue covering the base of the left lung. According to Owen,[3] this ligament in the common fowl takes an attachment to the penultimate rib. Such is not the case in any species of Penguin, in every one of which it blends with the fibrous tissue surrounding the

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[1] Stannius, quoted by Milne-Edwards, Leçons sur la Physiologie Comparée, vol. viii. p. 512.

[2] According to Owen (Cyclopædia of Anatomy, vol. i. p. 357), the mesentery of the common fowl is muscular in character.

[3] *Loc. cit.*, p. 357.

base of the lung. The peritoneal fold or mesentery is shorter than the oviduct itself, and consequently the latter is thrown into a number of sinuous curves, as represented in Pl. XVII. fig. 8. The duct commences close to the ovary by a dilated funnel-shaped extremity, which opens freely into the cavity of the peritoneum. In *Eudyptes chrysocome* the oviduct measures 6 inches in length. From its abdominal opening the tube, as it passes backwards, narrows rapidly to a constriction, which is situated 1½ inches behind its commencement. Behind this constriction, again, the tube to some extent dilates, and continues of uniform diameter to within 2 inches of its cloacal orifice, between which and the latter it is again somewhat expanded. The cloacal orifice is situated on the upper wall of the posterior cloacal chamber, and occupies a corresponding position to that of the left vas deferens in the male. Unlike the corresponding orifice in the male, however, the left oviduct does not open on a papilliform eminence, but directly into the cloaca, the orifice being undefended by any valve. The entire length of the oviduct is lined by a soft mucous membrane, which is thrown into longitudinal rugæ, and presents no trace of the villous processes observed by Owen[1] in this portion of the oviduct of the common fowl.

Variations.—The female organs in every species of Penguin exactly resemble those of *Eudyptes chrysocome* above described, and differ only in size. Further remark is therefore unnecessary.

PECULIAR GLANDS.

The Coccygeal Gland.

The coccygeal gland (Pl. X. fig. 5) is situated immediately beneath the skin of the rump, and rests in part upon the levatores coccygis muscles, and in part upon the quills of the large feathers of the tail. The gland consists of two lateral halves, each of which presents the form of an elongated pear-shaped sack, the base of which is directed forwards, the apex backwards. These two portions of the gland are closely united to one another for the posterior two-thirds of their length, their posterior extremities terminating on a large, conical, cutaneous papilla, which in *Eudyptes chrysocome* measures ¼ of an inch in length. On the apex of this papilla are placed the orifices of the two[2] ducts which convey the secretion of the gland to the surface of the skin. On making a section of the gland, each half is seen to be surrounded by a dense fibrous capsule, in the interior of which is placed the true secreting structure. This again consists of two parts, a dense circumferential, and a more centrally placed lax and spongy tissue. The secretion is apparently prepared in the circumferential, whence it passes into the central portion of the gland, which is composed of a quantity of loosely arranged trabecular tissue, surrounding a central canal. With the latter the duct

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[1] Cyclopædia of Anatomy, vol. i. p. 357.

[2] According to Owen, this papilla is "perforated by numerous orifices," Anatomy of Vertebrates, vol. ii. p. 230. In every species of Penguin there is but a pair of such orifices.

of the gland is continuous. It passes backwards to open on the surface of the cutaneous papilla, as above described.

In certain species of Penguin, but not in all, a distinct muscular slip, derived from the levator coccygis muscle, passes backwards, to be inserted into the base of each half of the coccygeal gland. This slip I have observed in *Eudyptes chrysolophus*, *Spheniscus magellanicus*, and *Pygosceles tæniatus*. The function of this slip, when present, is by no means apparent, as it can hardly act as a compressor of the gland.

Except in size, the coccygeal gland of different species presents no deviations from that above described in *Eudyptes chrysocome*.

Thyroid Gland.

The thyroid gland (Pl. XI. fig. 1) in every species of Penguin occupies the position common to all birds. In *Eudyptes chrysocome* it is rather smaller than a garden pea, and lies in contact with the inner side of the common carotid artery, half an inch from the origin of that vessel. In *Pygosceles* and in *Spheniscus demersus* it is situated 1 inch from the point of bifurcation of the innominate artery.

In every species of Penguin, with the exception of *Aptenodytes longirostris*, in which it consists of two distinct lobes, this gland resembles that of *Eudyptes chrysocome*.

ON THE SUBDIVISION OF THE SPHENISCIDÆ.

A reference to the foregoing description of the anatomy of the Penguins at once convinces us that these birds together form a natural group, every member of which is possessed of certain anatomical peculiarities which serve at once to associate it with its fellows, and to separate it from the members of other groups which more or less closely resemble the Spheniscidæ. To collect together the various distinctive features of the different anatomical systems of the Penguins, and to contrast them with those of other birds would be to repeat the summaries which are placed at the end of each of the foregoing sections, and is therefore unnecessary. Suffice it here to direct attention to the very remarkable uniformity of anatomical detail which prevails in respect of the muscular, nervous, blood-vascular, and urino-genital systems of every species of Penguin. It is true that, with regard to these systems, individual peculiarities manifest themselves in different species, but these are unimportant and of but little value in attempting to arrive at a natural subdivision of the group into genera and species. When, however, we proceed to the consideration of the osseous, digestive, and respiratory organs of these birds, we find that the individual peculiarities are so pronounced that, taking them into consideration, we experience no difficulty in associating together a greater or lesser number of species to form genera, every member of each of which agrees with its fellows in certain important particulars, at the same time that they differ from the members of every other genus.

The various species of Penguins which I have had an opportunity of examining have been arranged by ornithologists, relying on the consideration of skins and feathers, into five genera, namely—*Aptenodytes*, *Pygosceles*, *Spheniscus*, *Eudyptes*, and *Eudyptila*. Such are the genera to be found in Gray's hand-list of the genera and species of birds, and, with the exception of *Eudyptila*, in Sclater's Report on the Birds collected by the Challenger.[1] The examination of the complete anatomy of these birds appears to me, so far as the species examined are concerned, to lead to the conclusion that they ought all to be included within the limits of three genera,[2] to wit,—*Aptenodyptes*, *Spheniscus*, and *Eudyptes*.

In accordance with this view, the genus *Aptenodytes* would include the two species *longirostris* and *tæniatus*. The anatomy of these two birds, although presenting specific differences, does not, as it seems to me, justify their separation as types of *two* distinct genera, seeing that in every anatomical point which can be considered of generic value *Pygosceles* and *Aptenodytes* entirely agree. This much may certainly be said without fear of contradiction, that in respect of their anatomy *Pygosceles* and *Aptenodytes* differ less from one another than do undoubtedly distinct species of either the genus *Eudyptes* or *Spheniscus*. In all essential points of their anatomy, moreover, these two birds differ similarly from that of the members of other genera.

The distinctive features of the genus *Aptenodytes* are to be found in the large size of the birds composing it, forming as they do the largest members of the entire group of Spheniscidæ; in the greatly elongated form and the corresponding slenderness of the bones which enter into the formation of the upper and lower jaws; in the persistence throughout life of the inter-maxillary suture; in the elongation of the anterior narial apertures, and the relation which these bear to the lachrymo-nasal fossæ; in the narrowness of the supra-orbital grooves; in the small development of the transverse temporal crest; in the small size and vertical direction of the post-orbital processes; in the large size of the scapula; in the absence of a complete coracoidal foramen for the transmission of the nerve to the middle pectoral muscle; in the elongated form of the pelvis; in the parallelism of the conjoined metatarsal bones; in the elongation and papillate structure of the tongue and palate; in the form of the proventricular gland, which may present the form either of a triangular patch as in *Aptenodytes longirostris*, or of a complete belt as in *Aptenodytes tæniatus*; in the length of the small intestine, which varies from six

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[1] Challenger Reports, Zoology, vol. ii.

[2] Since writing the above, I have been able to consult Coue's paper on "Material for a Monograph of the Spheniscidæ," in Proc. Acad. Nat. Science Philad., 1872, p. 164, and am pleased to observe that, relying on an examination of the skulls of different species of Spheniscidæ, that author had previously arrived at the same conclusion as I have with regard to the subdivision of the group into three genera. In this conclusion we are supported by the high authority of Professor Huxley, in his Essay on the Classification of Birds, Proc. Zool. Soc., 1867, p. 458.

times the length of the vertebral column as in *Aptenodytes tæniatus*, to eight or ten times that length in *Aptenodytes longirostris;* in the absence of any differentiation of the syringeal from the adjoining tracheal rings; in the mobility of the syringeal rings upon one another; in the cartilaginous condition of the syringeal rings; in the amount of displacement downwards of the vibrating membrane of the syrinx beyond the point of bifurcation of the trachea; and in the presence of a tracheal septum, which varies in length from one-half in *Aptenodytes tæniatus* to three-fourths of that of the trachea in *Aptenodytes longirostris*.

If now we enquire whether any one of the characters above enumerated can, *per se*, be regarded as distinctive of the genus *Aptenodytes*, as compared with other genera, I reply that there are three which may be so regarded. These three generic characteristics are to be found—*firstly*, in the form of the skull as a whole; *secondly*, in the absence of a complete coracoidal foramen; and *thirdly*, in the form and structure of the syrinx. Given any one of the parts to which these remarks refer, and the identification of the Penguin possessed thereof as a member of the genus *Aptenodytes* may at once be accepted as proved.

In the possession of every one of the above-mentioned characteristics, the two species *Aptenodytes longirostris* and *Aptenodytes tæniatus* agree. At the same time the anatomical investigation of these two birds shows that in their anatomy, as in their external configuration, each is possessed of individual peculiarities which at once justifies us in considering them to be distinct species, but species which belong to one and the same genus.

Turning now to the consideration of the characteristics of the genus *Eudyptes*, we find that these are to be found in the oval form of the upper jaw, which is widest transversely about the middle of its length, and tapers forwards and backwards; in the relative tenuity of the central bar of the upper jaw, which does not fill up the interval between the lateral bars; in the elongated form of the anterior narial apertures, and the relation which their posterior extremities bear to the lachrymo-nasal fossæ; in the stoutness and lozenge-like form of the rami of the lower jaw bone; in the great breadth of the supra-orbital grooves, due to the presence of a supra-orbital ledge of bone which does not exist in *Aptenodytes*, and is developed to a much less extent in *Spheniscus;* in the moderate development of the transverse temporal crest, which is more pronounced in *Spheniscus* but scarcely exists in *Aptenodytes;* in the coalescence of the upper end of that crest with the cerebral portion of the cranium, and not with the cerebellar as in *Spheniscus;* in the vertical direction and intermediate size of the post-orbital process, as compared with that of *Spheniscus* and of *Aptenodytes;* in the strongly-pronounced curvature of the zygomatic arch; in the form of the scapula; in the presence of a complete coracoidal foramen; in the divergence of the lower end of the second from that of the third metatarsal bone; in the relatively greater breadth and shortness of the tongue, as compared with that of *Spheniscus* or of *Aptenodytes;* in the triangular or crescentic form of the proventricular gland; in the length of the small intestine, which varies from nine to eighteen times that of the vertebral column; in the fusion of a certain number of tracheal rings, which are always ossified, to form the framework of the lower larynx; in the parallelism of the pessulus of the last tracheal ring with the long axis of the trachea; in the close approximation of the vibrating membrane of the syrinx to the point of bifurcation of the trachea; and in the presence of a tracheal septum, which never exceeds in length one-half of that of the trachea, and usually falls considerably short of it.

If now it be asked whether any of the generic features of *Eudyptes* above enumerated are of themselves sufficient to distinguish the members of that genus from those which constitute the genus *Aptenodytes* on the one hand, or the genus *Spheniscus* on the other, the question may at once be answered in the affirmative. Two of the characters above enumerated are quite distinctive. *Firstly,* the form of the skull as a whole, and more particularly the small development of the transverse temporal crest, together with the lozenge-like form of the rami of the lower jaw bone, at once distinguish *Eudyptes* from *Spheniscus,* while the relative shortness of the upper and lower mandibles similarly distinguish *Eudyptes* from *Aptenodytes.* *Secondly,* the parallelism of the pessulus of the last tracheal ring with the long axis of the trachea at once distinguishes *Eudyptes* from *Spheniscus,* while the ossification of the rings which compose the framework of the syrinx, and their immobility upon one another, strikingly contrast with the cartilaginous nature and mobility of the syringeal rings upon one another in *Aptenodytes.*

Coming now to the consideration of the species which compose the genus *Eudyptes,* the question arises, How many of the birds which I have had an opportunity of examining constitute clearly defined species?

I am aware that even ornithologists are not now disposed to admit that the three varieties of *Eudyptes chrysocome* which inhabit Tristan d'Acunha, the Falkland Isles, and Kerguelen Island, ought to be elevated to the rank of distinct species. Mr. Sclater, the most recent writer on the subject, in his monograph on the birds obtained by the Challenger expedition,[1] groups these three varieties together, with the remark that "on comparison of the series from these three localities, we cannot satisfactorily recognise more than one species of Rock-hopper. The bird from Inaccessible Island has the elongated superciliary plumes more produced; those of the Falklands and Kerguelen have them rather shorter." In this conclusion I agree with Mr. Sclater, who, basing his conclusions upon an examination of skins, has arrived at the same conclusion as I have after an exhaustive anatomical examination of one and all of these varieties. I am strongly of opinion, however, that these three birds constitute well-marked varieties of the same species.

A reference to the preceding pages shows that in *Eudyptes chrysocome* from Tristan

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[1] Challenger Reports, Zoology, vol. ii. p. 129.

d'Acunha, the small intestine varies in length from nine to ten times, in *Eudyptes chrysocome* from the Falklands, from twelve to thirteen times, and in *Eudyptes chrysocome* from Kerguelen, from seventeen to eighteen times the length of the vertebral column. Moreover, in *Eudyptes chrysocome* from Tristan, the tracheal septum is relatively shorter than in *Eudyptes chrysocome* from the Falklands, while in *Eudyptes chrysocome* from Kerguelen it is, relatively to the trachea, longer than in either of the other varieties. Lastly, if we compare the skulls of these varieties, we find a difference in their size but not in their form. *Eudyptes chrysocome* from Kerguelen has a smaller skull than *Eudyptes chrysocome* from Tristan, and the skull of the latter is in turn exceeded in size by that of *Eudyptes chrysocome* from the Falklands.

Taking these facts into consideration, I am of opinion that while these birds must be included as members of one and the same species, they form well-marked varieties of that species. In this opinion, at least so far as *Eudyptes chrysocome* from Tristan is concerned, I am supported by the authority of Mr. Murray,[1] who observes that "all the birds on this Tristan group had the yellow superciliary plumes considerably longer than that of those got at Kerguelen and the Falklands. They also all seemed to me rather bigger birds. The Tristan birds are, I think, a well-marked variety."

The second so-called species of the genus *Eudyptes* which we have to consider is *Eudyptes chrysolophus*. This bird was recognised for the first time as a distinct species by Brandt,[2] who named it *Catarractes chrysolophus*. Since his time the majority of ornithologists, including Hyatt,[3] Coues,[4] and Sclater,[5] have accepted Brandt's conclusion that it is really specifically distinct from *Eudyptes chrysocome*. Mr. Sclater, the most recent writer on the subject, observes:[6] "Forster evidently had both the 'Rock-hopper' and 'Macaroni' Penguins under his eyes when he described his *Aptenodytes chrysocome*. Brandt first clearly separated the two species, which are quite distinct and easily recognised by the characters which he has given."

Such being the opinion of ornithologists, it may appear presumptuous on my part to throw doubt on the correctness of the conclusions at which they have arrived. An examination, however, of the anatomy of *Eudyptes chrysolophus*, and a comparison of it with that of *Eudyptes chrysocome*, compels me to entertain doubts as to whether these two ought to be regarded as perfectly distinct species. A consideration of the exterior alone of *Eudyptes chrysolophus* undoubtedly leads at once to the conclusion that Brandt was justified in regarding it as distinct from *Eudyptes chrysocome*. Not only does it differ from *Eudyptes chrysocome*, as pointed out by Brandt and Sclater, in the colour and

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[1] Challenger Reports, Zoology, part viii. p. 131.

[2] Bull. Acad. St. Petersburg, ii. p. 315.

[3] Proc. Boston Sci. of Nat. Hist., 1871, p. 250.

[4] Proc. Acad. Nat. Sci. Philad., 1872, p. 204.

[5] Challenger Reports, Zoology, part viii. p. 127.

[6] *Ibid*, part viii. p. 137.

arrangement of the feathers surrounding the head, but *Eudyptes chrysolophus* is altogether a larger and heavier bird than *Eudyptes chrysocome*. Moreover, an examination of the skeleton of *Eudyptes chrysolophus* shows that its vertebral column as a whole is not only about 2 inches longer than that of *Eudyptes chrysocome*, but that every bone both of the trunk and limbs is larger and stouter than the corresponding bones of *Eudyptes chrysocome*. A consideration of these points by themselves would at once have led me to agree with the authors mentioned, and to have concluded that *Eudyptes chrysolophus* was specifically distinct from *Eudyptes chrysocome*.

On the other hand, a comparison of the internal anatomy of the two birds shows that in every essential point that of *Eudyptes chrysolophus* agrees with that of *Eudyptes chrysocome*, and we look in vain for any anatomical feature in respect of the osseous, digestive, or respiratory organs which will enable us to decide definitely that any portion of these organs belongs to the one rather than to the other of these so-called species. The stomach in both presents a proventricular gland of the same form; in both the small intestine varies in length from twelve to thirteen times the length of the vertebral column; in both the length of the septum tracheæ relatively to that of the trachea itself is the same; and in both the structure and relations of the syrinx are similar. The bones of *Eudyptes chrysolophus*, as I have said, are larger than those of *Eudyptes chrysocome*, and the bulk of the whole bird exceeds that of *Eudyptes chrysocome* by one-eighth, and if we place the skulls of *Eudyptes chrysolophus* alongside of that of *Eudyptes chrysocome*, the large size of the skull of the former is strikingly apparent. At the same time, I failed to distinguish any specific character in the skull, apart from mere size, which would serve to distinguish the one from the other. Lastly, I have observed, when comparing the skulls of the three varieties of *Eudyptes chrysocome* with that of *Eudyptes chrysolophus*, that in respect of size there is a remarkable gradation from the smallest skull of *Eudyptes chrysocome*, through the larger skulls of the same species, to that of *Eudyptes chrysolophus*. The skull of *Eudyptes chrysocome* from Kerguelen is the smallest, and is exceeded slightly in size by that of *Eudyptes chrysocome* from Tristan, while the skull of *Eudyptes chrysocome* from the Falklands is the larger of the three. When the skull of *Eudyptes chrysolophus* is placed alongside that of the latter, although the disproportion in size is rather greater than that which obtains between the skulls of any of the three varieties of *Eudyptes chrysocome*, yet the skull of *Eudyptes chrysolophus* presents no more specific distinctive feature which would serve to distinguish it from the largest skull of *Eudyptes chrysocome* than is possessed by the largest skull of *Eudyptes chrysocome*, as compared with the smallest skull of the same species.

To sum up. I believe that if difference in size and colour of a few feathers of the head, combined with larger size of one of the birds as a whole, justifies us in asserting specific distinction between two birds, then, undoubtedly, *Eudyptes chrysolophus* is specifically distinct from *Eudyptes chrysocome*. On the other hand, the striking similarity of the entire anatomy of *Eudyptes chrysolophus*, as compared with that of *Eudyptes chrysocome*, leads me to the conclusion that in the former we are dealing with one of those extreme and exceptional varieties between which and distinct species it is almost impossible to draw a hard and fast line of demarcation. The most reliable test of distinct species is to be found in the fertility of the offspring derived from the union of two parents. But at present we, unfortunately, have no information as to whether *Eudyptes chrysocome* and *Eudyptes chrysolophus* interbreed with one another so as to produce fertile offspring. The facts, however, related by Murray[1] and Moseley[2] with regard to these birds show that while in some localities these two birds have distinct rookeries, at others their nests are intermixed, and thus afford facilities for intermarriage. I am, therefore, inclined to regard *Eudyptes chrysolophus* as the most aberrant variety of *Eudyptes chrysocome*, and one which is apparently about to cross the boundary line and to become a distinct species.

Coming now to the consideration of the genus *Spheniscus*, we find that the generic characteristics of this group are to be found in the form of the skull as a whole, in the great development of the transverse temporal crest, and in the coalescence of its upper end with the cerebellar portion of the skull, all of which features serve to distinguish the skull of *Spheniscus* on the one hand from that of *Aptenodytes* on the other; in the presence of a deep fossa on the lateral surface of the skull, which fossa is bounded posteriorly by the transverse temporal crest; in the relatively great breadth of the central as compared with that of the lateral bars of the upper jaw; in the fact that the central bar completely fills up the interval between the lateral bars; in the small size of the anterior narial apertures, and in the transference of their posterior extremities to a point altogether in front of the lachrymo-nasal fossæ;[3] in the breadth of the supra-orbital grooves, which are broader than in *Aptenodytes*, but narrower than in *Eudyptes*; in the great size and backward obliquity of the post-orbital processes; in the relatively slight curvature of the zygomatic arch, which at once distinguishes the skull of *Spheniscus* both from that of *Eudyptes* and of *Aptenodytes*; in the form of the rami of the lower jaw bone, which are more slender than in *Eudyptes* but less so than in *Aptenodytes*; in the form of the scapula; in the presence of a complete coracoidal foramen, in which respect *Spheniscus* agrees with *Eudyptes* but differs from *Aptenodytes*; in the relatively greater length of the metatarsus, which at once distinguishes *Spheniscus* from both the other genera; in the more complete separation of the individual metatarsal bones from one another than in either of the other genera; in the form of the tongue, which is intermediate in form between that of *Aptenodytes* and of *Eudyptes*; in the form of the proventricular gland, which may be either crescentic in

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[1] Challenger Report, Zoology, part viii. p. 128.

[2] Challenger Report, Zoology, part viii. p. 127.

[3] *Eudyptes minor* forms an exception to this arrangement.

form, as in *Spheniscus demersus* and *Spheniscus mendiculus*, or zonular, as in *Spheniscus magellanicus* and *Spheniscus minor*; in the length of the small intestine, which varies in length from seven times that of the vertebral column in *Spheniscus minor*, to nineteen times in *Spheniscus magellanicus*; in the ossification of the syringeal rings, and their immobility upon one another; in the obliquity of the pessulus with reference to the long axis of the trachea; and in the presence of a tracheal septum which may nearly equal the length of the trachea as in *Spheniscus magellanicus*, or may be entirely absent as in *Spheniscus minor*.

If now we consider the different species of the genus *Spheniscus* which I have had an opportunity of examining, it appears that ornithologists hold different views with regard to the specific distinctness of *Spheniscus magellanicus* as compared with *Spheniscus demersus*. On the one hand, Sclater[1] and others regard these two as perfectly distinct species, while, on the other hand, Coues[2] is of opinion that *Spheniscus magellanicus* is "simply a collared variety of *Spheniscus demersus*."

A careful examination of the entire anatomy of several specimens of each of these birds leads me to the conclusion that the view of the last-named author is the correct one, and that these two birds are simply varieties of one and the same species. The skulls of both (Pl. II. figs. 1–8) are in every respect similar, and the same remark holds good of every bone in the skeleton of each, with this exception, that the bones of *Spheniscus magellanicus* are slightly larger than those of *Spheniscus demersus*. It is true, as observed by Hyatt,[3] that "*Spheniscus magellanicus* is much the larger bird" of the two, but in view of the difference in size already noticed of different varieties of *Eudyptes chrysocome*, this feature of itself must be deemed of but little value in attempting to decide as to the specific distinctness of different birds. More reliable conclusions may be founded on the consideration of their entire anatomy. With regard to this I found that in two specimens of *Spheniscus demersus*, the proventricular gland presented the form of a crescentic or triangular patch, which was limited to the left wall of the stomach. In every specimen of *Spheniscus magellanicus*, again, which I dissected, the proventricular gland presented the form of a complete belt, which completely surrounded the gastric cavity. This difference would apparently justify us in concluding that these two birds are specifically distinct. On the other hand, it is to be noted that in a third specimen of *Spheniscus demersus* the proventricular gland was zonular in character, and although the separate glandules composing the belt were more sparsely distributed on the right than on the left wall of the stomach, yet at no point were these glandules entirely absent, as was the case on the right wall of the stomach in both the other specimens which I examined. In this third specimen of *Spheniscus demersus*, therefore, there was a manifest

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[1] Challenger Reports, Zoology, part viii. p. 125.

[2] Proc. Acad. Nat. Sci. Philad., 1872, p. 173.

[3] Proc. Boston Soc. Nat. Hist., vol. xiv. p. 249.

tendency to the formation of a glandular zone, similar in form to that of *Spheniscus magellanicus.* In *Spheniscus magellanicus,* moreover, the separate glandules are more distinctly isolated and more sparsely distributed on the right than on the left wall of the stomach, and do not form a uniform belt, as they do, for instance, in *Pygosceles.* I find therefore that, so far as the separation of *Spheniscus magellanicus* as a distinct species from *Spheniscus demersus* is concerned, the form of the proventricular gland does not afford a specific characteristic, seeing that these two so-called species insensibly shade into one another, and that while in one bird the glandular patch may be crescentic, in another it is zonular in form. That these remarks regarding the variability in form of the proventricular gland are applicable to species of genera other than *Spheniscus,* is shown by the fact that while in three specimens of *Aptenodytes longirostris* the gland patch was triangular in form, in the fourth it was completely zonular.

Turning now to the length of the small intestine in *Spheniscus demersus* and *Spheniscus magellanicus,* we find that in two specimens of *Spheniscus demersus* the small intestine measures 24 feet 6 inches, and 20 feet 8 inches respectively, while in *Spheniscus magellanicus* it measured in two specimens 30 feet 6 inches and 27 feet 5 inches respectively. In the latter, therefore, the length of the gut relatively to that of the vertebral column is greater than in the former, but the difference between these birds in this respect is not greater than that which obtains between undoubted varieties of other species, for example, between the different varieties of *Eudyptes chrysocome.* The examination, again, of the trachea of each of these birds shows that they are not specifically distinct. In *Spheniscus demersus* the septum tracheæ is relatively longer than in *Spheniscus magellanicus,* but the difference in length relatively to the trachea is much less pronounced in these two forms of *Spheniscus* than in different varieties of *Eudyptes chrysocome.* Nay more, the difference in length of the tracheal septum of *Spheniscus demersus,* as compared with that of *Spheniscus magellanicus,* is less than obtains between different individuals of even the same variety of *Eudyptes chrysocome.*

Taking these various facts into consideration, I am compelled to conclude that inasmuch as we look in vain for any distinctive features which are of specific value in the anatomy of these two birds, *Spheniscus magellanicus* and *Spheniscus demersus* must, in accordance with the opinion of Coues, be regarded simply as two varieties of one and the same species, for which the title of *Spheniscus demersus* should be retained. I would, moreover, add that these two varieties of *Spheniscus demersus* seem to me to be much more nearly related to one another than are the different varieties of *Eudyptes chrysocome.*

I have unfortunately had no opportunity of examining a recent specimen of the so-called *Spheniscus humboldti.*[1] This was first described as a distinct species by Meyen,[1] since which time it has been examined by Coues,[2] who considers it to be identical with

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[1] Nova Acta Acad. Cæs-Leo-Car., xvi. supp. i. 110, pl. xxi.

[2] Proc. Acad. Nat. Sci. Philad., 1872, p. 178.

Spheniscus demersus, and by Sclater,[1] who is of opinion that it is a "quite distinct" species from *Spheniscus demersus*. In the absence of an anatomical examination it is impossible to decide which view is correct, but I shall be surprised if farther research does not demonstrate that *Spheniscus humboldti* is simply a variety, and by no means a well-defined variety, of *Spheniscus demersus*. It appears to me that the difference in external appearance between *Spheniscus humboldti* and *Spheniscus demersus* is even less than that which exists between *Spheniscus demersus* and *Spheniscus magellanicus*, and in view of the similarity of the anatomy of the two last-mentioned birds, it appears to me likely that an accurate anatomical examination of *Spheniscus humboldti* will show that it is simply a variety of *Spheniscus demersus*, and one that differs less from *Spheniscus demersus* than does *Spheniscus magellanicus*.

Lastly, relying on the results afforded by a minute anatomical investigation, there can be no doubt that both *Spheniscus mendiculus* and *Spheniscus minor* constitute well-defined species, the specific characteristics of which are to be found in the foregoing pages.

Spheniscus minor appears to be the most aberrant species of the genus, and differs more from any of the other species than these do from one another in respect of the form of the skull, in that of the proventricular gland, in the length of the small intestine, and in the total absence of a tracheal septum. In some respects, moreover, especially in the form of the skull and in that of the conjoined metatarsal bone, *Spheniscus minor* seems to occupy an intermediate position between *Spheniscus*, as represented by *Spheniscus demersus*, and *Eudyptes*, as represented by *Eudyptes chrysocome*. Its relationship to *Spheniscus*, however, is closer than to *Eudyptes*. The difference between *Spheniscus minor* and the other species of the same genus nevertheless does not appear to me to be sufficient to justify the establishment of a distinct genus for the reception of this species, as has been done by several ornithologists.[2]

ORIGIN OF THE PENGUINS.

It has been remarked by Owen,[3] that in respect of several osteological features the Penguins present exceptionally reptilian characters. These characters are to be found more especially in the opisthocœlous character of the dorsal vertebræ, and in the form of the metatarsal bones which present an amount of differentiation from one another which, so far as I am aware, is met with in no other group of birds.

The reptilian arrangement of certain of the muscles of the Penguins has, moreover, been referred to by Gervais and Alix.[4]

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[1] Challenger Reports, Zoology, part viii. p. 126.

[2] Gray, Hand-list of Birds; Gould, Birds of Australia, vii. pl. lxxxv.; Bonaparte, Comptes rendus, 1856, tom. xliii. p. 646.

[3] Cyclopædia of Anatomy, Art. "Aves," vol. i. p. 270.

[4] Ostéologie et Myologie des Manchots.

So far as the metatarsal bones are concerned, it appears from the observations of Gegenbaur,[1] that even in those birds in which the metatarsal bones ultimately fuse to form a single undivided mass, these bones originally present the form of four distinct and separate elements. It seems, therefore, if conclusions based upon embryology are of any value, that we must conclude that birds as we now know them were derived from an ancestral group, the members of which, along with other peculiarities, were possessed of at least four distinct and separable metatarsal bones. These four bones were originally separate and distinct, but subsequently became more or less completely fused together to form the single metatarsal bone which is characteristic of the majority of birds. Inasmuch as the Penguins retain the individuality of the separate metatarsal bones to a greater extent than other birds, it would appear that they are the modern representatives of a group which had diverged from the primitive avian stem at a time when as yet the metatarsal bones had neither lost their individuality nor had become fused together to form the single bone which is one of the characteristics of the majority of birds of the present day.

This conclusion can only be denied on the supposition that the earliest members of the group of the Spheniscidæ were derivatives from the avian stem, at a period when the separate metatarsal bones had been already fused to form a single mass, as in modern birds; a supposition which appears to the last degree improbable, when we consider that in accepting it we must suppose that the avian metatarsal bones must in the first instance have undergone coalescence, and thereafter became differentiated from one another in the members of one particular group, and in one only. It would therefore appear that the group Spheniscidæ is one of considerable antiquity, and that it must have diverged from the avian stem at a time when as yet the metatarsal bones formed distinct and independent entities in the members of the entire class of birds.

At this time, moreover, birds had so far become differentiated from their reptilian ancestors, that their anterior extremity, instead of forming organs of support adapted to terrestrial progression, had become modified to form wings adapted to aerial progression. This conclusion is forced upon us by an examination of the wing of the Penguin of the present day, in which we find nearly every muscle which is characteristic of the wing of the ordinary bird represented, but represented not by muscular but by tendinous bands, which have attachments similar to those of the muscles in question. These tendons, inasmuch as they are functionally useless, could only have been derived through a process of structural degeneration from muscular bands which had at one time been functionally active in the ancestral Penguin, but which, in accordance with the law that when highly-organised tissues become functionally useless, they gradually degenerate and assume a lower form of organisation, and were consequently converted into tendon.

In the Penguins apparently the muscles of flight originally present had proved to be

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[1] Untersuchungen, Heft i., 1864.

either useless or even detrimental to the animal, and had hence undergone a process of atrophy, and become converted into non-contractile tendinous bands.

It appears to me, therefore, that, relying on the anatomy of the Penguins, we must conclude that they form the surviving members of a group which had early diverged from the primitive avian stem,[1] but that at the time when the separation took place the members of that stem had so far diverged from the primitive ornithoscelidan form as to be possessed of anterior extremities, which instead of forming organs of terrestrial, had become transformed into organs adapted to aerial progression, in other words, into true wings.

If this view be correct, palaeontological research ought in the course of time to disclose the existence of numerous Spheniscidine remains, which may enable us to trace the line of descent of the Penguins of the present day from the original avian stem, and through it the relationship which exists between the modern *Spheniscus* or *Eudyptes*, with their separate metatarsal bones and aborted wings on the one hand, and the majority of modern birds, with their conjoined metatarsal bones and perfect wings on the other.

In view of these observations it seems hopeless to attempt at present to trace the affinities of the Penguins to other genera of existing birds; and although in many respects they appear more nearly to resemble the group of palmipede birds than any other, yet I think it unnecessary, considering the present state of our knowledge of the anatomy of the latter, to found hypothetical conclusions as to the exact affinities of the Penguins upon anatomical data which everyone must acknowledge to be altogether insufficient for the purpose. I shall therefore content myself with remarking, in the words of Gervais and Alix, that "Si, au lieu de se borner à constater les affinités, on veut se placer au point de vue de la recherche d'un type ancestral commun aux Sphéniscidés et aux Palmipèdes, on voit que ce type hypothétique ne saurait être arrivé à produire celui des Sphéniscidés qu'après de nombreuses modifications."[2]

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[1] In corroboration of this opinion I subjoin the following :—

"When describing the fossil bones of the large Penguin, *Palaeeudyptes antarcticus*, Huxley, in a paper published in last year's volume of our Transactions, I find that I overlooked two very fine specimens that were in the museum.

"They were presented by Mr. Charles Traill, who found them in the white calcareous sandstone which is excavated at Fortification Hill, near Oamaru, in Otago, and which is well known as the Oamaru limestone.

"The bones are beautifully preserved in this matrix, which has been carefully cleared away to allow of the examination.

"They are the left humerus and coracoid of the right side, and belonged, I have no doubt, to the same individual bird as the metacarpal figured in last year's volume (pl. xvii. fig. 3). The humerus is one-sixth of an inch larger than the same bone in the Brighton fossil, and has a more marine appearance. Judging from the proportion of the bones, they must have belonged to a bird that had a stature of from 6 to 7 feet.

"Captain Hutton said he considered the age of the strata containing these bones to be upper Eocene, and that they are therefore among the oldest bird remains known."—Hector, J., *Trans. New Zealand Inst.*, vol. v. p. 438, 1872.

[2] Ostéologie des Manchots, p. 44.

SUMMARY AND CONCLUSION.

Before drawing this memoir to a close, it may be convenient that I should briefly summarise the leading peculiarities of the Penguins as compared with other birds, and direct attention to the principal facts contained in the foregoing pages.

From what has gone before it appears that the Spheniscidæ constitute an exceedingly well-defined group of birds, every member of which is characterised by the following skeletal features.

In respect of the axial skeleton, the cranium is truly schizognathous, and is chiefly remarkable for the great development of the transverse temporal crest, which separates the occipital from the temporal region of the skull. This crest, developed to some extent in all the members of the group Spheniscidæ, is more pronounced in certain genera than in others, being more strongly marked in *Spheniscus* than in either *Eudyptes* or in *Aptenodytes*, and more so in the former than in the latter genus.

The vertebral column of every member of the group is characterised (*a*) by the presence in the cervical region of well-developed sigmoidal curves, which are more pronounced than in other birds, and are doubtless correlated with the peculiarly erect attitude of the Penguins when on land; (*b*) by the opisthocœlous character of the dorsal vertebræ, a character which, judging from the frequency of its occurrence in the two groups, is more truly reptilian than avian; (*c*) by the mobility of the dorsal vertebræ upon one another, and the absence, even in the adult, of that complete anchylosis between the dorsal and lumbo-sacral vertebræ on the one hand, and of the latter with the pelvic bones on the other, which obtains in the majority of birds.

In respect of the appendicular skeleton, we find the bones of the wing in the Spheniscidæ modified in accordance with the alteration of function of that organ, and its conversion from an instrument of aerial to one of aquatic progression. These modifications are manifested in the enormous size of the scapula, which thus affords attachment to the powerful muscles of the shoulder joint, that is, to those muscles which act upon the wing as a whole; in the great strength of the coracoid bone, which in *Spheniscus* and in *Eudyptes* is perforated by a foramen for the transmission of the nerve to the pectoralis medius muscle; in the lateral compression of all the bones of the wing, a character which obtains among certain other diving birds, but which only reaches its maximum in the Spheniscidæ; in the presence of two sesamoid bones, developed in connection with the tendon of the triceps muscle; in the peculiar form and mode of articulation of the carpal bones; in the union of the first or radial, which, although independent in the embryo, becomes inseparably anchylosed with the second metacarpal bone in the adult; and in the absence of a free pollex.

The skeleton of the leg of the Penguin is modified to a less extent than is that of the wing, but here likewise certain peculiarities are met with. The patella is of larger size than, and differs somewhat in form from, that of the majority of birds; the tarsometatarsus presents features which serve at once to distinguish that bone from the corresponding skeletal element of any other group of birds, being altogether shorter and broader than in these, with the single exception of the genus *Fregatta*. From *Fregatta*, however, as from all other birds, the Penguin is distinguished by the clearly-defined separation of the metatarsal elements, the shafts of which are differentiated from one another, while in other birds these bones are indistinguishably fused together.

In respect of the form and mode of articulation of the various joints, with the exception of those of the wing, the Penguins do not differ from other birds. In the wing of the Spheniscidæ, in accordance with the alteration of function of that member, the various joints, with the exception of that at the shoulder, present an amount of rigidity met with in no other group of birds. The shoulder joint is as perfect in the Penguins as in other birds, but the more distal articulations are arranged so as almost entirely to prevent those movements of flexion and extension which are essential to an organ of flight. This limitation of movement is partly dependent on the form of the articulations, and partly on the arrangement of the ligaments, which here as elsewhere not only serve to attach the bones to one another, but to limit the amount of movement permissible at the various joints, in accordance with the anatomical arrangement of the muscles, and the physiological requirements of the organism.

The muscular system of the Penguins is characterised by the great development of the cutaneous muscles, which present an arrangement quite peculiar to the group. It has been suggested to me that the large development of the cutaneous muscles in these birds is probably a means whereby water may be readily expelled from the interstices of the plumage so soon as the bird quits the water. Were it otherwise, in the low temperature of the Antarctic region which the majority of these birds inhabit, the plumage would soon be frozen into an icy mass, the high temperature of the bird being of itself insufficient to obviate this, seeing that the ready conduction of heat from the interior of the organism is prevented by the great development of the subcutaneous fatty layer which obtains in every member of the group. The muscular system of the Penguins is further characterised by the great strength of all, and the peculiar disposition of certain, of the extensor muscles of the vertebral column, more especially of the biventer cervicis, which extends from the iliac bone to the skull, these peculiarities being associated with the remarkable attitude of the Penguin when on land; by the presence and arrangement of the transverse cloacal muscle; by the great strength of the muscles which act at the shoulder joint, that is, upon the wing as a whole; by the peculiar disposition of the brachialis internus muscle; and by the almost complete atrophy of the muscles which act upon the forearm and hand, the last-mentioned peculiarities being associated with the alteration in function of the wing, and its conversion from an instrument of aerial to one of aquatic locomotion. In respect of the muscles of the leg, the Penguins do not differ essentially from other Palmipedes.

Passing to the peculiarities of the arterial system of the Spheniscidæ, we find that these are no less characteristic of the group than are those of the bony and muscular systems. They consist in (*a*) the presence of two common carotid arteries of equal size, symmetrically disposed on either side of the middle line; (*b*), the peculiar mode of distribution of the subclavian artery, which breaks up into an axillary and brachial rete mirabile from which branches are derived for the supply of the forearm and hand; (*c*) in the absence of the sciatic artery as a direct branch of the abdominal aorta, and its substitution by a branch of the crural artery.

The venous system of the Penguins is characterised by the presence of two jugular veins of equal size, placed symmetrically on either side of the neck; by the junction of the sciatic with the crural vein, instead of with the inferior vena cava; and by the presence of a single vena portæ, which only subdivides immediately before it enters the liver.

The digestive organs of the Spheniscidæ present fewer characteristic features than do the other systems already referred to. The large size of the buccal papillæ is perhaps more characteristic of the group than is any other portion of their digestive system. The proventricular gland varies in form in different genera, and even in different species of the same genus. As a rule, it is either crescentic in form or presents a completely zonular character. The cæca are small and aduate. The bursa fabricii is usually of exceptionally large size, but both its size and structure vary in accordance with conditions concerning the exact nature of which we are at present ignorant.

The respiratory organs of the Spheniscidæ closely resemble those of other birds in their general arrangement. In one important particular, however, they differ from all with the exception of those of the Procellariidæ. The presence of a tracheal septum, which more or less completely divides the air tube into two lateral chambers, is met with only in the Spheniscidæ and in the Procellariidæ. This septum is usually but not constantly present in the Spheniscidæ. I found it in all the forms which I examined, with the exceptions of *Eudyptes chrysocome* from Tristan d'Acunha, and *Spheniscus minor*. The occasional absence of a tracheal septum, therefore, shows that this septum, *per se*, cannot be considered as a thoroughly and constantly reliable anatomical character of the group of Spheniscidæ, any more than of the Procellariidæ.

It will be noted that I failed to observe any peculiarity in respect either of the muscular or of the respiratory organs which would serve to explain the power which the Penguins possess of remaining submerged for a considerable period of time. This faculty is more probably due to a physiological adaptation of these birds to the necessities of their peculiar mode of life, rather than to any structural modification of the organs which are affected thereby. Mr. Murray[1] states that a rock-hopper Penguin (*Eudyptes chrysocome*), placed in a basket and submerged, "was dead in one minute and thirty seconds," from which we may conclude, considering the great vitality of these birds, that the period during which they usually remain under water when diving is considerably less. From observations made by myself with regard to the length of time which the diving birds of our own coasts (Guillemots, &c.) remain under water, it seems that the duration of each submersion varies from one minute thirty seconds to one minute forty-five seconds, and the length of time during which the Penguins can remain under water is apparently somewhat less. In the Guillemots, as in the Penguins, there is a total absence of any structural modification which would account for the possession of this faculty, which therefore in both cases appears rather to depend upon functional than upon structural modification.

In respect of the urinary and genital organs, the Penguins have their kidney divided into two lobes, while the male and female organs resemble those of birds in general, the latter presenting the usual atrophy of the ovary and oviduct of the right side.

The cutaneous system of the Spheniscidæ is thoroughly characteristic of the group, and differs from that of every other group of birds, in respect of the uniform distribution of the feathers over every part of the integument, and in the consequent absence of the bare tracts or apteria met with in other birds. The feathers each possess an "aftershaft," the structure of which is similar to that of the feather itself. The "remiges" or quill feathers are not distinguishable from the surrounding feathers; but the "rectrices" or quill feathers of the tail are clearly differentiated. These cutaneous peculiarities were long since recognised in *Aptenodytes patagonicus* and in *Spheniscus demersus*, by Nitzsch,[2] and I have now confirmed and extended the observation to every species of Penguin which I have dissected. The oil glands in the Spheniscidæ are of large size, and the duct of each terminates on the cutaneous surface by means of a single orifice.

Along with the skin it is convenient to direct attention to the great development of the subcutaneous fatty layer of the Penguins, as compared with other birds. This layer far exceeds in thickness that of the corresponding structure in the members of any other group of birds, and recalls to mind the fatty deposit or "blubber" of the Seals and Cetaceans. In the Penguins, as in the mammals just named, this deposit of fat appears to act as a non-conductor of heat, and serves to equalise the temperature of the bird,

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[1] Sclater, Challenger Reports, Zoology, part viii. p. 132.

[2] Pterylography, Ray Soc., edited by P. L. Sclater, F.R.S., p. 154.

which otherwise would be liable to alteration by the varying conditions to which by reason of its peculiar mode of life the animal is so much exposed.

Passing now from the anatomy of the Spheniscidæ, there are certain points to which, although not directly connected with the special subject of this memoir, attention may as well be directed in connection with the group of birds under consideration.

The mode of locomotion of the Penguins, both upon land and in water, is noteworthy. The peculiarly upright position of the birds when on land has formed the subject of remark of every traveller who has seen these birds in their native haunts, and has been frequently referred to in the preceding pages in connection with the anatomical arrangements which are correlated with it. One other peculiarity may be insisted upon in this connection. The position of the tarso-metatarsus of the Penguins is, so far as I am aware, peculiar among birds.[1] In all other birds, during terrestrial locomotion, the tarso-metatarsus is elevated so that only its distal extremity comes into relation with the ground, whereas in the Penguins the whole length of this bone is applied to the ground, the "heel" of the foot, physiologically considered, in the case of other birds being situated at the distal extremity of the tarso-metatarsus, while in the Spheniscidæ it is formed by the proximal end of that bone. In accordance with this arrangement, we find that while in the majority of birds the metatarso-phalangeal articulations admit of great mobility, in the Spheniscidæ, on the other hand, these joints are relatively stiff, and greater freedom of movement is permitted at the intertarsal articulation or ankle joint. May we not regard this plantigrade condition of the foot of the Penguin as a survival of a similar feature in the anatomy of the ornithoscelidan ancestors of the Spheniscidæ?

With regard to the method of locomotion of the Penguins in water, attention has been already directed to the peculiar mode of action of the wings as organs of propulsion, and to the corresponding alterations in structure of these organs from that of the typical avian extremity. The wing as a whole is freely moveable at the shoulder joint, but the more distally placed joints are relatively fixed. Thus the wing is converted into a paddle, well adapted to the necessities of the Penguin. The wing in many other aquatic birds is similarly used to enable the animal to propel itself through the water, but in none does the organ manifest the striking adaptation to this function that it does in the Penguins, chiefly on account of the fact that while in other diving birds the wing is used not only as an organ of aquatic but also of aerial progression, whereas in the Penguins its function is exclusively that of the former.

In the majority if not in all the truly aquatic and diving birds, with the exception of the Spheniscidæ, the legs come into play as accessory propulsive organs when the bird is diving. In this respect the Spheniscidæ differ essentially from those other birds which in

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[1] Attention was first directed to this peculiarity by C. Geoffrey, Note sur les Manchots, Bulletin de Sciences par la Société Philomathique, Paris, 1798, vol. i. p. 81.

respect of their habits most nearly resemble them. From the observations of Tegetmeier[1] it would appear that in diving the movements of the Penguins under water are accomplished solely by the use of the wings, the legs being extended behind the bird, just as they are during flight, and taking no part in the propulsion of the bird through the water. It thus appears that the posterior extremities of the Penguins act chiefly as organs of progression when the bird is on land or when swimming on the surface of the water, but that when diving the legs take no part in the locomotion of the bird, which under these circumstances becomes truly a subaqueous flight.

The geographical distribution of the Spheniscidæ is of interest.[2] The various members of the group are entirely confined to the southern hemisphere, not one single species of Penguin being found north of the equator. In the southern hemisphere, however, their distribution is very extensive, reaching from the Gallapagos Islands on the equator southwards to the Antarctic Islands. Of the various species of Penguin referred to in the preceding pages, *Spheniscus demersus* is confined to the vicinity of the Cape of Good Hope, *Spheniscus magellanicus* to that of Cape Horn, *Spheniscus mendiculus* to the coast of Chili, while *Spheniscus minor* inhabits the South Pacific, in the neighbourhood of Australia and New Zealand. The genus *Eudyptes* includes, according to ornithologists, along with others which I have not had an opportunity of examining, the two separate species *Eudyptes chrysocome* and *Eudyptes chrysolophus*. Of these *Eudyptes chrysocome* has much the more extensive geographical range, being met with as far north as the island of Tristan d'Acunha, whence it extends southwards to Kerguelen Island. *Eudyptes chrysolophus* inhabits the island of Kerguelen, whence it extends southwards to the islands of the Antarctic.[3] The genus *Aptenodytes* (including *Pygosceles*) has a wide geographical range, extending from the Falkland Islands in the north, to the islands of the Antarctic Sea in the south.

The limitation of the geographical range of the group of Spheniscidæ to the southern hemisphere is not a little remarkable, and so far as I am aware no explanation of the fact has hitherto been offered. That it does not depend on temperature is evident from the fact that they are met with from the equator southwards to the Antarctic Ocean.[4] It appears not improbable that it may depend on the relative abundance of the food supply (cephalopods and crustacea) found in the southern and northern hemispheres respectively.

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[1] Diving Birds in the Zoological Garden, The Field, April 28, 1883, p. 563.

[2] Wallace, Geographical Distribution of Animals, vol. ii. p. 366.

[3] Gray, Handlist of the Genera and Species of Birds, part iii. p. 90.

[4] With reference to this matter, I have been favoured with the following interesting remarks by the editor of the Challenger Reports. "The Penguins reach the equator only on the coast of Chili and Peru. Now the Peruvian current from the antarctic skirts along this coast, and takes a low temperature as far north as the Gallapagos Isles,—the temperature of the sea being there (equator) 62° to 66°, while in the middle of the Pacific (equator) the surface temperature is 81° to 88°. Temperature, therefore, most probably has something to do with the limitation of the geographical distribution of the Spheniscidæ."

The fact that the Challenger officers seldom noticed these birds more than 40 or 50 miles from land[1] or ice, seems to show that having once adopted a residence they are very far from being addicted to those migratory habits which their peculiar structure and mode of life seem so well adapted to encourage.

With regard to the distribution in time of the Spheniscidæ, we at present know almost nothing, our knowledge of fossil forms being limited to a humerus, coracoid, and tarso-metatarsal bone, which were discovered in the Eocene formation of New Zealand.[2] The metatarsal bone has been described by Prof. Huxley,[3] who established the genus *Palæeudyptes* for the reception of the bird of whose skeleton it formed a part. It apparently belonged to the skeleton of a bird closely allied to the genus *Eudyptes* of the present day, but evidently of much larger size than any living species of that genus. If the nature of the deposit from which this fragment was excavated has been correctly interpreted, it shows that the family of Spheniscidæ is one of great antiquity, and that it had even at that time deviated so far from the primitive avian stem as to present those modifications in structure which have remained unaltered down to the present time. This fact goes far to explain the difficulty which every one must acknowledge in attempting to allot to the Spheniscidæ their proper place in any classification of recent birds, a difficulty which will only disappear as the geological record is more fully deciphered, and the intermediate forms which at one time undoubtedly connected the Penguins with the primitive avian stem have been brought to light.

Passing now to the subdivision of the Spheniscidæ, it appears from the foregoing pages that the various species which I have examined may be grouped together into the three genera, *Spheniscus*, *Eudyptes*, and *Aptenodytes*, as shown in the table.

Family.	Genus.	Species.	Variety.
SPHENISCIDÆ, . .	*Spheniscus*	*demersus*	*magellanicus*.
		mendiculus	
		minor	
	Eudyptes	*chrysocome*	*Eudyptes chrysocome*, from Tristan. *Eudyptes chrysocome*, from Falklands. *Eudyptes chrysocome*, from Kerguelen.
		chrysolophus?	
	Aptenodytes	*longirostris*	
		tæniatus	

Of the various members enumerated above of the genus *Spheniscus*, it appears to me that *Spheniscus demersus* and *Spheniscus magellanicus* ought to be regarded as two varieties of one and the same species, while *Spheniscus mendiculus* and *Spheniscus minor* are undoubtedly distinct species. *Spheniscus minor* is moreover possessed of several cranial characters which approximate it to *Eudyptes*.

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[1] Sclater, Challenger Reports, Zoology, part viii. p. 132.

[2] Hector, J., Trans. New Zealand Inst., vol. v. p. 438, 1872.

[3] Quart. Jour. Geol. Soc., vol. xv. p. 670.

Of the so-called species associated together by ornithologists under the genus *Eudyptes*, I have examined two, *Eudyptes chrysocome* and *Eudyptes chrysolophus*. Of these two species, *Eudyptes chrysocome* presents three varieties, which are met with at the island of Tristan d'Acunha, the Falkland Isles, and Kerguelen Island respectively. That *Eudyptes chrysolophus* ought to be regarded as a species distinct from *Eudyptes chrysocome* is not doubted by any ornithologist, but an examination of the entire anatomy both of *Eudyptes chrysolophus* and of *Eudyptes chrysocome* appears to me rather to lend support to the view that they are simply two well-marked varieties of one and the same species of *Eudyptes*. The decision of this point must depend on the relative value attached by various ornithologists to difference in size and similarity of anatomical structure as elements in the determination of species as distinguished from variety.

The genus *Aptenodytes* includes the two species which I have examined,—*Aptenodytes longirostris*, and *Aptenodytes tæniatus*. The last named has been accepted by ornithologists as a type of another genus, *Pygosceles;* but I see no reason on anatomical grounds why it should not be included along with *Aptenodytes longirostris* as another species of one and the same genus.

I regret that I have not had an opportunity of dissecting a specimen belonging to the genus *Dasyramphus* of Gray, and am therefore unable to refer that genus to its proper place with reference to the other birds which I have examined.

Lastly, in respect of their affinities the Penguins appear to be more closely allied to the Palmipede than to any other group of birds, but the numerous important deviations which they present from every one of the various groups included within that very heterogeneous assemblage appear to show that the Spheniscidæ must have diverged at an early period from the primitive avian stem from which both groups were derived, and the connecting links having been lost, it seems at present hopeless to attempt to establish the exact affinities of the Penguins to other birds. At first sight, indeed, it appears that the nearest allies of the so-called wingless birds of the southern are to be found in the wingless birds of the northern hemisphere, but the researches of Prof. Owen[1] on the osteology of the Great Auk (*Alca impennis*), abundantly show that the two groups have but little in common. We are compelled therefore to postpone the accurate determination of the affinities of the Spheniscidæ till the progress of Palæontology shall have made us acquainted with the intermediate forms which connect the Spheniscidæ with the primitive avian stem from which both they and the other Palmipedes were originally derived.

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[1] Description of the skeleton of the Great Auk or Garfowl (*Alca impennis*). Trans. Zool. Soc., vol v. p. 317.

POSTSCRIPT.

Since the manuscript of the foregoing pages was placed in the hands of the printer, I have devoted attention to the collection of the eggs and young of the Challenger Penguins, the results of the investigation into the anatomy of which I proposed should form the second part of this memoir. The collection consisted of—

(*a*) Ten eggs of *Eudyptes chrysocome*, from Tristan d'Acunha.
(*b*) Two eggs of *Pygosceles tæniatus*, from the Falkland Islands.
(*c*) A quantity of eggs of *Eudyptes chrysocome*, from Tristan d'Acunha, containing embryos.
(*d*) Fourteen young Penguins from Tristan d'Acunha.
(*e*) Two young specimens of *Eudyptes chrysocome* from Kerguelen Island.

(*a*) Of the ten eggs of *Eudyptes chrysocome*, from Tristan d'Acunha, the majority did not appear to have been incubated, but in others the blastoderm was partially developed. In the latter, the pellucid and opaque areas presented a circular form, showing that the eggs had been removed from the nests shortly after incubation had commenced. The state of preservation of these eggs was not such as to warrant any expectation of important embryological results from examination of the blastoderm by means of the microscope, and I did not, therefore, proceed to examine them with the aid of that instrument.

(*b*) Both the eggs of *Pygosceles tæniatus* were so completely decomposed that it was impossible to determine with accuracy anything regarding their mode of development.

(*c*) All the eggs of *Eudyptes chrysocome*, from Tristan d'Acunha, which contained young birds were in an excellent state of preservation. The contained embryos were all of large size, indeed they appeared to be for the most part mature and ready to make their escape from the egg. In a few, however, the yolk sac had not yet been withdrawn into the cavity of the abdomen.

(*d*) and (*e*) The fourteen young Penguins from Tristan d'Acunha, and two young specimens of *Eudyptes chrysocome* from Kerguelen, were all small birds which had apparently only recently escaped from, or in some cases had been removed from, the egg at or about full time.

Such being the nature of the material at my disposal, it will be seen that, taking into consideration the gap which existed between the eggs in which the blastoderm had but just made its appearance, and those in which the contained embryos had almost arrived at maturity, it was impossible for me to draw up a complete account of the development of the Spheniscidæ such as I originally proposed.

I therefore abandoned the attempt and devoted attention to the skeleton of the embryos, in the hope that I might thereby be able to throw some light on the development of those skeletal features which are peculiar to the group. In this also I was unsuccessful, as I soon found that even in the youngest of the specimens at my disposal the skeleton was too far advanced to be of any service in this direction. MM. Gervais and Alix,[1] in their memoir so often quoted, have figured the bones of a young specimen of *Eudyptes*, and with these figures the skeletons of the specimens which I have examined agree. I have therefore been able so far to corroborate the observations of these anatomists, but the want of suitable material has prevented me from extending them by working out more fully the development of the group, as I originally intended.

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[1] Ostéologie et Myologie des Manchots.

JUNE 18, 1882.

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PLATE I.

Osteology of Penguins.

(All the figures are of the natural size.)

Fig. 1.—Lateral view of skull of *Eudyptes chrysocome*, from Tristan d'Acunha.

Fig. 2.—Vertex of skull of same.

Fig. 3.—Base of skull of same.

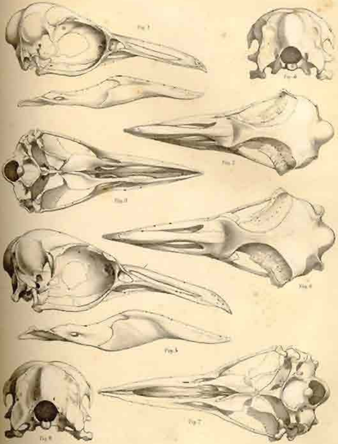
Fig. 4.—Occiput of skull of same.

Fig. 5.—Lateral view of skull of *Eudyptes chrysolophus*.

Fig. 6.—Vertex of skull of same.

Fig. 7.—Base of skull of same.

Fig. 8.—Occiput of skull of same.



1.2.3.4. EUDYPTES CHRYSOCOME. 5.6.7.8. E. CHRYSOLOPHUS.

PLATE II.

Osteology of Penguins.

(All the figures are of the natural size.)

Fig. 1.—Lateral view of skull of *Spheniscus demersus.*

Fig. 2.—Vertex of skull of same.

Fig. 3.—Base of skull of same.

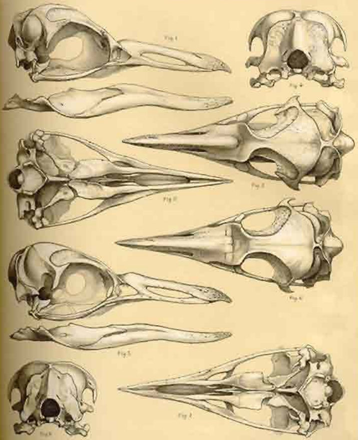
Fig. 4.—Occiput of skull of same.

Fig. 5.—Lateral view of skull of *Spheniscus magellanicus.*

Fig. 6.—Vertex of skull of same.

Fig. 7.—Base of skull of same.

Fig. 8.—Occiput of skull of same.



1.2.3.4. SPHENISCUS DEMERSUS. 5.6.7.8. S. MAGELLANICUS

PLATE II.

PLATE III.

Osteology of Penguins.

(All the figures are of the natural size.)

Fig. 1.—Lateral view of skull of *Spheniscus minor*.

Fig. 2.—Occiput of skull of same.

Fig. 3.—Base of skull of same.

Fig. 4.—Vertex of skull of same.

Fig. 5.—Lateral view of skull of *Spheniscus mendiculus*.

Fig. 6.—Vertex of skull of same.

Fig. 7.—Occiput of skull of same.

Fig. 8.—Base of skull of same.

Fig. 1.

Fig. 2.

Fig. 4.

Fig. 3.

Fig. 6.

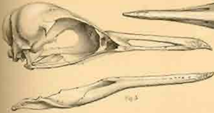


Fig. 5.

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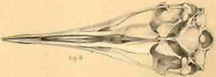


Fig. 8.

1.2.3.4. SPHENISCUS MINOR. 5.6.7.8. S. MENDICULUS.

PLATE III.

PLATE IV.

PLATE IV.

Osteology of Penguins.

(All the figures are of the natural size.)

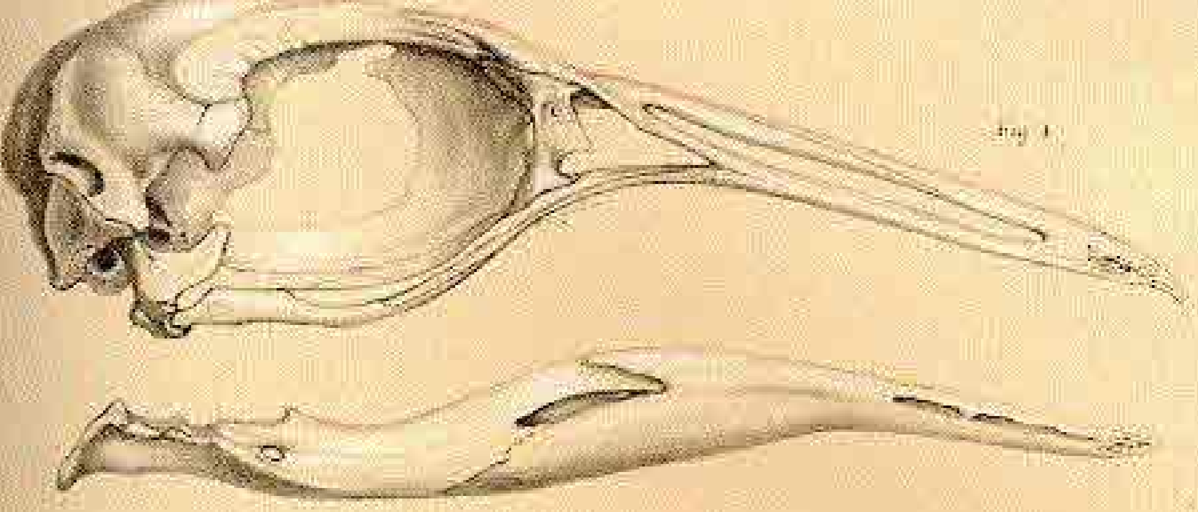
Fig. 1.—Lateral view of skull of *Pygosceles tæniatus.*

Fig. 2.—Occiput of skull of same.

Fig. 3.—Lateral view of skull of *Aptenodytes longirostris.*

Fig. 4.—Occiput of skull of same.

Fig. 1.



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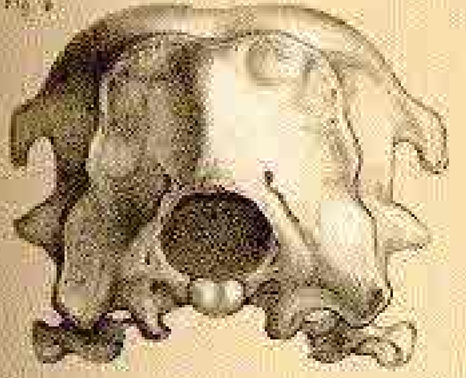

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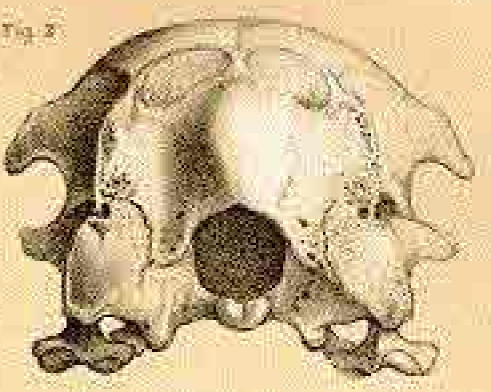

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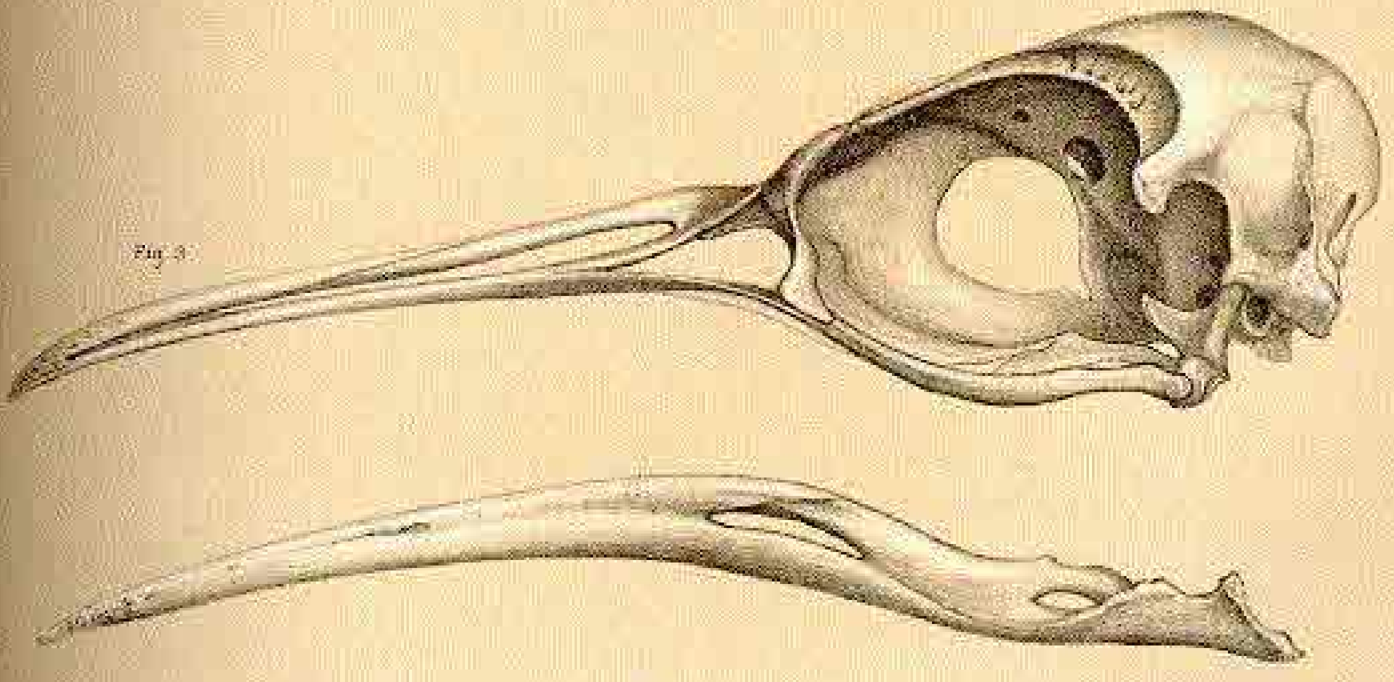


1.2. PYGOSCELES TÆNIATUS. 3.4. APTENODYTES LONGIROSTRIS.

PLATE V.

PLATE V.

Osteology of Penguins.

(All the figures are of the natural size.)

Fig. 1.—Vertex of skull of *Pygoscelis tæniatus*.[1]

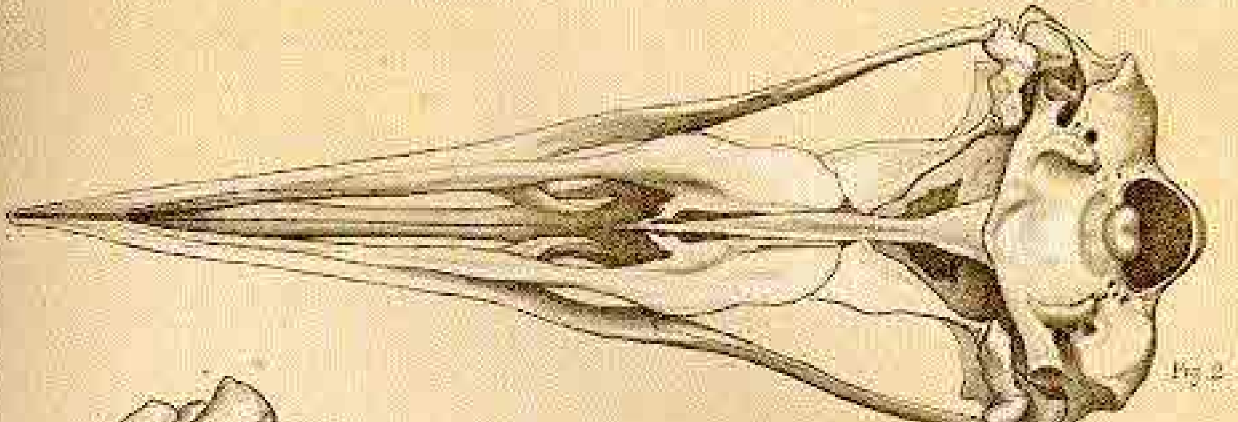
Fig. 2.—Base of skull of same.[1]

Fig. 3.—Vertex of skull of *Aptenodytes longirostris*.

Fig. 4.—Base of skull of same.

---

[1] The skull figured was that of a young bird, and the bones not yet being united, the palatal and pterygoid bones had parted and exposed the basi-sphenoidal rostrum. The relation which these bones bear to the rostrum, however, is the same as in other species.



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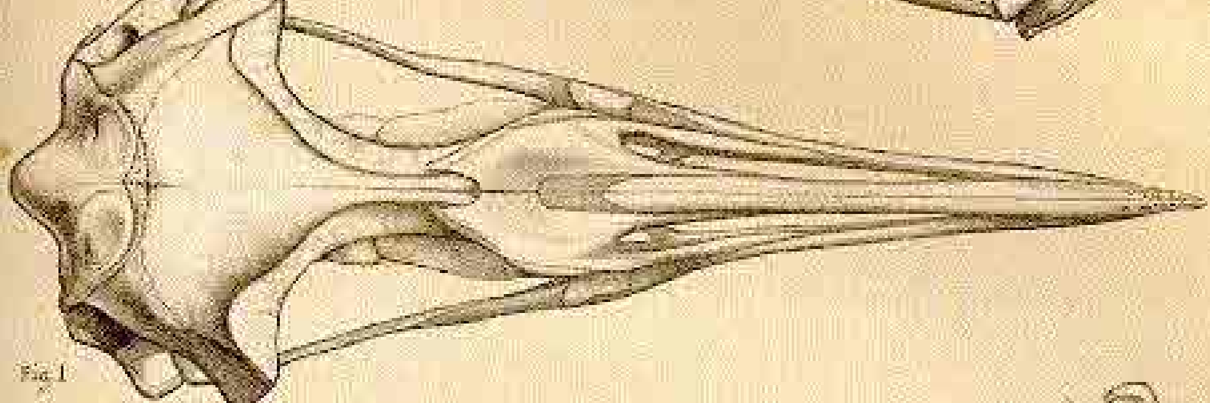

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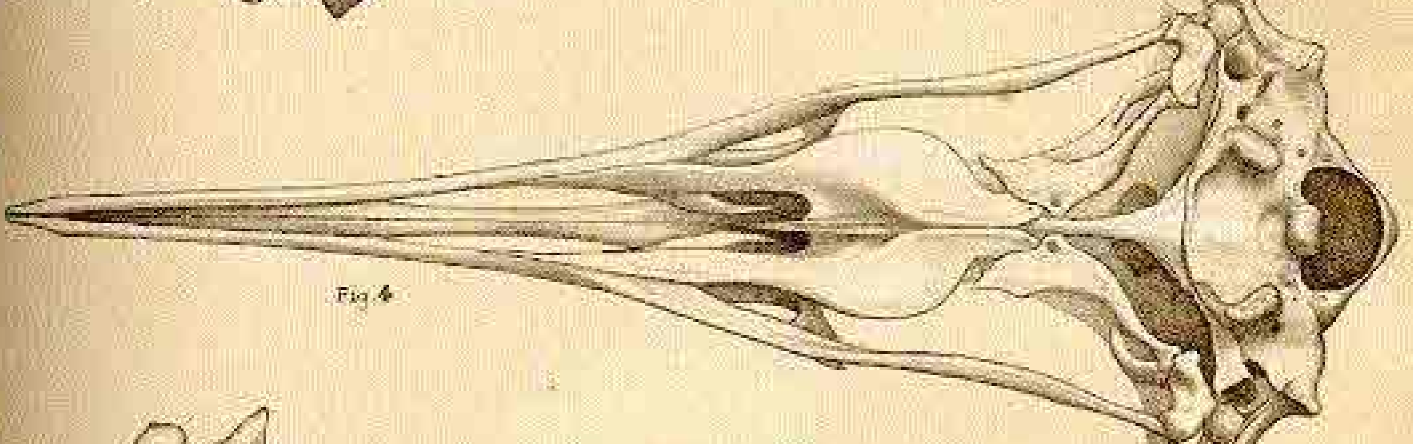


Fig. 4.

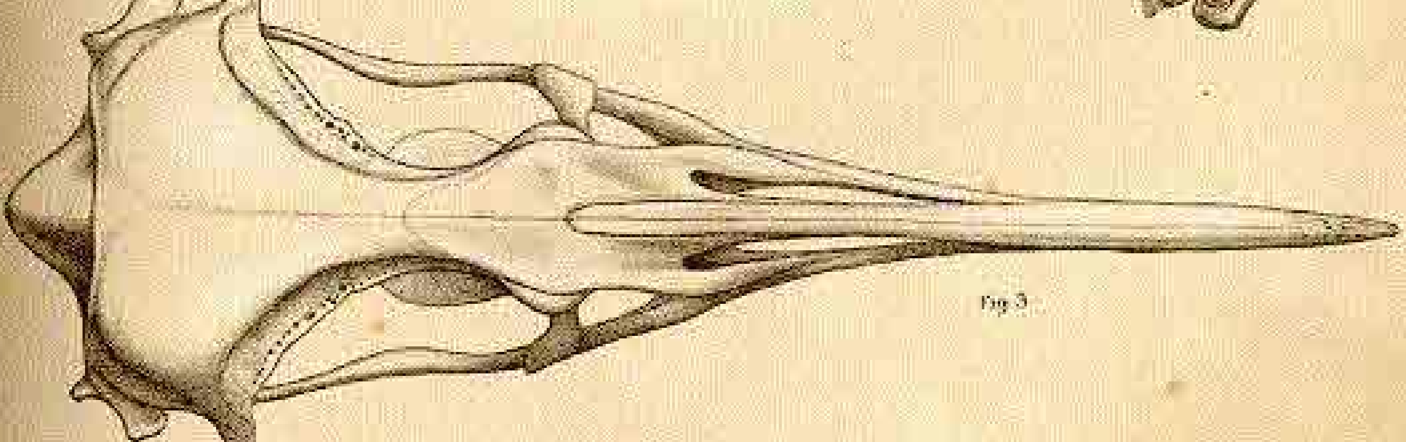


Fig. 3.

Berjeau del. et lith.

Hanhart imp.

1, 2, PYGOSCELES TÆNIATUS.
3, 4, APTENODYTES LONGIROSTRIS.

PLATE VI.

PLATE VI.

OSTEOLOGY OF PENGUINS.

(All the figures are of the natural size, except figs. 11 and 12, which are reduced to one-half of the natural size.)

Fig. 1.—Lower surface of sternum of *Eudyptes chrysocome*, from Tristan d'Acunha; natural size.

Fig. 2.—Lateral view of sternum of *Eudyptes chrysocome*, from Tristan d'Acunha natural size.

Fig. 3.—Anterior border of sternal keel of *Eudyptes chrysocome*, from the Falklands.

Fig. 4.—Anterior border of sternal keel of *Spheniscus demersus*.

Fig. 5.—Anterior border of sternal keel of *Pygosceles tæniatus*.

Fig. 6.—Anterior border of sternal keel of *Aptenodytes longirostris*.

Fig. 7.—Costal process of sternum of *Eudyptes chrysocome*, from the Falklands.

Fig. 8.—Costal process of sternum of *Spheniscus demersus*.

Fig. 9.—Costal process of sternum of *Pygosceles tæniatus*.

Fig. 10.—Costal process of sternum of *Aptenodytes longirostris*.

Fig. 11.—Posterior portion of sternum of *Eudyptes chrysocome*, from the Falklands; half the natural size.

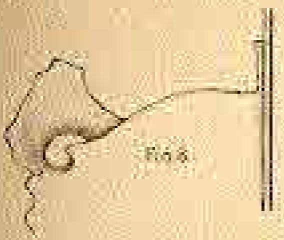
Fig. 12.—Posterior portion of sternum of *Pygosceles tæniatus*; half the natural size.

Fig. 13.—Ulnar carpal bone of *Eudyptes chrysocome*, from Tristan d'Acunha.

Fig. 14.—Ulnar carpal bone of *Spheniscus demersus*.

Fig. 15.—Ulnar carpal bone of *Aptenodytes longirostris*.


Fig. 7.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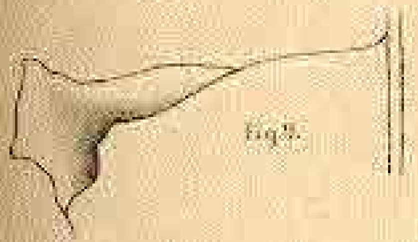
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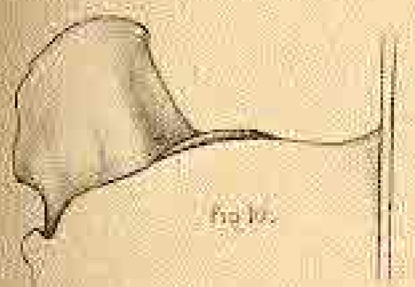
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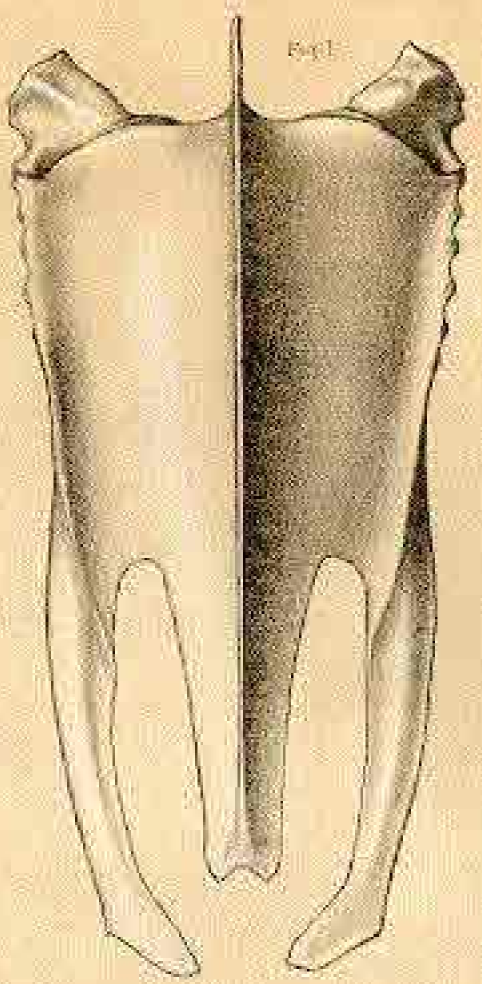
Fig. 1.


Fig. 3.

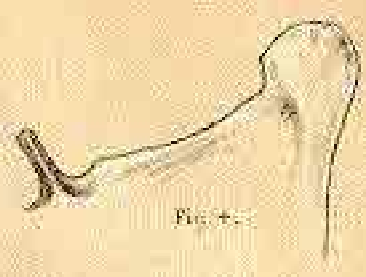
Fig. 4.


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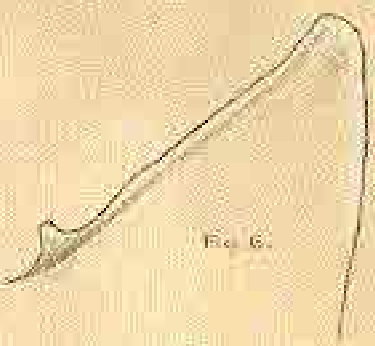
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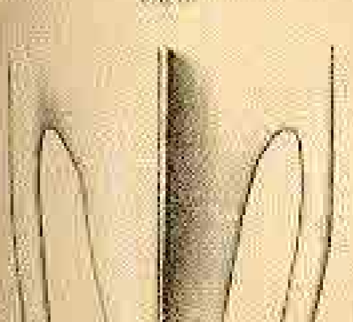
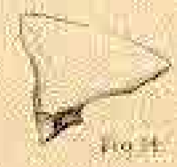


Fig. 12.


Fig. 15.


Fig. 13.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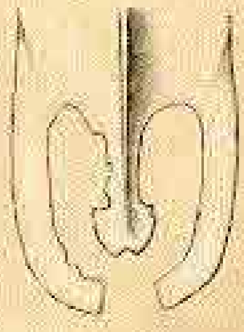
Fig. 11.


Fig. 2.

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1, 2, 3, 7, 11, 13, EUDYPTES CHRYSOCOME. 4, 8, 14 SPHENISCUS DEMERSUS.
5, 9, 12, PYGOSCELES TŒNIATUS. 6, 10, 15, APTENODYTES LONGIROSTRIS.

PLATE VII.

PLATE VII.

OSTEOLOGY OF PENGUINS.

Fig. 1.—Right scapula of *Eudyptes chrysocome*, from Tristan d'Acunha; natural size.

Fig. 2.—Right scapula of *Spheniscus demersus*; natural size.

Fig. 3.—Right scapula of *Pygosceles tæniatus*; two-thirds natural size.

Fig. 4.—Right scapula of *Aptenodytes longirostris*; two-thirds natural size.

Fig. 5.—Left coracoid bone of *Eudyptes chrysocome*; natural size.

Fig. 6.—Left coracoid bone of *Pygosceles tæniatus*; two-thirds natural size.

Fig. 7.—Interior of pelvis of *Eudyptes chrysocome*, from Tristan d'Acunha; natural size.

Fig. 8.—Exterior of pelvis of *Eudyptes chrysocome*, from Tristan d'Acunha; natural size.

Fig. 9.—Patella of *Eudyptes chrysocome*, from Tristan d'Acunha, outer surface; natural size.

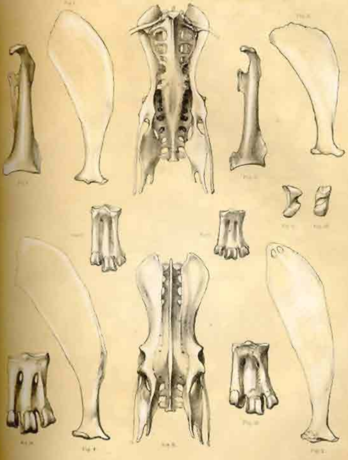
Fig. 10.—Patella of *Eudyptes chrysocome*, from Tristan d'Acunha, seen from the front; natural size.

Fig. 11.—Right tarso-metatarsal bone of *Eudyptes chrysocome*, from Tristan d'Acunha; natural size.

Fig. 12.—Right tarso-metatarsal bone of *Spheniscus demersus*; natural size.

Fig. 13.—Right tarso-metatarsal bone of *Pygosceles tæniatus*; natural size.

Fig. 14.—Right tarso-metatarsal bone of *Aptenodytes longirostris*; natural size.



1.5.7.8.9.10.11. EUDYPTES CHRYSOCOME. 2.12. SPHENISCUS DEMERSUS.
3.6.13. PYGOSCELES TÆNIATUS. 4.14. APTENODYTES LONGIROSTRIS.

PLATE VIII.

PLATE VIII.[1]

MUSCLES OF *Eudyptes chrysocome.*

Eudyptes chrysocome dissected to show the superficial layer of muscles. On the right side the pectoralis major has been reflected.

A.	Ambiens muscle.
Al.	Alar aponeurosis.
Ad. M.	Adductor magnus.
C.	Clavicle.
C. B.	Coraco-brachialis.
C. G.	Cerato-glossus.
C. T.	Cleido-thyroid muscles.
E. C. D.	Extensor communis digitorum.
G. a.	Anterior head of gastrocnemius.
G. i.	Inner head of gastrocnemius.
Inf. Sp.	Infra-spinatus muscle.
M. P.	Muscle des parures (dermo-humeralis).
Œ.	Œsophagus.
P. C.	Panniculus carnosus.
P. L.	Peroneus longus.
P. Maj.	Pectoralis major.
P. Med.	Pectoralis medius.
P. Min.	Pectoralis minor.
S.	Sartorius.
S. A.	Sphincter ani.
Sm. a.	Semi-membranosus (abdominal head).
Sm. p.	Semi-membranosus (pubic head).
T.	Trachea with the contractores tracheæ muscles.
T. A.	Tibialis anticus.
T. c.	Transverso-cloacal muscle.

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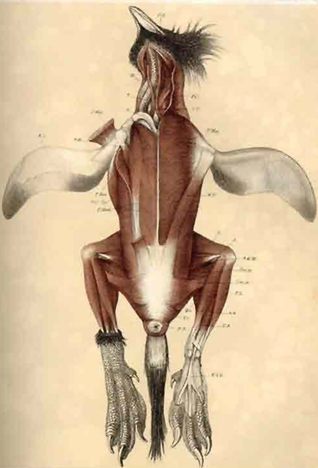
[1] For the original drawings of this and the two following plates I am indebted to the kindness of my friend, A. H. Young, Esq., F.R.C.S.



MUSCLES OF EUDYPTES CHRYSOCOME

PLATE IX.

PLATE IX.

MUSCLES OF *Eudyptes chrysocome.*

Fig. 1.—Lateral view of *Eudyptes chrysocome*, dissected to show the superficial muscles.

B.	Biceps femoris.
C. C.	Constrictor colli.
D. C.	Dorsal cutaneous muscle.
F. P.	Flexor perforatus digitorum pedis.
Ga.	Anterior head of gastrocnemius.
Ge.	Outer head of gastrocnemius.
G. Med.	Gluteus medius.
Inf. Sp.	Infra-spinatus.
L. D. a.	Latissimus dorsi (portion A).
L. D. b.	Latissimus dorsi (portion B).
M. P.	Muscle des parures (dermo-humeralis.)
P. C.	Panniculus carnosus.
P. L.	Peroneus longus.
P. Maj.	Pectoralis major.
P. Med.	Pectoralis medius.
R. F.	Rectus femoris.
S.	Sartorius.
S. A. Maj.	Serratus anticus major.
S. A. Min.	Serratus anticus minor.
S. T.	Semi-tendinosus.
T 1.	Triceps (first head).
T 4.	Triceps (fourth head).
T. C.	Transverso-cloacal muscle.
T. F.	Tensor fasciæ femoris.
T. P. L.	Tensor patagii longus.
U.	Uropygium.

Fig. 2.—View of muscles of left side of vertebral column of *Eudyptes chrysocome.*

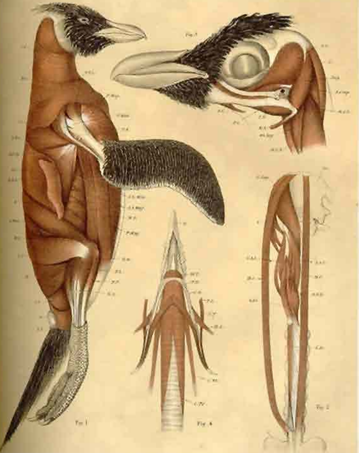
B. C., B. C.	Biventer cervicis. The muscle of the left side has been drawn aside to show the deeper muscles.
C.	Complexus.
C. A. I.	Cervicalis ascendens (lower portion).
C. A. S.	Cervicalis ascendens (upper portion).
I.	Iliac bone.
L. D.	Longissimus dorsi.
Oc.	Occiput.
S. Cap.	Splenius capitis.
S. S. C.	Semi-spinalis colli.
S. S. D.	Semi-spinalis dorsi.

Fig. 3.—Muscles of left side of head and neck of *Eudyptes chrysocome.*

C.	Complexus.
Dig.	Digastric muscle.
Ob. Inf.	Obliquus inferior.
P. L.	Protractor linguæ.
Pt.	Pterygoideus.
R. C. A.	Rectus capitis anticus.
R. C. L.	Rectus capitis lateralis.
R. L.	Retractor linguæ.
S. Cap.	Splenius capitis.
T. D.	Temporal muscle (deep portion).
T. S.	Temporal muscle (superficial portion).

Fig. 4.—Muscles of hyoid bone and tongue of *Eudyptes chrysocome*, seen from below.

C. G.	Cerato-glossus.
C. T.	Cerato-transverse.
C. Th.	Cleido-thyroid.
C. Tr.	Contractor tracheæ.
H. T.	Hyoideus transversus.
P. L.	Protractor linguæ.
R. L.	Retractor linguæ.
T. H.	Thyro-hyoid.
T.	Tongue.



MUSCLES OF EUDYPTES CHRYSOCOME.

PLATE X.

PLATE X.

MUSCLES OF *Eudyptes chrysocome*.

Fig. 1.—Palmar surface of wing of *Eudyptes chrysocome*, dissected to show the muscles.

Ab. D. S.	Abductor digiti secundi.	*F. P. D.*	Flexor profundus digitorum.
B. I.	Brachialis internus.	*F. S. D.*	Flexor sublimis digitorum.
F. D. M.	Flexor digiti minimi.	*T* 1.	First head of triceps.
F. M. B.	Flexor metacarpi brevis.	*T* 2.	Second head of triceps.
F. C. U.	Flexor carpi ulnaris.	*T* 4.	Fourth head of triceps.

Fig. 2.—Dorsal surface of wing of *Eudyptes chrysocome*, dissected to show the muscles.

B. I.	Brachialis internus.	*F. M. B.*	Flexor metacarpi brevis.
E. M. R. B.	Extensor metacarpi radialis brevis.	*T. P. L.*	Tensor patagii longus and Pectoralis major.
E. M. R. L.	Extensor metacarpi radialis longus.		
E. C. D.	Extensor communis digitorum.	*T* 1.	First head of triceps.
E. C. U.	Extensor carpi ulnaris.	*T* 3.	Third head of triceps.
E. I. P.	Extensor indicis proprius.	*T* 4.	Fourth head of triceps.

Fig. 3.—Muscles of shoulder of *Eudyptes chrysocome*.

B. C.	Biventer cervicis.	*S. A. Min.*	Serratus anticus minor.
Inf. Sp.	Infra-spinatus.	*S. Sp.*	Supra-spinatus.
P. Med.	Pectoralis medius.	*T. z.*	Trapezius.
R.	Rhomboideus.	*T.* 1 & 2.	First and second heads of triceps.
S. A. Maj.	Serratus anticus major.	*T. P. L.*	Tensor patagii longus.

Fig. 4.—Diagram to show the arrangement of the tendons of insertion of the latissimus dorsi in *Eudyptes chrysocome*.

F. P.	Fibrous pulley, through which the tendons pass.	*L. D. a.*	Latissimus dorsi (portion *a*).
		L. D. b.	Latissimus dorsi (portion *b*).
H.	Humerus.	*S.*	Scapula.

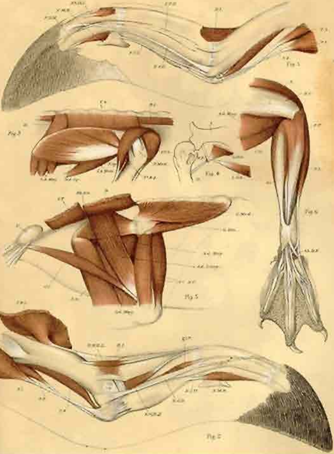
Fig. 5.—Dissection showing the muscles of the outer side of the thigh of *Eudyptes chrysocome*.

Ad. Long.	Adductor longus femoris.	*G. Min.*	Gluteus minimus.
Ad. Mag.	Adductor magnus femoris.	*Ob. Ex.*	Obturator externus.
B.	Biceps.	*S. M.*	Semi-membranosus.
C. C.	Cruro-coccygeus.	*S. T.*	Semi-tendinosus.
E. C.	Extensor cruris.	*U.*	Uropygium.
G. Med.	Gluteus medius.		

The dotted lines indicate the outline of the sartorius.

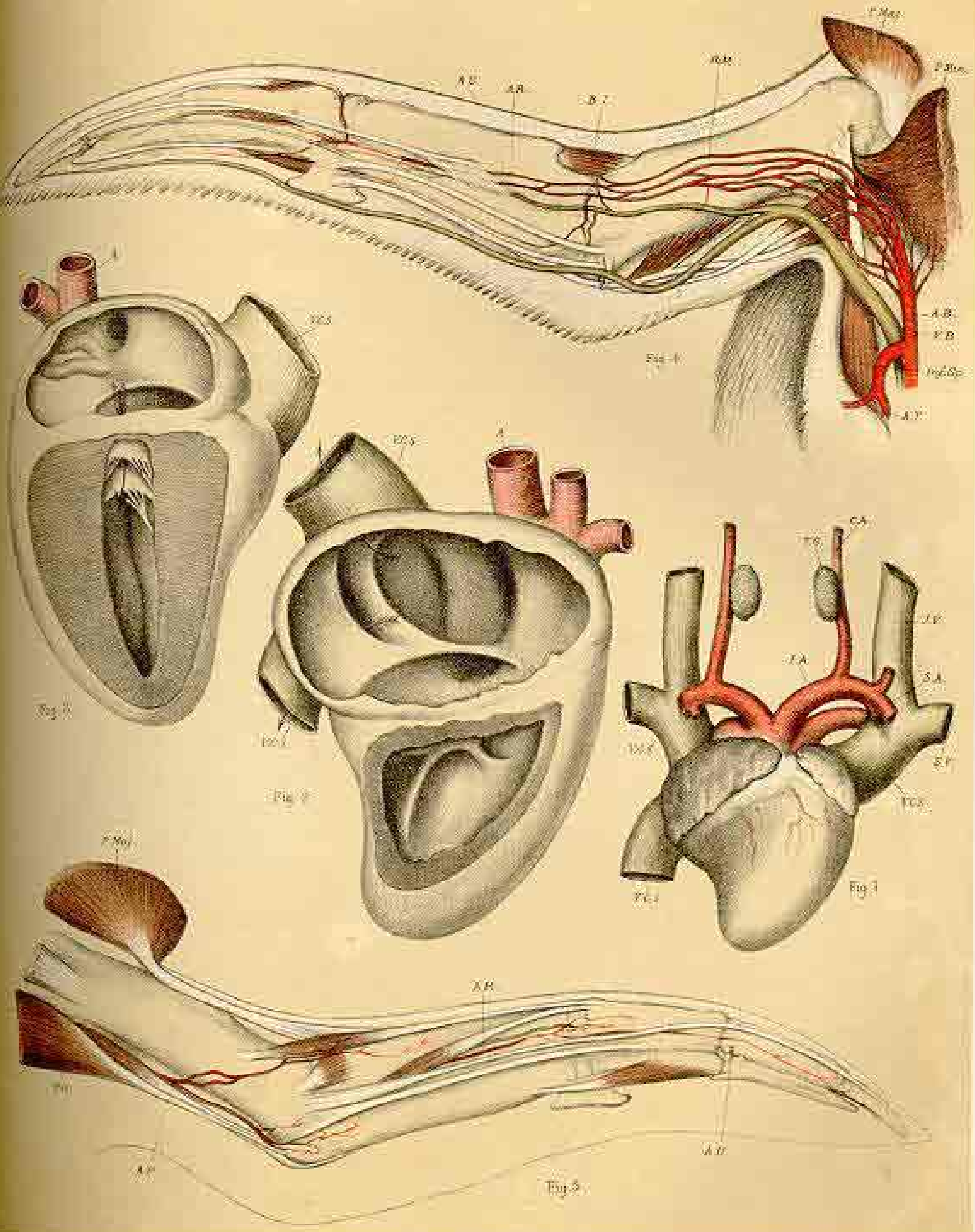
Fig. 6.—Muscles of the leg of *Eudyptes chrysocome*. The figure shows the arrangement of the tendons in the sole of the foot.

Ad. Mag.	Adductor magnus.	*G. i.*	Inner head of the gastrocnemius.
Ab. D. E.	Abductor digiti externi.	*P. L.*	Peroneus longus.
E. C.	Extensor cruris.	*S.*	Sartorius.
F. P.	Flexor perforatus digitorum.	*S. M.*	Semi-membranosus.



MUSCLES OF EUDYPTES CHRYSOCOME

PLATE XI.



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Bernhard imp.

ORGANS OF CIRCULATION

PLATE XII.

PLATE XII.

VISCERA OF PENGUINS.

Fig. 1.—Upper surface of brain of *Aptenodytes longirostris*; natural size.

Fig. 2.—Upper surface of brain of *Eudyptes chrysocome*; natural size.

Fig. 3.—Upper surface of brain of *Spheniscus demersus*; natural size.

Fig. 4.—Interior of stomach of *Spheniscus minor*; natural size. *D.* Duodenum. *M. S.* Muscular portion of stomach. *Œ.* Œsophagus. *P. G.* Proventricular gland.

Fig. 5.—Spleen of *Spheniscus minor*; natural size.

Fig. 6.—Lung of *Eudyptes chrysocome*, showing the foramina by means of which the air sacs communicate with the lung.

Fig. 7.—Diagram to show communications of the renal veins.

C. C.	Crural veins, each dividing into four branches—1, 2, 3, 4.
H.	Hypogastric veins.
C. M.	Coccygo-mesenteric vein forming the commencement of the vena portæ.
V. C. I.	Vena cava inferior.

Fig. 8.—Diagram of arterial system of *Eudyptes chrysocome*.

1. Aorta. 2. Innominate artery. 3. Subclavian artery. 4. Vertebral artery. 5. Internal mammary artery. 6. Thoracic artery. 7. Brachial artery. 8. Common carotid artery. 9. Subcutaneous cervical artery. 10. Anastomotic artery. 11. Œsophageal artery. 12. Lingual artery. 13 Bronchial artery. 14. Intercostal arteries. 15. Cœliac axis. 16. Splenic arteries. 17. Anterior gastric artery. 18. Hepatic arteries. 19. Posterior gastric artery. 20. Intestinal artery. 21. Superior mesenteric artery. 22. Renal arteries. 23. Lumbar arteries. 24. Crural artery. 25. Pelvic branch of crural artery. 26. Inferior mesenteric artery. 27. Hypogastric artery. 28. Middle sacral artery.

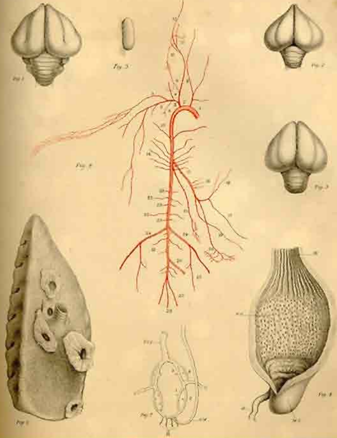

Fig. 1

Fig. 5

Fig. 2

Fig. 3

Fig. 4

Fig. 6

Fig. 7

Fig. 8

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Hanhart imp.

VISCERA OF

1.APTENODYTES LONGIROSTRIS. 2&6.EUDYPTES CHRYSOCOME

3.SPHENISCUS DEMERSUS. 4,5,S.MINOR.

PLATE XIII.

PLATE XIII.

Digestive organs of *Eudyptes chrysocome*, from Kerguelen Island.

Fig. 1.—Tongue and floor of mouth; natural size.

B. P.	Buccal group of papillæ.
L. F.	Apertures of ducts of lingual glands.
L. P.	Laryngeal pad, separated from its fellow by the superior aperture of the larynx.
Œ.	Commencement of the œsophagus.
T.	Tongue.

Fig. 2.—Roof of mouth; natural size.

P.	Horny plate which completes the palate in front.
P. G.	Apertures of ducts of palatal glands.
P. L.	Palate covered with recurved papillæ.

Fig. 3.—Exterior of stomach of *Eudyptes chrysocome*, from Kerguelen; half natural size.

D.	Duodenum.
G. S.	Glandular portion of stomach.
M. S.	Muscular portion of stomach or gizzard.
Œ.	Œsophagus.

Fig. 4.—Interior of stomach of *Eudyptes chrysocome*, from Kerguelen; half natural size.

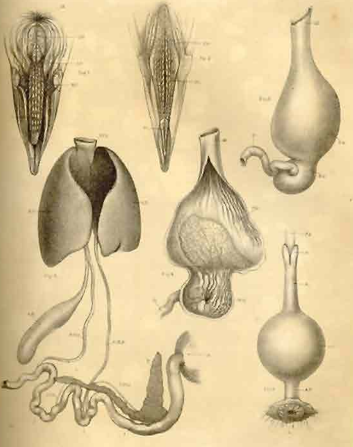
D.	Duodenum.
M. S.	Muscular portion of stomach or gizzard, showing the longitudinal rugæ converging towards the pyloric orifice.
Œ.	Œsophagus, showing the longitudinal rugæ.
P. G.	Proventricular gland.

Fig. 5.—Liver and pancreas of *Eudyptes chrysocome*, from Kerguelen; natural size.

G. B.	Gall bladder.
I. I. I.	Intestine.
L. H. D.	Left hepatic duct.
L. L.	Left lobe of liver.
L. P. D.	Lower pancreatic duct.
P. P.	Pancreas.
R. H. D.	Right hepatic duct.
R. L.	Right lobe of liver.
S.	Stomach.
U. P. D.	Upper pancreatic duct.
V. C. I.	Vena cava inferior.

Fig. 6.—Great intestine of *Eudyptes chrysocome*, from Kerguelen, seen from the front.

A.	Anus.
A. P.	Anal passage.
C.	Cæca closely applied to one another below the gut.
Cl.	Cloaca.
R.	Rectum.
S. I.	Termination of small intestine.



DIGESTIVE ORGANS OF EUDYPTES CHRYSOCOME

PLATE XIV.

PLATE XIV.

Digestive organs of Penguins.

(All the figures are of the natural size.)

Fig. 1.—Tongue and floor of mouth of *Eudyptes chrysolophus.*

B. P.	Buccal group of papillæ.
L. F.	Apertures of ducts of lingual glands.
L. P.	Laryngeal pad, separated from its fellow by the superior aperture of the larynx.
Œ.	Commencement of œsophagus.
T.	Tongue.

Fig. 2.—Roof of mouth of *Eudyptes chrysolophus.*

P.	Horny plate which completes the palate in front.
P. G.	Apertures of ducts of palatal glands.
P. L.	Palate covered with papillæ.

Fig. 3.—Tongue and floor of mouth of *Spheniscus magellanicus.* Letters as in fig. 1.

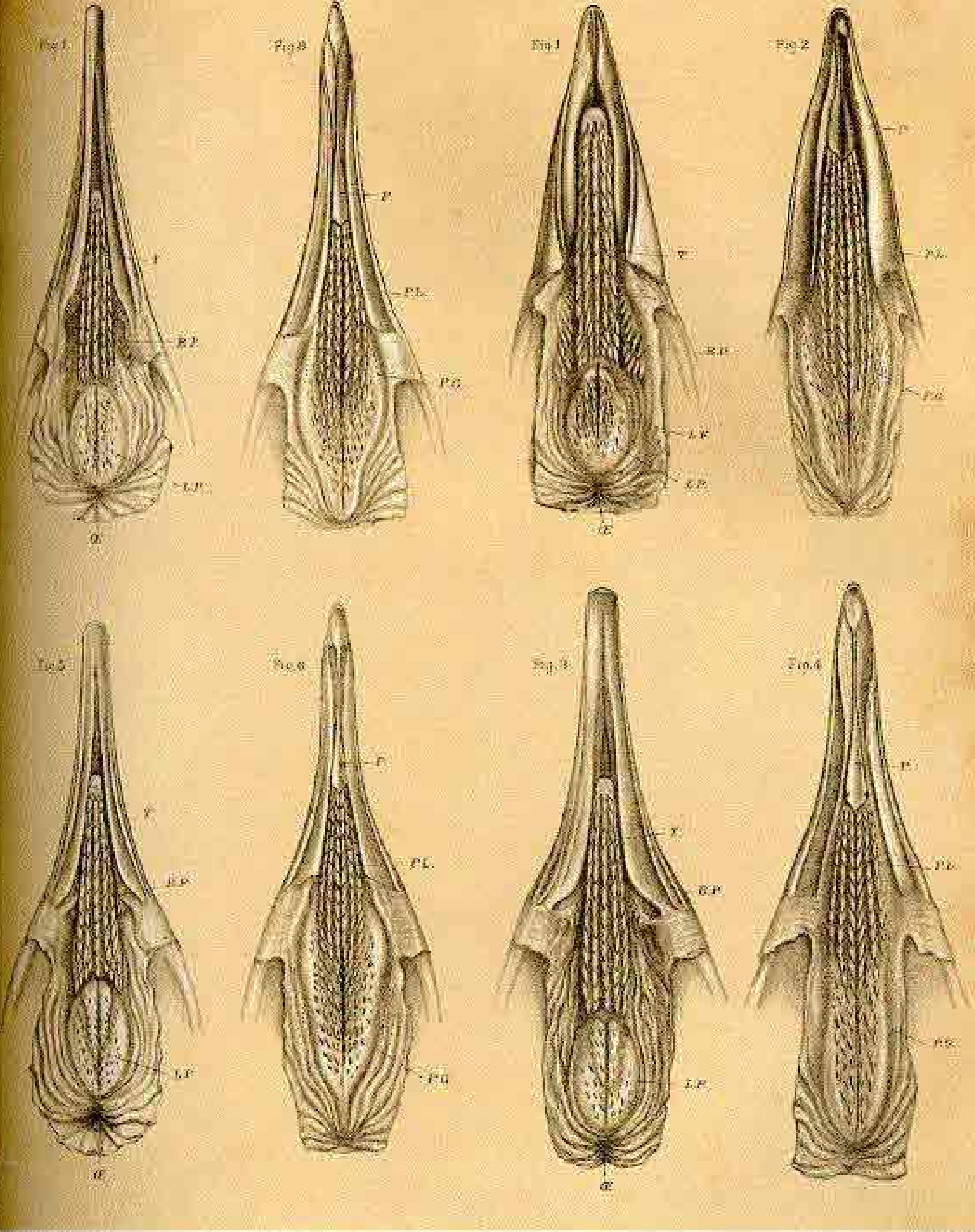
Fig. 4.—Roof of mouth of *Spheniscus magellanicus.* Letters as in fig. 2.

Fig. 5.—Tongue and floor of mouth of *Spheniscus demersus.* Letters as in fig. 1.

Fig. 6.—Roof of mouth of *Spheniscus demersus.* Letters as in fig. 2.

Fig. 7.—Tongue and floor of mouth of *Spheniscus mendiculus.* Letters as in fig. 1.

Fig. 8.—Roof of mouth of *Spheniscus mendiculus.* Letters as in fig. 2.



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DIGESTIVE ORGANS OF
1, 2, EUDYPTES CHRYSOLOPHUS. 3, 4, SPHENISCUS MAGELLANICUS.
5, 6, S. DEMERSUS. 7, 8, S. MENDICULUS.

PLATE XV.

PLATE XV.

Digestive organs of Penguins.

(All the figures are of the natural size.)

Fig. 1.—Tongue and floor of mouth of *Pygosceles tæniatus.*

B. P.	Buccal group of papillæ.
L. P.	Laryngeal pad, separated from its fellow by the superior aperture of the larynx.
Œ.	Commencement of œsophagus.
T.	Tongue.

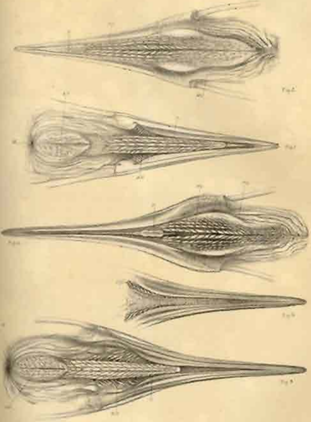
Fig. 2.—Roof of mouth of *Pygosceles tæniatus.*

P.	Horny plate which completes the palate in front.
P. G.	Apertures of ducts of palatal glands.
P. L.	Palate covered by papillæ.

Fig. 3.—Tongue and floor of mouth of *Aptenodytes longirostris.* Letters as in fig. 1.

Fig. 4.—Roof of mouth of *Aptenodytes longirostris.* Letters as in fig. 2.

Fig. 5.—Floor of mouth of *Aptenodytes longirostris* showing the double row of papillæ with which its margins are provided.



DIGESTIVE ORGANS OF

1.2 PYGOSCELES TÆNIATUS. 3.4.5. APTENODYTES LONGIROSTRIS.

PLATE XVI.

PLATE XVI.

DIGESTIVE ORGANS OF PENGUINS.

Fig. 1.—Interior of stomach of *Eudyptes chrysolophus*; half natural size.

D.	Duodenum.
M. S.	Muscular portion of stomach (gizzard).
Œ.	Œsophagus.
P. G.	Proventricular gland.

Fig. 2.—Interior of stomach of *Spheniscus demersus*; half natural size. Letters as in fig. 1.

Fig. 3.—Interior of stomach of *Spheniscus magellanicus*; half natural size. Letters as in fig. 1.

Fig. 4.—Interior of stomach of *Spheniscus mendiculus*; half natural size. Letters as in fig. 1.

Fig. 5.—Spleen of *Eudyptes chrysocome*, from Kerguelen; natural size.

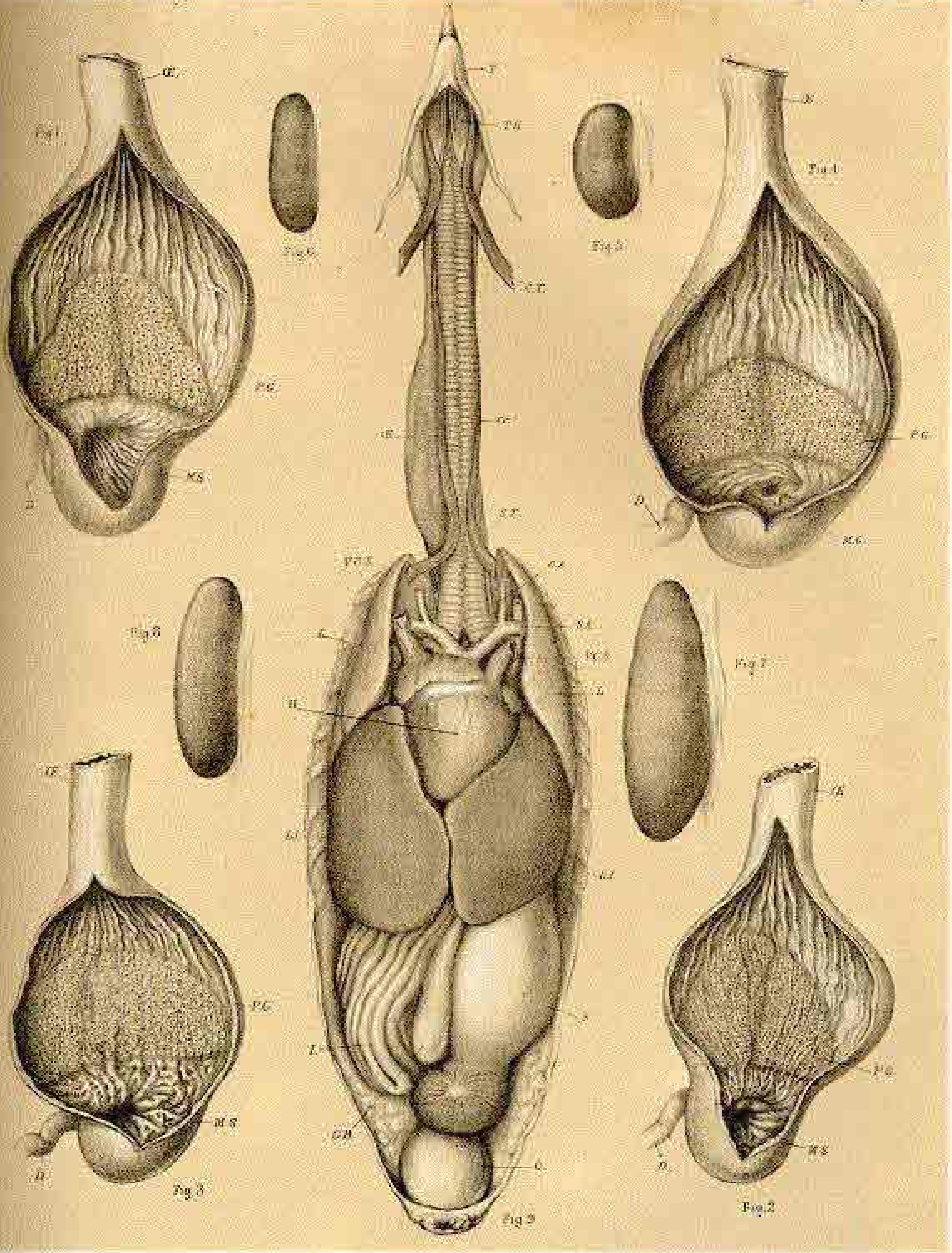
Fig. 6.—Spleen of *Eudyptes chrysolophus*; natural size.

Fig. 7.—Spleen of *Spheniscus demersus*; natural size.

Fig. 8.—Spleen of *Spheniscus magellanicus*; natural size.

Fig. 9.—Dissection of *Spheniscus demersus*, to show the relative positions of the thoracic and abdominal viscera in the Spheniscidæ.

C.	Cloaca.
C. A.	Carotid artery.
C. T.	Cleido-thyroid muscle.
G. B.	Gall bladder.
H.	Heart.
I.	Small intestine.
L. L.	Lungs.
LI. LI.	Liver.
Œ.	Œsophagus.
S.	Stomach.
S. A.	Subclavian artery.
S. T.	Sterno-tracheal muscle.
T.	Tongue.
T. H.	Thyro-hyoid muscle.
Tr.	Trachea.
V. C. S.	Vena cava superior right and left.



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Hanhart imp.

DIGESTIVE ORGANS OF
5, EUDYPTES CHRYSOCOME. 6, 1, E. CHRYSOLOPHUS. 2, 7, 9, SPHENISCUS DEMERSUS.
3, 8, S. MAGELLANICUS. 4, S. MENDICULUS.

PLATE XVII.

PLATE XVII.

VISCERA OF PENGUINS.

Fig. 1.—Interior of stomach of *Pygoscelis tæniatus*; one-half natural size.

D.	Duodenum.
M. S.	Muscular portion of stomach.
Œ.	Œsophagus.
P. G.	Proventricular gland.

Fig. 2.—Interior of stomach of *Aptenodytes longirostris*; one-half natural size. Letters as in fig. 1.

Fig. 3.—Spleen of *Pygoscelis tæniatus*; natural size.

Fig. 4.—Spleen of *Aptenodytes longirostris*; natural size.

Fig. 5.—Exterior of cloaca and bursa fabricii of male *Eudyptes chrysocome*, from Kerguelen, seen from behind; natural size.

A. P.	Anal passage.
B. F.	Bursa fabricii.
Cl.	Cloaca.
I.	Intestine.

The figure shows the small size of the bursa fabricii, as compared with the cloaca.

Fig. 6.—Cloaca, bursa fabricii, &c., of male *Aptenodytes longirostris*, seen from behind; natural size.

B. F.	Bursa fabricii opened to show the spongy character of its mucous membrane.
Cl.	Cloaca.
G. I.	Great intestine.
L. A.	Levator ani.
Ur.	Ureter.
V. D.	Vas deferens.

The figure shows the large size of the bursa fabricii, as compared with the cloaca.

Fig. 7.—Male urinary and generative organs of *Eudyptes chrysocome*, from Kerguelen, seen from the front; natural size.

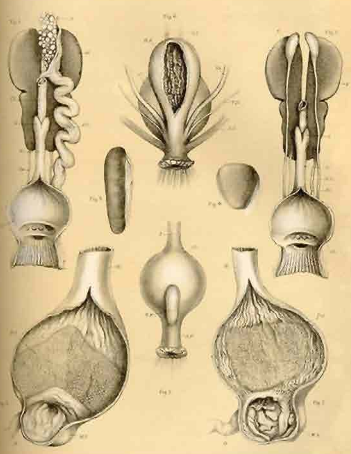
C.	Cæcum.
Cl.	Cloaca.
K.	Kidney.
R.	Rectum.
T.	Testicle.
Ur.	Ureter.
V. D.	Vas deferens.

This figure shows the cloaca opened to expose its two compartments. In the posterior compartment are seen the papillary eminences on the apices of which the ducts of the kidneys and vasa deferentia open. Behind the cloaca is the anal passage, with the orifice of the bursa fabricii.

Fig. 8.—Female urinary and generative organs of *Eudyptes chrysocome*, from Kerguelen, seen from the front; natural size.

C.	Cæcum.
Cl.	Cloaca.
K.	Kidney.
O.	Ovary.
Ov.	Left oviduct.
R.	Rectum.
S. I.	Small intestine.
Ur.	Ureter.

This figure shows the cloaca opened to expose its two compartments. In the posterior compartment are seen the papillary eminences on the apices of which the ureters open, the rudimental papilla which indicates the point of entrance of the atrophied oviduct of the right side, and the orifice of the left oviduct. Behind the cloaca is the anal passage, with the orifice of the bursa fabricii.



VISCERA OF
1.3. PYGOSCELES TÆNIATUS. 2.4.6. APTENODYTES LONGIROSTRIS.
5.7.8. EUDYPTES CHRYSOCOME.

PLATE XVIII.

PLATE XVIII.

RESPIRATORY ORGANS OF *Aptenodytes longirostris.*

(All the figures are of the natural size.)

Fig. 1.—Cartilages of the upper larynx, seen from below. *A. C.* Anterior extremities of the arytenoid cartilages. *T.* Trachea. *T. C.* Thyroid cartilage.

Fig. 2.—Cartilages of the upper larynx, seen from above. *A. C.* Arytenoid cartilage. *C. C.* Cricoid cartilage. *T.* Trachea. *T. C.* Thyroid cartilage.

Fig. 3.—Cartilages of the upper larynx, lateral view. *A. C.* Arytenoid cartilage. *C. C.* Cricoid cartilage. *T.* Trachea. *T. C.* Thyroid cartilage.

Fig. 4.—Muscles of upper larynx. *A. L.* Apertor laryngis. *L. P.* Portion of laryngeal pad. *S. L.* Sphincter laryngis. *T.* Trachea.

Fig. 5.—The upper larynx after removal of the sphincter laryngis. *A. L.* Apertor laryngis. *T.* Trachea. *T. C.* Thyroid cartilage.

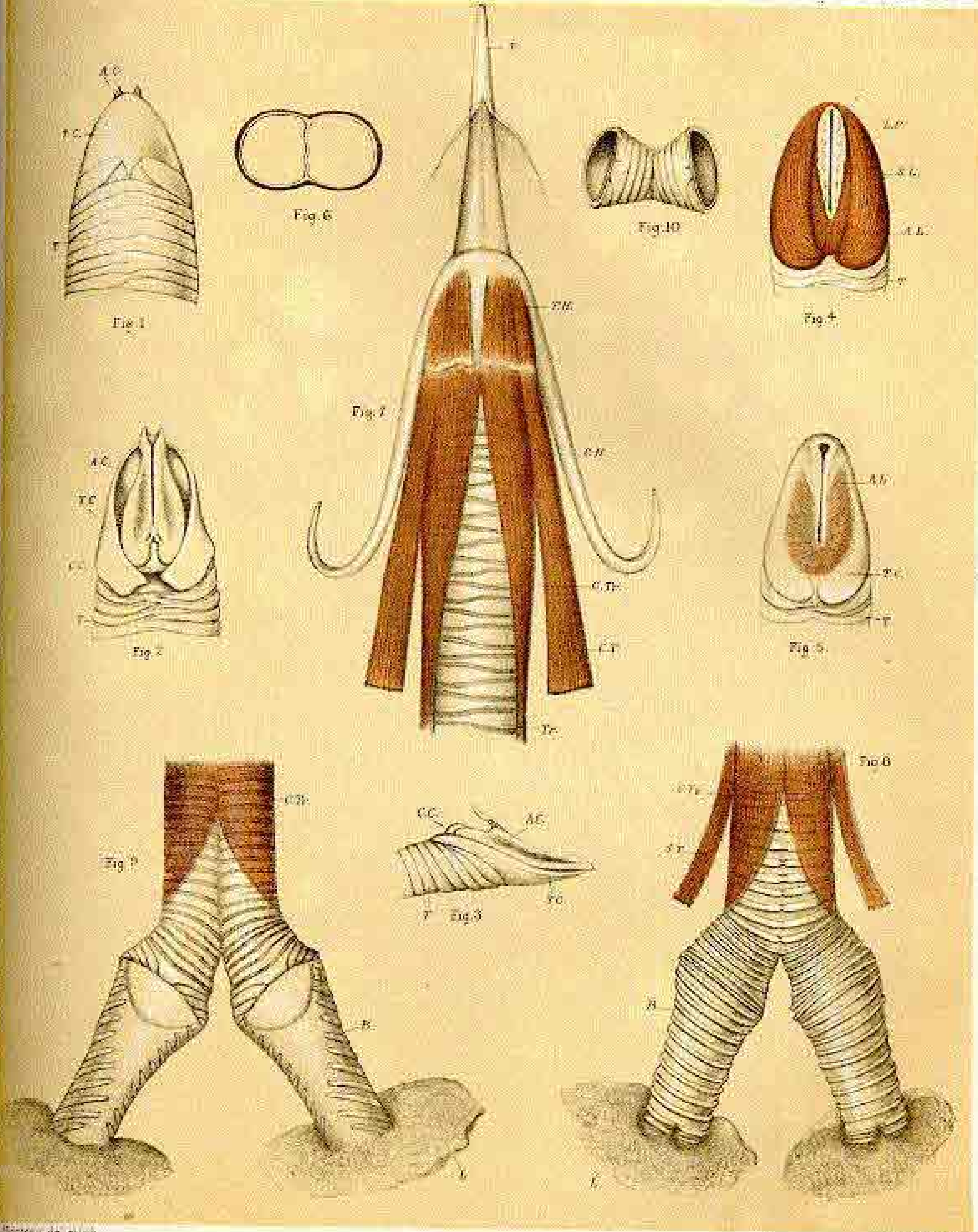
Fig. 6.—Transverse section of trachea, showing the septum which divides the tube into two passages.

Fig. 7.—Tongue, upper larynx, and anterior portion of trachea; ventral surface. *C. H.* Cornu of hyoid bone. *C. T.* Cleido-thyroid muscle. *C. Tr.* Contractor tracheæ muscle. *T. H.* Thyro-hyoid muscle. *T.* Tongue. *Tr.* Trachea.

Fig. 8.—Posterior extremity of trachea, with the lower larynx and bronchi; ventral surface. *B.* Bronchus. *C. Tr.* Contractor tracheæ muscle. *L.* Lung. *S. T.* Sterno-trachealis muscle.

Fig. 9.—Posterior extremity of trachea, with the lower larynx and bronchi; dorsal surface. *B.* Bronchus. *C. Tr.* Contractor tracheæ muscle. *L.* Lung.

Fig. 10.—Framework of lower larynx.



RESPIRATORY ORGANS OF APTENODYTES LONGIROSTRIS.

PLATE XIX.

PLATE XIX.

Respiratory organs of Penguins.

(All the figures are of the natural size.)

Fig. 1.—Posterior extremity of trachea of *Eudyptes chrysocome*, from Tristan d'Acunha; dorsal surface. *B.* Bronchus. *C. Tr.* Contractor tracheæ muscle. *L.* Lung. *P.* Fibrous pad attached to the membranous portion of the bronchus. *S. T.* Sterno-tracheal muscle.

Fig. 2.—Posterior extremity of trachea of *Eudyptes chrysocome*, from Tristan d'Acunha; ventral surface. *B.* Bronchus. *L.* Lung. *Tr.* Trachea.

Fig. 3.—Posterior extremity of trachea of *Eudyptes chrysocome*, from the Falkland Islands; dorsal surface. Letters as in fig. 1. The drawing shows the absence of the fibrous pad found in *Eudyptes chrysocome*, from Tristan d'Acunha.

Fig. 4.—Posterior extremity of trachea of *Eudyptes chrysolophus*; ventral surface. Letters as in fig. 2.

Fig. 5.—Posterior extremity of trachea of *Eudyptes chrysolophus*; dorsal surface. Letters as in fig. 1.

Fig. 6.—Framework of lower larynx of *Eudyptes chrysolophus*.

Fig. 7.—Posterior extremity of trachea of *Spheniscus magellanicus*; ventral surface. Letters as in fig. 2.

Fig. 8.—Posterior extremity of trachea of *Spheniscus magellanicus*; dorsal surface. Letters as in fig. 1.

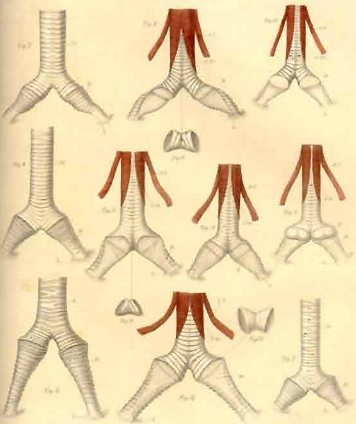
Fig. 9.—Framework of lower larynx of *Spheniscus magellanicus*.

Fig. 10.—Posterior extremity of trachea of *Spheniscus mendiculus*; dorsal surface. Letters as in fig. 1.

Fig. 11.—Posterior extremity of trachea of *Pygosceles tæniatus*; ventral surface. Letters as in fig. 2.

Fig. 12.—Posterior extremity of trachea of *Pygosceles tæniatus*; dorsal surface. Letters as in fig. 1.

Fig. 13.—Framework of lower larynx of *Pygosceles tæniatus*.



RESPIRATORY ORGANS OF
1.2. EUDYPTES CHRYSOCOME [illegible] 3.4. E. CHRYSOCOME [illegible]
5&6. E. CHRYSOLOPHUS. 7.8.9. SPHENISCUS MAGELLANICUS.
10. S. MENDICULUS. 11.12.13. PYGOSCELES TAENIATUS.

THE
VOYAGE OF H.M.S. CHALLENGER.

ZOOLOGY.

REPORT on the Pelagic Hemiptera procured during the Voyage of H.M.S. Challenger, in the years 1873–1876. By F. Buchanan White, M.D., F.L.S.

I. HISTORY AND BIBLIOGRAPHY.

The only Pelagic Hemiptera, and indeed the only truly pelagic insects, belong to the genus *Halobates* and one or two allied genera. *Halobates* was founded in 1822 by Professor J. Friedrich Eschscholtz, of the University of Dorpat, for the reception of three species taken during von Kotzebue's voyage round the world in the ship "Rurick." Since that time a few other species have been described, but specimens are still rare in collections, and consequently little has been added to our knowledge of the genus.

A special interest is attached to these animals, as being the only pelagic representatives of their class. It is true that a few other insects are marine,[1] but they are all found in close proximity to the shore, whereas the species of *Halobates* usually, and in some cases only, occur at a considerable distance from any land. Moreover, their structure would seem to indicate that they are archaic forms of very great antiquity, and hence all that can be learned with regard to them is of very great importance.

Abundantly as they seem to be distributed in the tropical seas, specimens are very rare in collections, and, when named at all, are in most cases wrongly determined.

For these reasons it has been deemed advisable to attempt a monograph of the genus, though it is probable that many species yet remain to be discovered by those who have the opportunity and the will to turn their attention in this direction.

The literature of the genus is not extensive, but, as it is much scattered, it has been

---

[1] Amongst these may be noticed species of *Aëpus*, *Hesperophilus*, *Micralymma*, &c., belonging to the Coleoptera; *Aëpophilus* amongst the Hemiptera; two Caddis-flies (*Philanisus plebejus* and *Molanna*, sp.) amongst the Neuroptera; and a few Diptera (such as *Chironomus oceanicus*); which either in the perfect or in the larval condition habitually live below high-water mark. In addition to these some other species are to be found occasionally in salt or brackish water.

thought desirable to reproduce in this monograph the more important parts of it, in order that those who wish to study the species in their native localities may have every facility for so doing. Moreover, since the types of several of the described species have apparently disappeared, it is desirable that the student should have, in an easily accessible form, the exact words of those who have written on the subject.

We will therefore begin by reproducing, in chronological order, the more important writings on the subject.

I.—J. Friedrich Eschscholtz.

Entomographien, Erste Lieferung, 1822, p. 106, Taf. ii. figs. 3, 4, and 5. Also *Naturwissenschaftlich. Abhandl. aus Dorpat*, 1823, p. 163, Taf. ii. figs. 3, 4, and 5.

"78a. *Halobates.*

"Diese neue Wanzengattung aus der Familie Cimicides Ploteres Latr. ist mit Velia und Gerris Latr. sehr nahe verwandt und hat sich den Ocean zum Jagdrevier erwählt; man kann sie so bezeichnen:

"Antennæ articulo basali elongato. Rostrum breve, conicum, vagina triarticulata. Collare annuliforme. Thorax maximus, apterus. Tarsi antici triarticulati; articulo secundo ultra tertium unguiculatum protenso; posteriores biarticulati, exunguiculati.

"Der Kopf ist vorgestreckt, breit. Augen gross; Nebenaugen fehlen. Kopfschild vorgestreckt, gewölbt. Oberlippe eiförmig, gekrümmt, spitz. Rüsselscheide dreigliedrig; das erste Glied kurz breit, das zweite das längste, und das Endglied gekrümmt und spitz. Borsten drei. Fühler vor den Augen auf einer starken Erhöhung des Kopfs sitzend, viergliedrig, fadenförmig; das erste Glied das längste.

"Halsschild sehr kurz, ringförmig. Mittelleib sehr gross, ungeflügelt. Hinterleib sehr kurz. Afterdecke des Männchens spitz; des Weibchens gross breit rautenförmig. Vorderbeine kurz mit dicken Schenkeln; Schienen von gleicher Länge mit letztern, walzenförmig, am Ende mit einem nach innen vorspringenden hakenförmigen Fortsatze, der in eine Furche zwischen Beinwurzel und Schenkel passt; die Füsse dieser Beine scheinen, von oben betrachtet, nur aus zwei ziemlich langen dicken Gliedern zu bestehen; aber an der Unterseite des zweiten längern Gliedes bemerkt man noch ein drittes sehr kurzes abstehendes Glied, das am Ende mit zwei gekrümmten Haken bewaffnet ist.

"Mittlere Beine zwei bis dreimal länger als der Körper, dem Mittelleibe an seinem untern und hintersten Theile angefügt; Hüftglied sehr dick, kurz; Gelenkkopf lang und mit seinem zugespitzten Ende dem Schenkel von der Seite angeheftet; Schenkel sehr lang, walzenförmig; Schienen dünner und um mehr als die Hälfte kürzer. Füsse zweigliedrig; das erste wenig kürzer, als die Schienen und gewöhnlich gekrümmt; das Endglied kurz, fein und am Ende mit einigen langen Haaren bewaffnet.

"Hinterbeine über den mittlern eingefügte, um ein Drittheil kürzer als diese, mit längern Hüftgliedern, feinern Schienen und Fussgliedern, von welchen letztern das erste Glied kaum länger als das zweite zugespitzte und langebehaart ist.

"Der Körper ist mit sehr feinen silberfarbenen Schuppen bedeckt, die Beine gewöhnlich schwarz. Die Thierchen springen auf der Oberfläche des Meeres herum, und kommen nur in den Tropen oder in der Nähe derselben vor. Drei mir bekannt gewordene Arten unterscheiden sich folgendermassen:

"78. b. *Halobates micans* (Taf. ii. fig. 3).

"H. corpore conico, subtus argenteo, supra cinereo æneo micante; oculis atris.

"Im südlichen stillen Meere und im südlichen atlantischen Meere.

"Länge $1\frac{1}{3}$ Linien, grösste Breite eine Linie. Kopf breiter wie lang, gewölbt, der grösste Theil grau, der vordere Rand silberweiss. Augen zur Seite des Kopfs hervorstehend, gross, schwarz. Fühler etwas länger als der halbe Körper, am Ende etwas verdickt, Glieder walzenförmig, schwarz, matt; das erste so lang, als die übrigen zusammengenommen, die beiden folgenden gleich lang, das letzte etwas länger als das vorhergehende.

"Halsschild breiter als der Kopf (ohne Augen), mehr als dreimal breiter als lang, vorn stark und hinten kaum merklich ausgeschnitten, Seiten gerade, hinabhängend, Oberfläche kaum gewölbt mit zwei länglichen Eindrücken am Vorderrande; grau etwas glänzend. Mittelleib vorn etwas breiter, als das Halsschild, bis hinter der Mitte ziemlich stark erweitert, dann gleich breit, fast zweimal so lang als Kopf und Halsschild zusammen, vorn gewölbt, hinten ausgehöhlt abschüssig, mit einer kleinen etwas unbestimmten mittlern Längskante am letztern Orte; schwärzlich grau mit Messingglanz. Hinterleibsringe weissgrau. Unterseite des ganzen Körpers silberweiss. Beine schwarz, Vorderschenkel bläulich an der Innenseite weiss behaart; so auch die Vorderschienen.

"Ich sah von dieser Art nur einige Männchen.

"79. *Halobates sericeus* (Taf. ii. fig. 4).

"H. corpore ovali, subtus argenteo, supra albo cinereo; oculis flavis.

"Im nördlichen stillen Meere in der Nähe des Aequators.

"Länge $1\frac{1}{3}$, Breite $\frac{2}{3}$ Linien, Körper länglich. Kopf etwas grösser und starker gewölbt, als beim vorigen; mit zwei kleinen Punkten, weissgrau. Augen gelbbraun. Fühler wie beim vorigen; so auch das Halsschild, nur sind hier die Quereindrücke stärker. Mittelleib vorn deutlich breiter, als das Halsschild, anderthalbmal so lang als Kopf und Halsschild zusammen, in der Mitte ein wenig erweitert, Oberfläche vorn schwach gewölbt, hinten flach, weissgrau, ohne Glanz; Hinterleibsrücken von derselben Farbe. Körper unten silberweiss, flach. Vorderbeine grau, hintere Beine schwarz.

"Von dieser sehr häufigen Art sind mir beide Geschlechter vorgekommen.

"30. *Halobates flaviventris* (Taf. ii. fig. 5).

"H. corpore cylindrico, subtus argenteo, supra albo; abdomine maculisque pectoris apice flavis.

"Im südlichen atlantischen Meere.

"Länge 2 Linien, Breite $\frac{2}{3}$ Linien. Kopf stark gewölbt, weiss, im Rücken eine gelbliche erhabene Linie. Fühler fast so lang als der Mittelleib, schwarz; das erste Glied viel länger als die übrigen etwas dickern, das zweite etwas länger als jedes der beiden letztern unter sich gleich langen Glieder. Augen bei einem Exemplare ganz schwarz, beim andern gelb.

"Halsschild drittehalbmal so breit als lang, weiss, mit zwei eingedrückten Punkten. Mittelleib vorn viel breiter als das Halsschild, lang, in der Mitte kaum breiter als an beiden Enden, vorn gewölbt, hinten platt mit zwei eingedrückten Punkten. Körper unten silberweiss; der Bauch und ein grosser Fleck auf dem hervorragenden Theile der Brust, welcher die mittlern Beine trägt, gelb. Vorderbeine im Verhältniss zu den übrigen Arten lang, schwarzgrau; die übrigen Beine sehr lang und fein, schwarz.

"Ich sah nur zwei Weibchen. Ein Halobates, der sich im Brittischen Museum befindet, ist in der Nähe des Ausflusses des Congostroms gefangen worden; zu welcher Art er aber gehöre, ist mir nicht bekannt."

[Though the description of the genus is erroneous in several important particulars (the rostrum is four and not three-jointed, the front tarsus is two and not three-jointed, and the hind tarsus is one-jointed, and has, as well as the middle tarsus, claws), it must be remembered that appliances for the examination of the smaller parts of insects were not so perfect in 1822 as they are now, and that Eschscholtz's descriptions are on the whole much more correct than some subsequent writers have imagined. It is to be noted that he confounded the sexes, a mistake in which he has been followed by almost all his successors.—F. B. W.]

II.—F. L. DE LAPORTE, Comte de Castelnau.

Essai d'une Classification Systématique de l'ordre des Hémiptères. Guérin-Méneville's *Magasin de Zoologie*, p. 24, 1833.

"Genre 4. *Halobates*, Esch.

"Antennæ sat breves, articulis 4, post primum fractæ; 1° cæteros unà longitudine æquante; 3° præcedenti breviore; ultimo cylindrico, subovato.—Rostrum brevissimum validum.—Tarsi elongati, articulis vix conspicuis; antici haud unguiculati.—Corpus brevissimum, convexum; abdominis articulis vix conspicuis, imbricatis.—Pedes postici suprà intermedios inserti.

"Tête large, yeux assez saillant; corselet grand, presque carré, alongé, coupé carrément en arrière; pas d'écusson; abdomen ne formant pas la sixième partie de la longeur du corselet; pattes antérieures courtes, les autres très longues; base des cuisses postérieures placées au-dessus des intermédiaires.

"Ces insectes habitent parmi les plantes marines des mers de l'océan Indien.

"*Halobates micans*, Escholtz., Entom., 1822, p. 106, No. 78.

"Ajoutez; *H. flaviventris* et *H. sericeus* du même, et une nouvelle espèce que nous possédons et qui vient des mers de la *Nouvelle-Guinée*."

[The author figures in outline *H. flaviventris*, Esch., and gives enlarged drawings of an antenna and front leg. Notwithstanding his remark "haud unguiculati," the front tarsus is represented with two claws. The hind tarsus is represented as two-jointed. Whatever species the drawing was taken from, it certainly does not represent *H. flaviventris*, Esch.—F. B. W.]

III.—Dr. Hermann Burmeister.

Handbuch der Entomologie. Zweiter Band, p. 208, 1835.

"1. (92.) Gatt. *Halobates*, Esch., Lap.[1]

"Fühler viergliedrig, das erste Glied so lang als das zweite und dritte zusammen, beide von gleicher Länge, das vierte etwas länger und dicker. Augen vorragend, keine Nebenaugen. Mittelbrustring sehr gross, stark nach hinten verlängert, so dass die Gelenkgruben der Mittelbeine unter denen der hinteren stehen. Flügel fehlen. Beine ungleich, die vorderen kurz mit verdickten Schenkel, aufrechtstehend; Füsse zweigliedrig, Krallen in einen Ausschnitt an der Unterseite in der Mitte des zweiten Gliedes befestigt, klein. Die vier hinteren Beine, besonders die mittleren, stark verlängert, fein, verjüngt; Fussglieder ungleich, das erste 6 mal so lang als das zweite, an den hintersten Beinen fast gleich lang, gewimpert. Hinterleib äusserst klein, kegelförmig, eng an den Bruststkasten angezogen.

"Die Arten leben auf der Oberfläche des Meeres zwischen den Tropen; drei wurden zuerst von Herrn Eschscholz auf Kotzebue's erster Reise um die Welt entdeckt, andere an der Küste von Mexico und Brasilien gefangene befinden sich im Königl. Museum.

"1. *H. micans*.—Corpore conico, subtus argenteo, supra cinereo, aeneo-micante; oculis atris. Long. $1\frac{2}{3}$.'''"

"Esch., Entomogr. (In den *Naturwissenschaftlich. Abhandl. aus Dorpat*, 1823. 8.) p. 163. 78. 6. tab. 2. fig. 3.

"Auf dem südlichen stillen Meere und dem südlichen atlantischen Meere.

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[1] "Wie leichtfertig Herrn Laporte's Untersuchungen zum Theil sind, davon liefert Nichts einen besseren Beweis, als wenn mann seine Charakteristik dieser Gattung mit der Natur vergleicht."

"2. *H. sericeus.*—Corpore ovali, subtus argenteo, supra albo-cinereo; oculis flavis. Long. $1\frac{1}{3}'''$.

"Esch. ebenda p. 164. 79. tab. 2. fig. 4.—Laport. Hém., pp. 24. 4.

"Ziemlich häufig auf dem nördlichen stillen Meere in der Nähe des Aequators.

"3. *H. flaviventris.*—Corpore cylindrico, subtus argenteo, supra albo; abdomine maculisque duabus pectoris apicalibus flavis.

"Esch. ebenda 165. 80. tab. 2. fig. 5.

"Auf dem südlichen atlantischen Ozean."

[Dr. Burmeister follows Eschscholtz in ascribing two joints to the hind tarsus. He is also mistaken in thinking that the relative lengths given by him of the joints of the middle tarsus are generic characters. They, in fact, differ in the various species.—F. B. W.]

IV.—ROBERT TEMPLETON, R.A.

Description of a new Hemipterous Insect from the Atlantic Ocean. *Transactions of the Entomological Society of London*, vol. i. p. 230, 1836.

"HYDROMETRIDÆ, Leach.

"Genus *Gerris*, Latr.

"Sub-genus *Halobates*, Eschscholtz (Entomographien).

"Sp. *H. Streatfieldana*, pl. xxii. fig. A.

"Broadly ovate, or lozenge-shaped, brilliant black; eyes, two minute spots near the prothorax, and the sides and apices of the first uncovered pair of abdominal annuli (4th and 5th) rufous; beneath brownish-black, the first five abdominal rings yellowish with rufous apices, offering the appearance of five narrow transverse fasciæ; last rings broad and rufous black. Apterous.

"Length, 0·13 inch.

"Found on the Atlantic Ocean, in longitude 20° under the line.

"This beautiful species was captured nearly midway between the continents of Africa and America, by Colonel Streatfield, 87th R.T.F., whose name I have in consequence done myself the favour to affix to it, as being most appropriate, and as a slight testimony of the grateful recollection I have of his kindness in presenting me with many interesting species of insects and other rarities. The sea was quite smooth, with a gentle swell, at the time the insect was caught; a number were swimming about among the Porpitæ, which formed the first object of attraction, and fortunately directed attention to the insect. The singularity of its distance from any land, and the possibility of its being driven off from the African coast by the south-eastern gales, gave full play to conjecture, and excited our attention to the little creatures in the water, in the hope of ascertaining on what objects it preyed; but all possibility of discovering this was quickly put a period to by the S.E. trade sweeping over the surface and banishing all traces of the Medusæ and their companions.

"This species obviously belongs to a section or sub-genus distinct from that in which our linear European species are placed, and characterised by the contracted dimensions of the body, and the dilatation of the head and prothorax and the shortness of the latter. When examined minutely we find the whole body covered with minute hairs, those on the legs predominating beneath, the upper curving downwards. The head is somewhat triangular, with two cupped processes laterally, within which lie the bases of the antennæ; two small rufous maculæ are on the sides of the middle line closely adjoining the prothorax. The eyes are large, rufous, semi-globular, and occupy the space between the base of the head and the processes of the antennæ, emarginating the corselet laterally. The antennæ are about two-thirds the entire length of the body; the first joint slender and curved outwards, the last thickest, attenuating towards the tip.

"The prothorax is excessively short, collar-like, and gently channeled above into three sub-equal divisions, which nearly disappear in the dried specimen. The first pair of legs, arising closely to the mesothorax beneath, are moderately long, rather robust; the coxa short, obconic, and curved; the femur slightly *f*-shaped, with four or five strong black spines near its base exteriorly; tibia basally attenuated, arising with a curve from the preceding joint and with four or five strong black spines inferiorly, apically giving origin to a strong obtuse process, which projects backwards and outwards from near the articulation. Tarsus with the two joints sub-equal, the last diminishing in diameter beyond its middle, after giving attachment to two strong claws and an anomalous horny process on the under side, and also furnished with two long curved spines arising from the back part on each side, and lying adpressed among the hairs.

"The metathorax and mesothorax seem confounded together, presenting superiorly an hexagonal figure, a little longer than broad, the anterior side being carried a little forwards, so as to leave the lateral angles behind the centre. The posterior surface is transversely striate from being impressed upon the abdominal rings. The sides in the dried specimen become somewhat hoary from the light thrown back by the minute hairs. Beneath it is somewhat similar in form, but excavated behind, exposing in the sinus the abdominal rings. The sides posteriorly are rugose, with trochantines, from whence proceed directly backwards the coxæ of the last four legs, that of the posterior pair lying beneath the other on each side. The legs are slender, the middle pair exceeding the first, and the last pair the middle, by about one-third.[1] The last also has the apical half of the tibia, and first joint of the tarsus, with a row of long hairs beneath. Above the origins of the legs we find rudimentary processes, which as the insect is apterous, must be looked upon as those of the undeveloped wing."

[This species has apparently not been taken again.—F. B. W.]

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[1] The middle legs here described are really the hind legs.—F. B. W.

V.—LE MARQUIS MAXIMILIEN SPINOLA.

Essai sur les Hémiptères Hétéroptères, p. 64, 1837.

"Il n'est pas encore démontré que les *Halobates* connus soient des insectes parfaits. Les derniers anneaux de l'abdomen ne paraissent pas être entièrement développés, et si les observations du Comte Alphonse Castiglioni sur les métamorphoses de la *Ploiaria domestica* Scop. méritent notre confiance, comme je le crois, l'exemple de cette larve qui sort de l'œuf avec un simple rudiment d'abdomen confirmerait nos doutes relativement aux *Halobates*.

"Ex. *Halobates sericeus*, Esch.

"L'*Hydrometra abbreviata*, Fab. ne serait-elle pas un *Halobates* et est-elle réellement des Pyrénées ?"

[According to Stål, Fabricius described the larva of *Limnotrechus lateralis* or of *Limnotrechus asper* under the name *Hydrometra abbreviata*.—F. B. W.]

VI.—Professor ÉMILE BLANCHARD.

Histoire Naturelle des Insectes. t. iii. p. 98, 1840.

"*Halobates*, Esch., Lap.

"Ce genre a la plus grand analogie avec celui des *Gerris*, il n'en diffère réellement que par la forme ramassée du corps, et surtout de l'abdomen, dont les segments sont très-courts et relevés ; les antennes aussi sont beaucoup plus courtes, leurs pattes n'atteignent un aussi grand développement et les organes du vol manquent totalement.

"Les *Halobates* courent sur les eaux de la mer près des côtes ; on n'en a jamais rencontrés pourvus d'élytres et d'ailes : ce qui, joint a la forme rabougrie de leur corps, a fait présumer que ces insectes n'avoient pas atteint leur entier développement et qu'ils pourroient bien être de veritables *Gerris* a l'état de larve.

"Eschscholtz en a fait connaître plusieurs espèces dans son Entomographie.

"1. *Halobates micans*.

"Esch., Ent., p. 163, n. 78, tab. 2. fig. 3.—Burm., Handb. der Ent., t. ii. p. 208, n. 1.

"Long. 2 lig.—Corps cônique, grisâtre en dessus, chatoyant le bronzé, entièrement d'un blanc argenté en dessous ; yeux noires ; pattes grisâtres, couvertes de duvet argenté comme les autres parties du corps.

"Cette espèce vit dans l'Océan-Atlantique.

"2. *Halobates sericeus.*

"Esch., Ent., p. 164, n. 79, tab. 2. fig. 4.—Lap., Hémipt., p. 24, n. 4.—Burm., Handb. der Ent., t. ii, p. 209, n. 2.

"Long. 1 lig. ½.—Cette espèce se distingue de la précédente par son corps plus ovalaire et d'une moindre taille, par ses yeux d'un jaune pâle et le duvet qui recouvre le corps d'un gris-blanchâtre.—Cette espèce se trouve dans les mers équatoriales."

VII.—C. J. B. AMYOT and AUDINET SERVILLE.

Histoire Naturelle des Insectes. Hémiptères, p. 411, 1843.

"Genre 335.—Halobate. *Halobates*, Esch.

Lap.—Burm.—Blanch.

"*Tête* triangulaire, avec un prolongement court et mousse entre les antennes.—*Yeux* gros, globuleux, saillants, débordants un peu les côtés du prothorax.—*Ocelles* nuls.—*Antennes* de quatre articles cylindriques; le second un peu plus court que le premier; le troisième un peu plus long que le premier et que le dernier (dans les larves, le premier est aussi long que tous les autres pris ensembles; le second à peine plus long que le troisième); le quatrième un peu épaissi et à peine plus long que le second.—*Bec* très-court, gros à la base et pointu au bout (dans les larves, les deux premiers articles, qui semblent n'en former qu'un seul, sont courts, annuliformes; le troisième le plus long, le quatrième court).—*Prothorax* en losange aux quatre côtés à peu près égaux, s'étendant postérieurement à angle aigu et couvrant entièrement le mésothorax (très-court dans les larves, avec le mésothorax très-grand, formant la majeure partie du corps, et point d'écusson).—*Élytres* un peu plus longues que l'abdomen, assez amples, offrant deux cellules basilaires allongées et trois discoïdales à la suite; ailes un peu plus courtes que les élytres (les élytres et les ailes manquant, suivant tous les auteurs qui n'ont vu que les larves).—*Abdomen* conique, à peu près aussi long que le reste du corps (très-petit, presque non apparent en dessus dans les larves, tous les segments pouvant néanmoins être comptés sous le ventre et les organes sexuels assez développés).—*Pattes antérieures* courtes; cuisses un peu épaissies; jambes ayant une dent à l'extrémitié; tarses de deux articles à peu près d'égale longeur, cylindriques; crochets insérés dans une échancrure au milieu du deuxième article; pattes intermédiaires très-longues, filiformes, insérées très-loin des pattes antérieures à cause de la grandeur du mésosternum, les postérieures très-fines, plus courtes que les intermédiaires, très-près des quelles elles sont insérées; cuisses intermédiaires plus longues que les jambes; les quatre derniers tarses de deux articles cylindriques, frangés, dont le premier six fois plus long que le second dans les tarses intermédiaires, tous deux presque d'égale longeur dans les tarses posterieures; crochets ne nous paraissant pas exister?

"Du grec ἅλως? aire, et βαινω, marcher.

"On avait soupçonné déjà que les individus sur lesquels ce genre avait été établi, n'étaient que des larves; nous en avons la preuve aujourd'hui, d'après l'espèce ailée que nous décrivons ci-après. Mais un fait qui n'avait jamais été relevé, c'est que De Géer paraît evidemment avoir décrit et figuré (Mém. III. 320, 321, 322; et pl. 16, fig. 16, 17, 18, et 19) des larves et une nymphe de ce genre, observées par lui en Suède, quoique toutes les espèces existant maintenant dans les collections viennent des tropiques, où on les trouve à la surface des mers. Cet auteur tombant en cela, ce nous semble, dans la plus étrange erreur, n'a voulu les considérer que comme *les petits* d'une espèce de Gerris, et cependant il a décrit et figuré la nymphe elle-même avec ses moignons d'ailes et l'abdomen aussi court que dans la larve, quand il décrivait et figurait plus haut la larve de cette espèce de Gerris avec l'abdomen aussi développé que dans l'insecte parfait, d'où résultait la preuve que l'abdomen conservait toujours la même proportion relative dans les différentes périodes de développement de l'insecte, et que par conséquent il 'y avait là deux espèces différentes. Latreille (Nouv. dict. hist. nat. [1803] IX. 415) à rapporté toutes les observations de De Géer à ce sujet, en se laissant abuser lui-même par l'auteur, et continuant à prendre les uns pour les petits des autres;[1] mais ce qu'il y a de singulier, c'est qu'il ait dit ensuite (*loc. cit.*, 416) que l'espèce à laquelle appartenaient ces *petits* à abdomen avorté, etait des Indes-Orientales, quand il avait dit une page plus haut (*id.* 414) que De Géer avait observé en Suède les trois espèces dont il parlait.

"1. H. albinerve. *Halobates albinervus.*"

[This fresh-water species has been removed to the genus *Brachymetra*, Mayr, and therefore need not be further considered here, beyond calling attention to the fact that of course the generic characters of *Halobates*, Esch., are not the same as those of *Halobates*, Amyot et Serv.—F. B. W.]

"2. H. soyeux. *Halobates sericeus*, Esch.

"Entomogr., *Trans. des Sciences nat. de Dorpat.* 1823. 3, p. 164. 79. tab. 2. fig. 4.—Burm., Ent. ii. 209. 2.—Blanch., Hist. nat. ins. iii. 98. 2.

"(Long., 9,004). Larve. Corps ovulaire, d'un soyeux blanchâtre en dessous, d'un cendré grisâtre en dessus. Mâle et femelle.

"Cap de Bonne-Espérance. M. Burmeister dit: Du nord de la mer Tranquille, près de l'Equateur."

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[1] The authors remark in the *errata* (p. 648), "Au lieu des cinq lignes qui suivent et où nous avons mal interprété la pensée de Latreille il faut lire ce qui suit: Il avait bien distingué toutefois trois espèces dans les individus décrits et figurés par De Géer, la troisième étant celle dont la larve et la nymphe avaient l'abdomen tronqué; mais il s'est trompé en attribuant à cette espèce la synonymie du *Gerris paludum*, Fabr., dont la larve et la nymphe ont l'abdomen aussi développé que l'insecte parfait."

VIII.—Dr. G. A. W. Herrich-Schäffer.

Die wanzenartigen Insecten. Band viii., p. 108, tab. cclxxxvi., 1848.

"Genus *Halobates*, Esch.

"Eine ganz eigenthümliche Form; eiförmig, mit grossem Kopfe, grossen vorstehenden Augen, kurzem Thorax, vorstehenden Schultern, ohne Spur von Flügeldecken und Flügeln, langen Beinen, deren vorderste die dicksten und kürzesten, deren vier hintere weit hinter der Mitte des Körpers eingefügt, seitlich ausserordentlich von einander entfernt sind und deren Glieder sich endwärts haarförmig verdünnen. Die Mittelbrust ist ungemein gross und reicht weit hinter die Mitte des Körpers. Der Hinterleib ist äusserst klein, conisch, beim Weibe mit eckigem Anhange.

"Schnabelscheide bis zur Mitte der Hinterbrust reichend, dreigliederig, das mittlere Glied am längsten; Fühler von mehr als halber Körperlänge, fadenförmig, Viergliedrig, das erste Glied am längsten. Nebenaugen kann ich nicht entdecken. Der Prothorax ringförmig, unten mit breiter, seichter, nicht scharf begrenzter Längsrinne; die Vorderbeine entspringen am Hinterrande der Vorderbrust, nahe beisammen. Die Mittelbrust nimmt mehr als die halbe Körperlänge ein, die Mittelbeine sind an ihren hinteren seitlichen Ecken in ungeheuerer Entfernung von einander eingefügt. Die Hinterbrust ist ganz von der Mittelbrust verdeckt und steht nur jederseits an der oberen Körperfläche als Lappen vor, so dass die Hinterbeine kaum etwas weiter nach rückwärts eingefügt sind als die Mittelbeine, aber etwas höher. Keine Spur von Einfügungsstellen der Flügel oder Decken.—An den Vorderbeinen alle Glieder ziemlich gleich dick, also fadenförmig; Hüften kurz, Schenkel etwas länger als die Schienen; Fuss kürzer, zweigliedrig, das erste Glied kürzer. Die vier Hinterbeine borstenförmig, die mittlern länger; die Glieder der Füsse kann ich nicht genau unterscheiden; es scheinen deren zwei, das zweite viel kürzer.

"Die Arten leben auf der Oberfläche des Meeres zwischen den Tropen, wahrscheinlich gesellschaftlich; Burmeister kennt mehrere Arten.

"I. Vorderschienen am Ende erweitert, Vorderfuss mit zwei Krallen in einem Ausschnitte der Mitte des Endgliedes, Schenkel aller Beine länger als ihre Schienen. Die Hintertarsen (nur des Mannes?) lang borstig. Körperfläche grau, durch feine Behaarung seideglänzend."

"Tab. cclxxxvi. fig. 880 mas, 881 foem.

"*Halobates sericeus*, Esch.

"Cinereus, oculis subferrugineis.

"Eschscholtz, Entomographien, 1822, t. 2. fig. 4.

"Aschgrau, die Augen braungelb.

"Beide Geschlechter von Herrn Sturm, welcher sie aus der Südsee von Herrn Eschscholtz erhielt.

"Folgende Arten sind mir unbekannt:

"*H. micans*, Esch., Entom., t. 2. f. 3.—Burm., p. 209.

"Cinereus oculis atris.

"Aschgrau, die Augen schwarz.

"Aus dem südlichen stillen und atlantischen Meere. Herr Eschscholtz sah nur einige Männchen.

"*H. flaviventris*, Esch., Entomogr., t. 2. fig. 5.—Burm., p. 290.

"Cinereus oculis atris, abdomine et pectoris apice flavescentibus.

"Vielleicht das andere Geschlecht zu voriger, aus dem südlichen atlantischen Ocean; Herr Eschscholtz sah nur zwei Weibchen."

II. Vorderschienen ohne Erweiterung, Vorderfuss ohne Krallen; Schenkel der Mittelbeine kürzer als ihre Schienen, Schenkel der Hinterbeine lang borstig; Körper glatt, fleckig."

[In this section is placed *Halobates pictus*, Germ., which, being a fresh-water and not a marine species, and being moreover not a true *Halobates*, need not be further considered. In the generic description some of Eschscholtz' mistakes are repeated.—F. B. W.]

IX.—Léon Fairmaire.

Annales de la Société Entomologique de France. Bulletin Entomologique. Année 1848. Deuxième Trimestre, p. xxvi.

"M. Amyot, dans son *Histoire Naturelle des Hémiptères*, p. 412, dit: 'On avait déjà soupçonné que les individus sur lesquels ce genre avait été établi n'etaient que des larves, nous en avons la preuve aujourd'hui d'après l'espèce ailée que nous d'ecrivons ci-après.'

"MM. Burmeister et Spinola, sans être aussi affirmatifs, croient aussi qu'on ne connait encore que les larves des *Halobates.* Il n'y a que le fondateur du genre, Eschscholtz, et M. E. Blanchard, qui n'expriment aucun doute sur l'état parfait de ces insectes. Je crois être à même de résoudre cette question en détruisant l'argument apporté par M. Amyot, et en apportant des preuves directes à l'appui de mon opinion.

"M. Amyot decrit sous le nom d' *H. albinervus* un insecte très voisin des *Gerris*, ailé et provenant de capitainerie de Goyaz; or, cette province, située entre des montagnes, est à 200 lieues de la mer, ce qui exclut toute idée d'insecte maritime et explique pourquoi l'auteur ne veut pas admettre les *Halobates* tels qu'ils ont été decrits par Eschscholtz.

"Notre collègue M. Ch. Coquerel, à qui nous devons des observations intéressantes sur l'entomologie de Madagascar, a rapporté des mers qui avoisinent cette île une certain nombre de véritables *Halobates* aptères, de tout âge, de tout sexe et de deux espèces, parfaitement conservés dans de l'esprit de vin. Parmi eux se trouvaient deux énormes femelles, au ventre rebondi, qui au premier coup d'œil, me parurent porter dans leur flancs la solution de la question. En effet, avec l'aide du scalpel, je fis sortir de l'abdomen 15 ou 20 corps oblongs, assez gros, d'un jaune soyeux pâle, qui envahissaient même une portion du thorax ; c'etaient des œufs.

"Maintenant se présente une objection. Les œufs prouvent-ils l'état parfait de la mère ? Selon moi, oui, jusqu' à preuve du contraire. Je sais bien qu'il y a quelques exemples du contraire dans les Orthoptères : ainsi M. Ch. Coquerel m'a montré un kakerlac pondant des œufs et n'ayant encore que des moignons d'élytres ; mais je ne crois pas que dans l'ordre des Hémiptères on ait encore signalé pareille anomalie. M. Amyot veut qu'un insecte ne puisse être parfait sans ailes ; mais qu'entend-on par état parfait ? Il me semble qu'il ne saurait y avoir d'ambiguité : c'est l'état de puberté, c'est le moment où l'insecte jouit de toutes ses facultés, et celle de se reproduire est plus importante que celle de voler. Quant aux ailes, il est vrai qu'elles sont le signe patent de la perfection, mais elles ne sont pas indispensables : dans les Coléoptères, nous en avons de fréquents exemples, et dans les Hémiptères la punaise des lits nous prouve tous les jours que certains insectes peuvent vivre, s'accoupler et mourir sans ailes. Dira-t-on qu'elle n'arrive jamais à l'état de perfection ? D'ailleurs, pour les *Halobates*, naviguant le plus souvent à des centaines de lieues de tout rivage, à quoi leur servirait d'être ailés ? Leur corps me semble destiné à se passer de ces aides aériens : les anneaux supérieurs de l'abdomen sont convexes, coriaces, et on distingue à peine la suture des premiers avec le thorax et entre eux : il y a bien de chaque côté une sorte de moignon d'aile, mais il est à l'état rudimentaire et semble n'être placé là que pour la forme.

"Les espèces qui m'ont fourni ces observations sont les *Halobates flaviventris* et *sericeus*, que M. Ch. Coquerel a trouvés ensemble, le premier beaucoup plus rare que le second, et presque toujours sur les *Fucus*, appelés vulgairement *raisins des tropiques*. Notre collegue, qui en a remarqué des milliers, n'a jamais vu un seul individu ailé, particularité qui ne lui aurait pas échappé."

X.—CARL STÅL.

Nya Hemiptera. *Öfversigt af Kongl. Vetenskaps-Akademiens Förhandlingar.* Elfte Årgången. No. 8, p. 238, 1854.

"*Halobates*, Esch.

"1. *H. lituratus* : *H. picto* similis ; sordide flavotestaceus ; thorace margine antico, lineis 4 fere basalibus abbreviatis, mediis utrimque oblique transversis, curvatis, media longitudinali, laterali utrimque subrecta, nigrofuscis; femoribus anticis utrimque longitudinaliter, tibiis tarsisque totis nigricantibus. Long. 5, lat. 2¾ millim.—China."

[This species is not a true *Halobates*, but is the type of a new genus.—F. B. W.]

XI.—Dr. George Carl Berendt.

Die im Bernstein befindlichen organischen Reste. Bd. ii. p. 19, tab. ii. fig. 8, 1856.

[Dr. Berendt describes and figures an insect which he considers may perhaps be the larva of a *Halobates* or some allied genus. The figure shows rudiments of elytra and wings, besides other characters not belonging to *Halobates*. Under these circumstances, further consideration of it is not necessary.—F. B. W.]

XII.—Carl Stål.

Konglika Svenska Fregatten Eugenies Resa. Insekter. Hemiptora, p. 264, 1858.

"Fam. Ploteres.

"124. *Halobates lituratus*.

"Flavo-testaceus; antennis basin versus exceptis, fuscis; macula intraoculari obsoleta, vitta thoracis, scutelli margine basali tenuissime, lineis quatuor basalibus (intermediis longioribus, apicem versus sublatioribus), lineaque percurrente media et postice utrinque linea intus latiore, apicem versus angulata et in pectore continuata, hujus etiam linea laterali, tibiis tarsisque nigro-fuscis; femoribus anticis intus et extus vitta fusca, apud ♂ incrassatis. ♂ ♀. Long. 5, lat. 2¾ millim.

"*Halobates lituratus*. Stål, Öfv. af K. Vet.-Ak. Förh., 1854, p. 238.

"Patria: China (Wampoa).

"*H. picto* affinis, pictura aliter distributa. Caput flavo-testaceum, maculis una majore vel duabus minoribus intraocularibus fuscis. Antennæ corporis fere dimidia longitudine, fuscæ, basin versus flavo-testaceæ. Thorax flavo-testaceus, linea longitudinali media, margine antico et interdum macula utrimque prope lineam longitudinalem nigrofuscis. Scutellum flavo-testaceum, lineis longitudinalibus, una media percurrente, unaque antice utrimque cum macula oblonga vel vitta subobliqne longitudinali brunnescente cohærente, margine antico anguste lineaque utrimque posteriore oblique longitudinali, apice rotundato-angulata et in pectoris latere retrorsum currente, nigro-fuscis; pectore etiam linea percurrente striolaque disci utrimque longitudinalibus nigro-fuscis. Pedes fusci, femoribus flavo-testaceis, anticis utrimque fusco-vittatis, apud marem incrassatis."

XIII.—Dr. Anton Dohrn.

Zur Heteropteren-Fauna Ceylon's. *Stettiner Entomologische Zeitung*, vol. xxi., p. 408, 1860.

"103. *Halobates Ståli*, n. sp.

"H. supra niger, opacus; capite sordide flavo-testaceo, macula magna media, 3 anticis minoribus nigris, oculis fusco-fulvis, nigro-maculatis; thorace antice maculis 2 semicircularibus, postice 2 mediis parallelis longitudinalibus, 1 utrimque uti comma figurata aliaque utrimque transversali, semicirculari, tertia utrimque minore apice disci, tunc in parte prope insertionem pedum una transversali, 2 longitudinalibus, 3 apicalibus, minoribus flavo-testaceis; subtus cum lateribus flavo-testaceis, his longitudinaliter nigro-strigatis, macula supra coxas anticas, lineisque 2 plus minusve latis femorum anticorum nigris; antennis, pedibusque mediis posticisque nec non tibiis anticis nigrescentibus; rostro flavo-testaceo, apice nigro.—7 millim."

[This is probably congeneric with *H. lituratus*, Stål.—F. B. W.]

XIV.—Dr. Gustav L. Mayr.

Reise der österreichischen Fregatte Novara um die Erde. Zoologischer Theil, Band ii. Abth. 1. Hemiptera, p. 177, 1866.

"HALOBATES, Esch.

"Dorp., Abh. i., 1822.

"*H. lituratus*, Stål.

"*Halobates lituratus*, Stål, Eug. Resa, Ins., p. 264 (1858).

"Hongkong.

"Dr. Stål's Beschreibung ist durch Folgendes zu ergänzen: Die Schnabelscheide reicht nur bis zum Vorderrande der Mittelbrust; die Vorderschienen haben am Ende einen zahnartigen Fortsatz und sind daselbst nicht erweitert (bei *H. pictus*, Herr.-Schaeff. soll dieser Fortsatz fehlen), zweites Tarsenglied der Vorderbeine unten nahe der Mitte mit einem Ausschnitte, in welchen die Krallen eingefügt sind; die Schenkel der vier hinteren Beine sind länger als die Schienen (während nach Herrich-Schaeffer bei *H. pictus* die Mittelschenkel kürzer als die Mittelschienen sind). Da Dr. Stål angibt: '*H. picto affinis, pictura aliter distributa*,' so sollte man meinen, dass sich *H. lituratus* von dieser Art nur durch die Färbung unterscheidet. Wenn aber die von mir untersuchten Exemplare richtig bestimmt sind (was wohl vorauszusetzen ist, da Stål's Beschreibung mit denselben übereinstimmt), so finden sich bei *H. lituratus* Merkmale, welche diese Art von *H. pictus* wesentlich unterscheiden."

XV.—GEORG RITTER VON FRAUENFELD.

Verhandlungen der kaiserlichen und königlichen zoologisch-botanischen Gesellschaft in Wien. Band xvii. pp. 456–460, Taf. xii. fig. 1–10. 1867.

"*Halobates Wüllerstorffi*, n. sp. Bei Cap Frio nächst Rio Janeiro 20–30 Meilen vom Lande.

"*Halobates flaviventris*, Eschsch. In der Nähe der Nicobaren.

"*Halobates lituratus*, St. Im chinesischen Meere.

"*Halobates micans*, Eschsch. Vor Ceylon, beiläufig 3° N. Br.

"Eschscholz hat die Gattung *Halobates* in seinen Entomografien aufgestellt. Es ist das einzige wirklich und ausschiesslich im Meere lebende Insect, da ich ausserdem nur ein Paar Fliegerlarven kenne, die ihre Verwandlung im Seewasser bestehen, Belostomen aber, die öfter schon im Meere gefangen wurden, bestimmt nur zufällig und ausnahmsweise sich daselbst finden. Sie hüpfen auf der Oberfläche des Wassers in grossen Schaaren gesellig in meilenweiter Entfernung vom Lande umher.

"Eschscholz beschreibt und bildet 3 Arten ab: *micans*, *sericeus* und *flaviventris*. Templeton hat in der Trans. of the ent. Soc. eine neue Art.: 'Streatfieldana' beschrieben. Zwei weitere Arten *pictus* Grm. und die in 'Eugenie's Resa' von Stål neuerlichst beschriebene 'lituratus' unterscheiden sich von jenen vier einfarbigen Arten durch ihre bunte Zeichnung. Die von Am. Serv. als *Halobates albinervus* aufgestellte Art wurde von Gust. Mayr wegen der vorhandenen Flügeldecken als Gattung *Brachymetra* abgetrennt. *H. sericeus* und *pictus* sind in den wanzenartigen Insecten von Herrich-Schäffer auf. Taf. 286 abgebildet.

"Ich habe die Seewanzen während der Fahrt mehrfach beobachtet und mehrere Arten vom Fenster meiner Cabine aus mit einem Netze an einer langen Stange aufgefischt. *H. lituratus* St. fing ich auf der Fahrt von Manila nach Hongkong mitten im chinesischen Meere. Von einfarbigen Arten habe ich 3 beobachtet, und zwar eine, die für unbeschrieben halte, *H. Wüllerstorffi* bei Cap Frio nächst Rio Janeiro, ferner eine vor Ceylon in beiläufig 3° N. Br., welche ich zu *H. micans*, Esch. ziehe, und eine dritte endlich, in grosser Anzahl in der Nähe der Nicobaren, welche ich zu *flaviventris* Esch. bringe, obwohl sie nicht besonders nich dessen Beschreibung übereinstimmt. Von dieser letzten von welcher Eschscholz nur 2 Weibchen sah, habe ich beide Geschlechter und eine grosse Menge Larven gefangen.

"Eschscholz sagt in seiner Gattungs-Diagnose: Tarsi antici triarticulati; die Füsse dieser Beine scheinen von oben betrachtet nur aus 2 ziemlich langen dicken Gliedern zu bestehen, aber an der Unterseite des zweiten längern Gliedes bemerkt man noch ein drittes sehr kurzes, abstehendes Glied, das am Ende mit 2 gekrümmten Haken bewaffnet ist.

"Dieses zweite Glied hat in seiner Mitte unten einen Ausschnitt, in dessen Grund die Doppelklaue eingefügt ist, zwischen der eine gleichfalls gekrümmte feine Borste sitzt. Der unterhalb stehende, die Klauen nicht überragende Fortsatz ist schlank keglich. Ich habe nur nach starken Pressen bei völliger Zertrümmerung des Gliedes dieses Zäpfchen abzutrennen vermocht. Es dürfte also vielleicht nicht als drittes Glied zu bezeichnen sein, um so mehr, als die Klauen am Grunde desselben sitzen (fig. 8, 9, 10).

"Ich will die neue Art und das Männchen von *H. flaviventris*, Esch. beschreiben, und den übrigen das zur Ergänzung Nöthige beifügen.

"*H. Wüllerstorffi*, n. sp. (fig. 1, 2).

"Schwarz, aschgrau bereift, namentlich an den Seiten und am Bauch lichter seidenglänzend. Alle Beine glänzend stahlblau.

"Kopf dreieckig, etwas schmäler als das Halsschild. Die grossen schwarzen Augen jedoch weit darüber vorstehend. Halsschild in der Mitte hinten und vorn eingeschnürt, mit 2 nur bei dem Männchen sichtbaren leichten Quereindrücken. Der hoch gewölbte Mittelrücken vorn etwas breiter als das Halsschild; oval, bei dem Männchen an der Seite stärker gebaucht, bei dem Weibchen daselbst etwas weniger. Der sehr reduzirte Hinterleib beim Männchen abgerundet, beim Weibchen mit einem grossen, bei allen Arten dieser Gattung gewöhnlichen rautenförmigen Anhang. Die schwarzen Fühler (fig. 6) viergliederig. Erstes und zweites schlank, gleichdick, an der Spitze etwas geknöpft, das erste zweimal so lang als das zweite, das dritte und vierte merklich verdickt, cylindrisch, an den Enden abgerundet; zwischen dem zweiten und dritten Glied eine kleine runde Abschnürung, die dem dritten Gliede angehört. Das dritte Glied merklich kleiner als das zweite. Das vierte etwas grösser als das zweite, mithin fast 1½ mal so lang als das dritte. Vorderbeine kräftig; Huften der Mittelbeine sehr kurz, jene der Hinterbeine mehr als 3 mal so lang, cylindrisch. Schenkel der Mittelbeine dicker als jene der Hinterbeine und 1⅔ mal so lang. Schienen dünner wie die Schenkel, doch auch diese an den Mittelbeinen etwas dicker als an den Hinterbeinen; an beiden gleichlang. Tarsus zweigliedrig; an den Mittelbeinen das erste Glied wenig kürzer als die Schienen, etwas gekrümmt, zweites Glied sehr kurz. An den Hinterbeinen beide kurz. Sämmtliche Beine des Männchens sind glänzend stahlblau; beim Weibchen sind jedoch nur die Vorderbeine und die Huften der Hinterbeine stahlblau, Schenkel und Schienen dieser zwei Beinpaare, die auch etwas länger als beim Männchen sind, schwarz, mit sehr schwachem blauen Schein. Füsse und Fühler sind zart behaart.

"♂ Lang 4 mm., breit an der dicksten Stelle 2·5 mm. Schenkel der Mittelbeine lang 4·5 mm.

"♀ Lang 4·3 mm. mit dem rautenförmigen Anhang, breit an der dicksten Stelle 2·35 mm. Schenkel der Mittelbeine lang 5 mm.

"*H. micans*, Esch. Von dieser Art habe ich gleich Eschscholz nur Männchen gefangen;

sie gliecht sehr der so eben beschriebenen *H. cyanipes*,[1] nur sind die Fühler (fig. 5), die gleichfalls zwischen dem 2 und 3 Glied eine rundliche Abschnürung haben, schlanker. Das erste Glied ist länger als bei *H. Wüllerstorffi*, dagegen das zweite und dritte fast gleichlang. Auch die Beine sind etwas schwächer als bei jener Art, doch so ziemlich von gleichem Verhältniss; sie unterscheiden sich aber durch die Färbung, indem sie wie Eschscholz angibt, schwarz sind, und nur die Vorderschenkel einen bläulichen Schein haben. Die Färbung des Thieres selbst, die Eschscholz als ‘schwarzlichgrau mit Messingglanz, Hinterleibsringe weissgrau, unterseite das ganzen Körpers silberweiss’ angibt, stimmt nicht ganz genau. Meine Exemplare sind aschgrau bereift, ohne Spur eines gelblichen Glanzes, und auf der Unterseite wohl heller, doch keineswegs silberweiss.

“ ♂ Lang 4 mm., breit an der dicksten Stelle 2·25 mm., Schenkel der Mittelbeine lang 4·6 mm.

“ *H. flaviventris*, Esch. (fig. 4).

“ ♂ Oval, am Rücken nicht sehr hoch gewölbt. Oben licht aschgrau bereift; am Kopf neben den stark hervorragenden, bei verschiedenen Individuen theils hell, theils schwarzbraunen Augen, beiderseits ein braungelber Fleck, die sich am Hinterrande mit einer, schmalen Linie vereinigen. Auf der Seite und unten silberig glänzend. Der ganze Bauch, die Unterseite des Halsringes, die Hüfthöcker der sämmtlichen Beine und ein Mittelstreif (fehlt beim Weibchen), der an der Bauchwurzel breiter ist und über die ganze Mittelbrust verschmälert bis zum Halsring zieht, gelb. Die sehr zarten Fühler (F. 7), die nicht jene rundliche Abschnürung wie die beiden vorigen Arten, zwischen dem zweiten und dritten Glied besitzen, an den Wurzeln, häufig bis zur Hälfte des Gliedes gelb. Die kräftigen Schenkel der Vorderbeine gleichfalls an der Wurzel, und eben so oftmals ziemlich ausgedehnt gelb, sonst obenauf schwarz, unten aber durchaus gelb. Die vier sehr zarten Hinterbeine schwarz, nur die Hüften auf der Unterseite gelb. Der After bildet ein stark vorragendes Zäpfchen. Lang 4 mm., breit an der dicksten Stelle 2·25 mm., Schenkel der Mittelbeine 4·6 mm.

“Beim Weibchen habe ich nur zu bemerken, dass auch hier die Fühler an der Wurzel stets mehr oder weniger ausgedehnt gelb sind, wovon Eschscholz nichts erwähnt, sowie dass die Fühlerglieder alle gleichdick sind, und das 2, 3, 4 Fühlerglied gleichlang, während sie Eschscholz ungleich angibt. Auch die Hüften der Vorderbeine, sowie die Unterseite des Halsringes sind wie beim Männchen stets gelb. Das übrige stimmt mit dessen Beschreibung überein.

“Ich bin bei der ausserordentlichen Genauigkeit der Angaben Eschscholz's nicht ganz sicher, ob die von mir gefangene Art wirklich zu dessen *flaviventris* gehört, wollte jedoch auf diese Abweichungen hin keinen neuen Namen geben.

“Die Larven (F. 3), die ich zalreicher als das ausgebildete Thier gefangen, sind nur wenig kleiner und an denselben kein Geschlechtsunterschied zu entnehmen. Sie sind

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[1] “*Cyanipes*” is evidently a *lapsus calami* for “*Wüllerstorffi*.”—F. B. W.

lederhäutig, mit einzelnen Chitinplatten, und zwar 2 querovale auf dem Halsring; 2 länglichovale auf der Vorderhälfte des Mittelrückens, hinter jedem derselben ein quer nierenförmiges; auf den 4 ersten der 7 deutlich untershiedenen Hinterleibsringe an der Seite eine sehr kleine rundliche, eine längliche obenauf am Hüfthöcker der Hinterbeine. Diese sämmtlichen Platten sind aschgrau bereift, die Hautdecke dazwischen braun, längs den Seiten des ganzen Leibes gelb, weiss schimmernd, die letzten Hinterleibsringe hellgelb. Die Afterdecke ist schwarz, mit einer breiten gelben Querbinde, von welcher nach vorn eine gelbe Mittellinie geht, die das Schwarz des vordern Theiles mitten trennt. Die Unterseite ist ganz ledergelb. Die Fühler sind wie beim ausgebildeten Thiere, nur matter schwarz. Auch die Vorderbeine sind an der Wurzel gelb, haben jedoch nur ein Tarsenglied, das durch einen Einschnitt unten, etwas ausser der Mitte einen spitzen Zahn trägt. Die Hüften der Hinterbeine unten gelb. Die Farbe sämmtlicher Beine matt bräunlichschwarz.

"Ausgebildetes ♂ 4·2 mm. lang, breit 2·4 mm, Schenkel der Mittelbeine 5 mm. lang.

"♂[1] 4·1 mm. lang mit dem Anhang, 1·9 mm. breit, Schenkel der Mittelbeine 5·1 mm. lang."

[This is the most important paper on the subject since the genus was founded, but the author has curiously adhered to the original error of confounding the sexes. It is to be noted that the species he refers to *flaviventris*, Eschscholtz, is not that species,—a fact of which he seems to have had some suspicion, but he was unwilling to found a new species without a certainty that he was right in so doing,—a very commendable cautiousness.—F. B. W.]

XVI.—Professor ENRICO HILLYER GIGLIOLI.

Breve cenno sulla distribuzione geografica dell' emittero Halobates, Eschscholtz. *Bullettino della Società Entomologica Italiana*, Anno secondo, p. 260, 1870.

"Sembrerà strano il fatto di cogliere un insetto in alto mare, a grandi distanze da qualsiasi terra; eppure l'entomologia non manca di rappresentanti anche in mezzo all' Oceano, e di contribuire essa pure il suo obolo alla fauna pelagica.

"Sin dal 1822 Eschscholtz descrisse col nome di *Halobates*[2] un insetto che vive camminando sulla superficie mobile dell' Oceano, come fanno le communi *Hydrometra* sulle nostre acque stagnanti.

"Le affinità del genere *Halobates* sembrano essere col genere *Gerris* di Latr.; esso infatti comprende insetti piccoli, atteri, con elitre rudimentarie, addome corto e conico, i quali vivono nei mari tropicali. Westwood[3] li considerava come insetti ancora allo

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[1] The sign ♂ is here evidently given in mistake for ♀.—F. B. W.

[2] Entomographien, 1 Lieferung, Berlin, pp. 106–111, tab. iii. fig. 3–5, 1822.

[3] Introduction Modern Classific. of Insects, ii. p. 470 (Nota).

stato di larva ed Amyot[1] è dell' istesso avviso, mentre Blanchard sostiene l'opinione dell' Eschscholtz, giudicandoli insetti perfetti. Fairmaire[2] tra individui portati dal Signor Coquerel dai mari del Madagascar, trovò due femmine coll' addome pieno di uova, le quali come molte centinaie d'individui già esaminati *non avevano ali*. Dunque debbono per questo essere considerati larve? *Cui bono* le ali ad un insetto che vive in alto mare?

"Io sono interamente dell' opinione del Fairmaire; e chi ha veduto questi emitteri ad enormi distanze da qualunque terra non pùo pensare altrimentri.

"Di questo genere varie specie sono già stato descritte. Io non intendo entrare in argumento cosi intricato che verrà trattato da persone assai più competenti di me nella monografia entomologica del viaggio della '*Magenta*': intendo soltanto accennare alle località ove trovai gli *Halobates* durante il mio viaggio di circumnavigazione. E siccome l'argomento è nuovo, credo che ciò non sarà privo d'interesse.

"Pescai il primo *Halobates* nell' Atlantico Australe il 29 dicembre 1865 in lat. 16° 11′ Sud, long. 36° 00′ Ob. Parigi; a circa 400 miglia dalla costa Americana. Il giorno seguente ne furono presi altri, ma non erano numerosi.

"Nel maggio 1866, altri *Halobates* furono pescati nello stretto di Banca, golfo di Siam, ed in vicinanza delle isole Pulo Condore, ove il mare per larghissimo tratto era coperto da *Trichodesmium*, sparso alla superficie dell' acqua come minuta segatura.

"Il 10 febraio 1867 entrammo di nuovo nell' Oceano indiano, in cui trovammo un *Halobates* abondantissimo. Dal 12 febbraio (in lat. 11° 33′ S., long. 106° 40′, E. Gr.) al 17 dello stesso mese (in lat. 15° 59′ S., long. 105° 48′ E. Gr.) entro gli stesso limiti il mare era sparso di fiocchi di *Trichodesmium*.

"Traversato il Pacifico, incontrammo di nuovo il nostro emittero abbondante a qualche centinajo di migla dalla Costa Americana, dal 29 agosto (in lat. 21° 27′ S.) al 6 settembre (in lat. 29° 21′ S.).

"Finalmente, *l'Halobates* fu ripreso nell' Atlantico, nel viaggio di ritorno (gennaio 1868), in due occasioni; il primo in lat. 26° 38′ S., il secondo in lat. 4° 28′ Nord.

"Ad un esame non minuzioso tutti questi *Halobates* mi sembravano appartanere ad una sola specie.

"Concluderò col dire come questi strani insetti sono sparsi lungo la zona tropicale in tutti i mari, e non hanno certamente bisogno di alghe per sostenersi sull' acqua, come sembra voler asserire il Coquerel. Io non trovai un solo *Halobates* nel *Mar di Sargasso*, ed il *Trichodesmium* col quale lo trovai associato due volte, non è certamente capace di servir loro da zattera.

"Un ricca serie d'individui dalle diverse località venne reportata, ed in un colle altre collezioni zoologiche del viaggio della *Magenta* si trova nel R. Museo di Torino."

[Three of Dr. Giglioli's specimens—kindly lent to me by the Turin Museum—are

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[1] Hist. Nat. des Hémiptères, p. 412.

[2] *Ann. Soc. Ent. de France*, sér. 2, t. ii. p. xxvi., 1848.

referrible, partly to *H. Wüllerstorffi* and partly to a new species. What the others may be, I of course cannot say, but it is not improbable that there are other species amongst them.—F. B. W.]

XVII.—Robert M'Lachlan, F.R.S.

The Entomologists Monthly Magazine, vol. vii. 1870–71.

After giving a summary of Professor Giglioli's paper, the author proceeds to say :—

"These notes have a peculiar interest for me, as exciting reminiscences of a voyage of thirteen months' duration I made when a youth, in 1855–56. This voyage was marked by a most immoderate amount of calms (in one case extending to thirty consecutive days, in the hottest part of the China Sea), and I lost no opportunity of fishing up—and, I am sorry now to say, casting away,—the, to me, wonderful forms always floating around. Long before crossing the line, on the outward voyage, I was struck by small whitish creatures which often appeared coursing with great rapidity over the surface of the ocean ; at length one was captured, and I well remember my astonishment on finding it was a spider-like insect, of the affinities of which I then knew nothing. They disappeared, or rather were lost to view, as soon as a breath of wind caused a ripple on the surface, but were common in that most unpleasant form of sea-disturbance in which there are great 'smooth' waves, the effect of a recent storm, but with no present wind. In the Atlantic, Indian, and Pacific Oceans, it only needed the required state of the sea to bring these merry coursers to view, and certainly often without the presence of the smallest piece of floating sea-weed. Those who have voyaged will bear me out when I say that, excepting in the mysterious Sargasso-sea, in the course of the oceanic currents, and in the vicinity of land, sea-weed may be looked for with as much chance of finding it as daisies. I should here state that the brilliant white appearance of the insect on the ocean is caused by the pellicle of air that surrounds it, the creature itself being blackish. If these notes should be read by any one of those 'who go down to the sea in ships,' I would remind him that, if he can throw any light upon the life-history of this most wonderful insect (how many species there may be I know not), he will confer the utmost benefit upon natural science. The *Trichodesmium* alluded to by Giglioli is a minute confervoid plant which sometimes covers the surface of the ocean like fine sawdust."

XVIII.—Professor Karl Semper.

The Natural Conditions of Existence as they affect Animal Life, p. 144 ; also note on p. 434, 1881.

"In the Pacific Ocean and Philippine Sea I have myself often found various insects and even spiders in the sea, sometimes swimming in great numbers on the surface, sometimes creeping between rocks under water by the shore. A bug of the genus *Halobates* (fig. 35) is particularly common in these seas, besides the above-mentioned larvæ of flies. This genus was discovered by Eschscholtz, and now includes fourteen species living in seas the most remote from each other. The species in question runs about like our Water-Bug, *Hydrometra*, in great numbers and in every stage of development, on the high seas hundreds of miles from land."

And a note on p. 434: "Eight species of the genus, as I am informed by my friend Dr. Hagen, have been described; that described in the text and discovered by me is a new species and the largest of all. They are found in the Atlantic, Indian, and Pacific Oceans, as well as in the Chinese Sea, but only in tropical or sub-tropical regions."

[Professor Semper tells me that the woodcut given in his work is a correct representation of the species referred to, and that the expression "now includes fourteen species" was written by mistake. The species in question probably belongs to a new and undescribed genus.—F. B. W.]

In addition to the literature reproduced above, there are various other references to the genus, but as they contain nothing of importance it is unnecessary to mention them further.

In addition to the specimens taken by the Challenger expedition, I have had the advantage of having been able to study specimens belonging to several museums and private collections, both in Britain and on the continent of Europe; and my best thanks are due to all those who have in this and other ways assisted me. The museums to which I am indebted for the loan of specimens are the following:—Berlin (through Dr. Peters), Brussels (through M. A. de Borre), Liverpool (through Mr. T. J. Moore), Oxford (through Professor Westwood), Stockholm (through M. C. Aurivillius), Turin (through M. L. Camerano), Vienna (through Dr. Rogenhofer). I have also to thank Professor Westwood, of Oxford; Dr. Signoret, of Paris; Mr. J. W. Douglas, of London; and Dr. G. Hay, of Aden, for the loan or gift of specimens from their private collections; and for information and other assistance, Mr. John Murray of the Challenger; Mr. R. M'Lachlan, F.R.S.; Dr. Murie, the Librarian of the Linnean Society; Dr. Dohrn, of Stettin; M. L. Fairmaire, of Paris; Dr. G. L. Mayr, of Vienna; Mr. C. Ritsema, of the Leyden Museum; Professor Semper, of Würzburg, Mr. J. T. Carrington, F.L.S.; the naturalists of the British Museum; and lastly, Mr. Edwin Wilson, for the painstaking skill with which he has drawn the illustrations.

II. ANATOMY AND DESCRIPTION OF GENERA AND SPECIES.

On examining the various species that have been placed in the genus *Halobates*, it soon became evident that they could not with propriety be retained in one genus, and that, in fact, they make part of at least three genera. As, however, this paper deals only with those genera, some, if not all, of the species of which are marine, two genera only require to be noticed. These are *Halobates* proper and a new genus *Halobatodes*. Had the species of the latter genus not existed, there would also be grounds for establishing a new sub-family for the genus *Halobates*. As it is, *Halobatodes* (of which the typical species is *Halobates lituratus*, Stål) and *Stephania* (a new genus proposed for the reception of *Halobates pictus*, Germar) form connecting links between *Halobates* and the more typical genera of the sub-family *Hydrobatina*, in which *Halobates* has hitherto been placed. To retain it in this position, however, some modification in the definition of the sub-family will be necessary; as, for example, in this respect, that, while the *Hydrobatina* are said to have two-jointed tarsi, *Halobates* has the hinder tarsi only one-jointed.

The two genera under consideration may be thus distinguished:—

1. Body thickly clothed with short pubescence; front tibia with a triangular dilatation near the apex; middle tibia and first joint of tarsus with a long fringe; hind tarsus with one joint, ... *Halobates*
2. Body more sparsely clothed with short pubescence; front tibia cleft, but not with a triangular dilatation at the apex; middle tibia and tarsus without a long fringe; hind tarsus with two joints, ... *Halobatodes*.

HALOBATES, Eschscholtz.

Entomographien, i. p. 106, 1822.

Body oval or oblong.

Head shortly triangular.

Antennæ four-jointed, with two intermediate jointlets. First joint always the longest.

Rostrum four-jointed; first and second joints very short, the latter ringlike; third joint the longest.

Eyes large, situated at the back of the head, and resting partly on the pronotum.

Prothorax transverse, much broader than long, not confluent with the mesothorax.

Mesothorax and metathorax together cylindrical, coalescent, the boundary between them scarcely distinguishable; no scutellum nor scutellar process.

Elytra and wings always wanting.

Front legs short, rather stout. Tibia with a triangular process near the apex. Tarsus two-jointed; second joint with claws inserted about the middle.

Middle and hind legs long and slender, inserted at the sides of the posterior end of the thorax; the hind legs inserted above the middle legs. Middle legs with tibia and first joint of tarsus furnished with a fringe of long hairs; tarsus two-jointed, the second joint clawed before the tip. Hind legs with one-jointed tarsus clawed before the tip.

Abdomen very short, first three segments covered above by the metanotum. Apex of the abdomen in the male with a conspicuous rhomboidal appendage.

DETAILS OF STRUCTURE.

Halobates presents a peculiar appearance on account of the great development of the thorax in comparison with the abdomen, thus approaching in facies the larvæ of some other genera of *Hydrobatina*. The body is covered with very short and close pubescence of a grey colour, which is the predominating tint of the species, few of which have any conspicuous markings, at least on the upper surface. In all there are two reddish or yellowish spots at the back of the head, but in most cases these are not conspicuous. Several of the species have pale markings on the under side.

The Head and its Appendages.

The Head viewed from above is shortly triangular; viewed from the side, the vertex is more or less convex, while the frons is sloped very much downwards. The vertex is convex, at least in the middle, but is usually widely but shallowly depressed on each side near the hind margin; while there is another more slight depression before the middle lobe of the face. In the female the latter depression is more conspicuous than in the male. The posterior depressions do not extend so far as the orbits, the inner sides of which are slightly tumid. In the posterior depressions is generally a rufous spot, usually ill-defined and not conspicuous, but forming in a few species a conspicuous, oblique, reddish-yellow mark on each side of the middle of the back of the head. The hind margin between the eyes is convexly rounded, and in one or two species the edge is more or less narrowly elevated. The front of the head is sloped downwards, and is nearly, but not quite, perpendicular. The middle lobe of the face is at least twice as broad as the side lobes, a little dilated at the apex, somewhat prominent and truncate. The side lobes are sub-triangular and rather inconspicuous. The sides of the head are blunt and not margined. On each side of the upper surface of the head are three more or less conspicuous black points, rising above the pubescence, one at the posterior angle near the eye, one situated more inwardly, and in a line with the front of the eyes, and one near the inner angle of the base of the antenniferous tubercles (Pl. III. fig. 7). Under the microscope these spots are seen to be tubercles destitute of the pubescence which covers the rest of the head. The summit of each tubercle is concave with raised margins, and, situated within the rim and to one side, is a smaller tubercle, bearing a short hair (Pl. III. fig. 8). In two species (*wüllerstorffi* and *sericeus*) the apex of these tubercles is from ·02 mm. to ·022 mm. in diameter, and the length of the hair ·06 mm. to ·10 mm. On examining one of the tubercles from the inside of the head it appears to be hollow, with the base of the hair protruding (unless this is an optical illusion) for some way into the cavity. It is probable that these tubercles are organs of one of the senses, possibly that of sight. The situation of the posterior ones corresponds with that of the ocelli, with which the Hemiptera are frequently provided, but when these are present in the Heteroptera they are never more than two in number, and true insects in the adult condition have very rarely, if ever, more than three,[1] though there is reason to believe that the anterior ocellus when present really consists of two ocelli coalesced. This anterior pair would correspond to the middle pair in *Halobates*, and the anterior pair (in this genus) has disappeared in other insects (as has in some cases the middle pair, and in others all the pairs), though still existing in some groups of the Arthropoda. The nature of these tubercles seems to have been hitherto overlooked, and it is much to be desired that naturalists who have the opportunity should examine the structure in fresh specimens, and ascertain with what part (if any) of the nervous system they are connected.

The Eyes are large and prominent, situated at the hinder angles of the head, and extending for about one-third of their length behind it, resting on the sides of the thorax. The orbit, especially above and below, and in a less degree in front, is provided with several irregular series of long, strong hairs, curved at the tip, the hairs nearest the eye being the largest. Viewed from above, the eye is semi-circular in outline, with the inner edge slightly convex; viewed from the side it is roundly oval; viewed from below the outline is similar to that from above. The facets of the eye are hexagonal. In *wüllerstorffi* their diameter is about ·035 mm.; in *sericeus* about ·025 mm. The outer free periphery has (in two species) about 25 facets.

The Antennæ are attached to the inner anterior apex of conspicuous tubercles, which are situated on the side of the head between the eyes and the apex of the face. These

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[1] Some Aphides are said to have six.

tubercles viewed from above are irregularly conical, and connected with the vertex by a tumid ridge, which is more distinct in the female; viewed from below the tubercle points downwards, and the tip extends a little beyond the base of the antenna. Round the insertion of the antennæ the tubercle is furnished with a coronet of stiff hairs, curved at the apex. The antennæ themselves are at least half the length of the body, and are four-jointed, with two intermediate jointlets (Pl. III. fig. 1), one between the second and third joints of the antennæ, and one between the third and fourth; in each case the jointlet belongs to the joint preceding it. In one species the jointlets are said, but I think erroneously, to be absent.[1]

The first joint is the longest, and often nearly, and sometimes quite, as long as the other three joints taken together; very narrow at the extreme base, thick above the base, then narrowing to the middle, and often slightly incrassate at the apex; usually slightly curved; covered with numerous semi-adpressed hairs, except at the extreme base; the apex with stronger and longer hairs.

The other joints have similar pubescence to the first, except that the fourth has not stronger hairs at the apex. These joints vary in length and thickness in the various species, but usually the second is gradually incrassate from base to apex; the third is thicker than the second, and often shorter; and the fourth is generally the thickest of all, sometimes incrassate upwards, and sometimes attenuate from the middle upwards. The jointlets have a finer integument (not furnished with pubescence) than the true joints, and are usually of a paler colour than these. That between the second and third joints is narrow at the base and widens to the apex; the other is much smaller, and ring-like. In some species the antennæ are provided with a few fine spines.

The Rostrum is four-jointed, and reaches to the front margin of the mesosternum. The labrum is pentagonal, the basal sides oblique, and the apical sides forming a triangle; it reaches to or beyond the apex of the second joint of the rostrum.

The first joint of the rostrum is stout, and broader than long. The second is ring-like, and less than one-half the length of the first. The third is much the longest, stout, widened a little above the base, then diminishing to the apex. The fourth is much shorter than the third, less stout, and triangular in outline. The apex terminates in three short processes, one above and two below (Pl. III. figs. 2 and 3). The upper process (between which and the rest of the joint is a rather ill-defined transverse suture) is the broadest, and is rounded at the end; the two under processes are gradually narrowed to the end, which is gently rounded, their inner margins are sub-parallel, and their tips are shortly longitudinally striate. Between them is the end of the furrow in which the mandibles lie. In a line with the inner edges of the two inferior processes the margins of the furrow for the mandibles are longitudinally thickened, and have in the terminal joint of the rostrum a dark spiral line running round each (Pl. III. fig. 3). This spiral line is not continued into

[1] See the description of *Halobates frauenfeldanus*, *postea*.

the third joint, but in the latter the furrow is finely transversely wrinkled. The integument of the fourth joint has several rows of a few rather stout hairs with tubercled bases.

The Mandibles (Pl. III. fig. 4) seem to be triquetrous, with one side broader than either of the other two, and are scarcely dilated at the apex, which is very hard but not extremely finely pointed. On the outer edge, between the narrow sides, is a row of saw-like, back-pointing teeth of unequal length. These teeth gradually increase in length from the apex backwards, the fifth or sixth being the longest; after that they rapidly decrease in length till they become little more than slight elevations of the edge of the mandible. In number they vary in different species, but the average number is probably about twelve. In one species (*wüllerstorffi*) the breadth of the mandible a little behind the apex and across the narrower side is about ·012 mm. and on the broader side about ·024 mm.; in another species (*sericeus*), the breadths are respectively about ·012 mm. and ·018 mm. The mandibles can be traced back from the base of the rostrum into the head. On entering the head they suddenly diverge, the space between them being about as broad as the base of the rostrum. They then go nearly straight backwards to a point on a level with the base of the antenniferous tubercles, and are then suddenly bent forwards and outwards, the portion after the abrupt bend being either gradually dilated or split into several portions which diverge a little. This is the appearance presented by specimens mounted in Canada balsam, and lack of material has unfortunately prevented me from attempting to dissect out the parts.

The Maxillæ (or the organs which in the Hemiptera are supposed to represent the first pair of maxillæ) are much more complex in structure than the mandibles. Though often, like the mandibles, protruded from the apex of the rostrum, they can be retracted at least so far as that their tips reach only to the apex of the third joint of the rostrum. Though not inseparably united to each other, the two maxillæ are yet for a considerable portion of their length so closely connected that they form but one organ. Moderately magnified and viewed directly from above, this appears to be a rather blunt and stout bristle lying between the mandibles, but when a higher magnifying power is used, the structure is seen to be rather complex. As the specimens which I have examined are mounted in Canada balsam, and all the parts do not lie in the same plane, and as moreover I have not had an opportunity of making transverse sections, the following description (made with the aid of an amplification of 900 diameters), is probably only approximately correct. Viewed from above the organ presents the appearance of four parallel lines, the distance between the inner two being rather greater than between the outer and inner on either side (Pl. III. fig. 5). Towards the apex the outer and inner line on each side approach each other, and form a point which curves rather abruptly inwards, the point on one side overlapping and touching the point on the other, thus forming a rather blunt apex to the organ. On the outer edges, from the tip for a considerable way backwards, are a series of fine, rather irregular hairs, at first directed outwards and a little backwards, and then bent backwards. Between the outer and inner line on each side, is a series, beginning at the apex, and running back for a considerable way, of somewhat semilunar-shaped tubercles (Pl. III. fig. 6); while between the two inner lines is a close series of fine curved transverse lines, below which may be seen—by altering the focus—another series of similar lines, whose direction from side to side is a little different. If the organ is viewed in profile, the appearance is altogether different, as each maxilla exhibits on one side a series of comb-like teeth, which, beginning at the curved apex, runs back for a considerable way (Pl. III. fig. 6, *a*). What I conceive (perhaps erroneously) to be the real structure of the organ is this. Each maxilla consists of a fine tube, longitudinally open on the inner side and fringed on the outer (from the apex for some distance), with fine back-pointing hairs. The fine curved transverse lines which are seen in the central longitudinal space of the organ are fine curved hairs, which cross from one maxilla to the other, and of which there are on each maxilla a series both above and below (Pl. III. fig. 5, *a*). The semilunar-shaped tubercles are the comb-like teeth viewed directly from above, and which can only be properly made out when the organ is seen partly in profile. On tracing the organ further back, but while it is still included in the rostrum, both the back-pointing lateral hairs and the comb-like teeth disappear, but the inner series of curved hairs are continued. On tracing them backwards into the head the maxillæ can be seen to gradually diverge, and each of them then appears as if finely transversely striate in the middle line. Gradually and slightly dilating, and continuing to diverge, they can be traced backwards into the mesothorax for some distance. The breadth of the maxillæ a little behind the apex is in *sericeus* about ·025 mm. and in the larva of *lagunus* about ·014 mm.

The under side of the head is flatly convex, with a concave hind margin. The gula is broad, reaching to the hind margin. In form it varies somewhat in different species; sometimes the sides are slightly elevated, and sometimes there is a central longitudinal obtuse keel.

THE THORAX.

The thorax constitutes by much the largest part of the body, and increases in width more or less from the front to beyond the middle.

Of the three segments which compose it, two only can be easily distinguished, since the mesothorax and metathorax are coalesced, while the prothorax and mesothorax are quite distinct from each other.

The Prothorax.

The Pronotum is transverse and collar-like, the length in the middle being two to three times less than the breadth, which is less than the head with the eyes. The front margin is usually rather strongly concave between the eyes to receive the head;

the hind margin between the posterior angles is also concave, but often only slightly so, and in every case less concave than the front margin. The sides are a little oblique, so that the pronotum is a little wider behind than in front; gently rounded and convex, with the anterior and posterior angles also rounded. The disk is somewhat convex, or flat, somewhat slightly raised longitudinally in the middle line, or with a finely impressed line there. On each side of the middle line there is frequently a more or less distinct small transverse fovea situated a little behind the front margin; in some cases there is a larger fovea on each side, situated behind the anterior fovea. These foveæ may be of *post-mortem* origin. One species is described as being provided with three longitudinal furrows. Sometimes the pronotum is depressed in the middle of the hind margin. Its shape varies a little in the sexes.

The Prosternum is rather shorter than the pronotum, the front margin is less concave, and the hind margin is slightly convex. Of the disk the outer third on each side (except the extreme margin) is occupied from the front to the back by the large swollen acetabula of the front legs. The middle third is more or less strongly elevated on the longitudinal middle line.

The acetabula, viewed from the side, are perpendicular or slightly oblique behind, where they are highest; and from the back to the front present a strongly convex outline. Viewed from the front they are somewhat triangular in outline. The opening of the acetabula looks backwards, and a little inwards, and rests behind against the mesosternum. The anterior rim has a large triangular notch (Pl. I. fig. 8, *ac.*), whose apex reaches to within a short distance of the front margin of the prosternum. From its apex a slit or suture proceeds to, or almost to, the front margin.

The Mesothorax and Metathorax.

These two segments are coalesced, and together occupy frequently about three-fifths of the entire length of the body. They form also by far the broadest and deepest part. The suture between them is most frequently indicated merely by a sharp short transverse impression (not always to be discerned) situated on each side within, and a little in front of, the ridge leading to the hind legs. Below no part of the metathorax is visible.

The Mesonotum is more or less distinctly wider in front than the pronotum. The front margin is convex in the middle, and then concave at each side to receive the posterior angles of the pronotum; the anterior angles are produced a little in a forward direction. The sides are rounded and convex, and the width increases backwards—varying a little according to species and sex—till the greatest width is attained at, or a little before, or a little behind, the middle. The disk is frequently more or less convexly swollen (more rarely nearly flat), and is highest in the middle anteriorly. Sometimes there is a very fine impressed longitudinal central line. Posteriorly the mesonotum with the metanotum slopes more or less rapidly backwards between the insertion of the legs.

The middle and hind legs are inserted together at the sides of the posterior end of the thorax, but the hind legs are inserted above the middle legs, and their acetabula extend a little further back than the middle acetabula (Pl. I. fig. 8, δ γ). The middle acetabula, which occupy the lower posterior hind angles of the thorax, are, viewed from the side, cylindrical, and a little broader than long. Above they are covered by the hind acetabula. Viewed from below they are cylindrical, joined on the inner side by the concave hind margin of the mesosternum, which is continued nearly to the apex of each acetabulum. The opening is nearly circular, and looks backwards. On the outer side of the middle line below is a suture or slit of greater or less length.

The hind acetabula occupy the upper posterior angles of the thorax, and are cylindrical, longer than, but not so stout as, the middle acetabula, behind which they extend for about half their length, reaching to the apex of the middle coxæ. The posterior half of the acetabulum is slightly hollowed below, where it impinges on the middle coxa.

Between the middle and hind acetabula is a deep narrow longitudinal furrow, anteriorly forked, the branches being less deeply impressed. The upper branch is the longer, and goes upwards and a little forwards, and marks the base of the acetabulum. The lower and shorter branch runs forwards and a little downwards, and is formed for part of its length by the slit-like opening of the mesothoracic spiracle. In *wüllerstorffi* the slit of this spiracle is about ·2 mm. long; and in *sericeus* ·16 mm. The opening of the acetabulum is circular, and looks backwards and a little inwards, the free ends of the acetabula being nearer together than their bases.

Lying on the inside of the hind acetabulum is a narrow, almost parallel-sided plate, rather longer than the acetabulum, pointed in front and truncate behind; and divided from the acetabulum on the outer side and from the thorax and abdomen on the inner side by deep narrow furrows. The surface of the plate is not horizontal, but usually slopes more or less steeply to the inside, so that the outer edge is on a level with the upper surface of the hind acetabulum. In some cases, however, the slope is reversed, more especially in gravid females. Posteriorly the plate reaches beyond the end of the hind margin of the thorax, and the transverse impression or suture between the thorax and abdomen is continued across it. The situation of the smaller posterior part of the plate thus marked off varies a little in the sexes, and even in some of the species. In the male it is usually opposite the first free abdominal segment, and more rarely opposite (*e.g.*, in *Halobates sericeus*) the second free segment, which is its usual position in the female. In the latter this part of the plate is also smaller and more detached. Beyond this detached portion traces of similar plates may be seen at the sides of the basal free abdominal segments. It is evident, therefore, that the plate and its continuation are formed by the pleura (or epimera) of the thorax and abdomen. By some writers this plate has been described as the rudiments of the elytra and wings; and as these organs in insects are expansions of the sides or pleura of the thorax, this view is in a limited sense correct. As *Halobates*, however, has never been found with elytra or wings, and has probably never possessed them, it will, on the whole, be as well not to consider the plates in question to be rudimentary organs.

Between the plates the thorax diminishes in width backwards, and is marked on each side by transverse impressions, deepest at the sides, and rarely going across from one side to the other. These impressions indicate the position of the first three segments of the abdomen, which are covered by the integuments of the thorax.

The Mesosternum is more or less flat. The anterior angles are somewhat tumid, and have within them (at least sometimes), a short oblique furrow, in which lies the base of the anterior trochanter. The hind margin is more or less widely and deeply concave. No part of the metathorax is visible below.

THE ABDOMEN.

The abdomen, viewed from above, is small, rather depressed posteriorly, and, as regards the portion not concealed by the thorax, sub-triangular in outline, the apex of the triangle having attached to it in the male the conspicuous lozenge-shaped third genital segment, and in the female, being conical. The abdomen rarely reaches backwards much beyond the trochanters of the hind legs.

Including the genital segments, the abdomen consists of nine segments, of which the first three are covered above by the metanotum, and the last three are the genital segments.

The Abdomen of the Male.

Dorsal Surface.—(Pl. I. fig. 8, ♂ β). The hind margins of the first two (covered) segments, when they can be traced across, are rather strongly concave, or even sometimes slightly angulated; the hind margin of the third segment (coinciding with the hind margin of the metanotum) is less concave, or sometimes nearly straight. These three segments are longer in the middle than at the sides. Occasionally the suture between the second and third segments can be traced across the side plate (pleuron) mentioned in the description of the thorax. In most species the division between the third and fourth segments is well defined on this plate.

The fourth segment (the first free one) is usually the longest of the free segments, the remaining two being rather shorter and subequal in length to each other. At the sides of the basal segments there are sometimes slight indications of a connexivum (pleuron), but owing to the position of the abdomen this is very inconspicuous and obscure. The genital segments will be described separately.

Ventral Surface.—(Pl. I. fig. 8, ♂ *ab.b.*). All the six abdominal segments are uncovered. The first five are very short, ring-like, subequal in length, and more or less retracted within each other. The first is more or less covered at the sides by the mesosternum.

On the middle of it is a tubercle whose apex looks backwards and downwards, and is pierced by a somewhat transverse perforation. All the species, and both sexes, are furnished with this tubercle, though in some specimens it is scarcely visible, from the segment being retracted below the mesosternum.

What may be the nature of this tubercle, and its use, must remain uncertain until observations have been made on the living animal. There is nothing, so far as I am aware, corresponding to it in any other true insect. It is possible that its homologies may be found in the "ventral tube" of the Collembola. If such be the case the use may be to secure attachment to the animals on whose juices *Halobates* doubtless feeds, but it is somewhat idle to speculate on the origin and use till actual observations have thrown some light on the nature of the organ. (See note in the Appendix.)

The sixth segment is longer (sometimes much longer) than the others, and the sides are produced obliquely backwards to clasp the sides of the first genital segment. In all the segments the hind margins on the ventral surface are nearer the base of the abdomen than the hind margins on the dorsal surface.

The Abdomen of the Female.

On the *dorsal surface* it is, on the whole, similar to the male abdomen, with the exception of the differences in the structure of the pleuron mentioned in the description of the thorax.

On the *ventral surface* (Pl. I. fig. 7 ♀ *ab. b.*) all the six segments are ring-like. The sixth is prolonged a little at the sides. The first segment is furnished with a tubercle as in the male.

The Genital Segments of the Male.

The First Segment is, on the dorsal surface, ring-like, and similar to the last abdominal segment, but not so broad. Below it is nearly as long as (or even sometimes longer than) the whole of the abdominal segments taken together, while in shape it is transversely oblong or nearly square.

The Second Segment is almost hidden, both above and below, by the first, the only parts usually visible being a small, crescent-shaped, or semilunar plate above, while below all that can be seen is a long horn-like process on each side.

On dissection the true form of the segment is seen to be as follows:—

Above (Pl. III. figs. 20 and 21), transversely oblong, about four times as broad as long; hind margin much prolonged in the middle, the prolongation (the apex of which is the only part visible without dissection) presenting a rounded outline posteriorly.

Below, the middle of the hind margin is concave, giving rise near each side to a long horn-like process which lies along the side of the next segment, and reaches to or beyond the middle of its length (Pl. III. fig. 22). These processes differ in shape in different species, but deficiency of material to dissect has prevented me from describing them minutely in more than two species (Pl. III. figs. 23 and 24). It may be noted that in one species the left horn is always bent outwards and forwards (Pl. III. fig. 22); in all the other species examined by me both horns are symmetrical. The posterior angles of the segment are in some species furnished with a tubercle-like prolongation; in others this prolongation is situated between the angle and the base of the horn.

The Third Segment.—Above, the visible part of this is very conspicuous as an appendage to the end of the abdomen, in outline somewhat like the fluke of an anchor, with the lateral angles more or less produced and the general shape varying according to the species (Pl. III. figs. 20 and 25). The disk is longitudinally convexly elevated from the base (which is sometimes slightly gibbous) to the obtusely conical apex. The sides are somewhat flat, or even slightly depressed. The apex of the segment, viewed from above or from below, looks like an obtusely conical tubercle (Pl. III. figs. 25 and 26; and Pl. I. fig. 1, *g a*), but closer examination shows that the lower half of it is a nearly circular very convex plate, attached by the basal angles to the plate above. Between these plates is a horizontal fissure (at the very apex of the abdomen), in which the intestinal canal opens. The plates are therefore the podical plates. On dissection, the under surface of the upper or lozenge-shaped plate shows a deep longitudinal hollow, in which the intestine lies (Pl. III. fig. 26). The under surface of the extended sides is sometimes armed with short spines.

The third segment below is not continuous at the sides with the third segment above, and in its normal condition (that is, without having been dissected out) appears as a long, oval, convex plate, overlapped at the sides and end by the upper plate, and additionally protected at the sides by the horns of the second segment (Pl. I. fig. 1, *g a*). In some species the margin appears to be a little thickened, and to form a ledge on which the horns rest. On dissection, the plate presents internally (Pl. III. fig. 27) a deep concavity, filled by the horny case which contains the copulatory apparatus. The basal angles are expanded and go upwards and inwards to meet the base of the lozenge-shaped plate whose attachment is between them, the point of attachment being concealed by the produced hind margin of the second segment.

The horny capsule (Pl. III. fig. 28) just referred to is, viewed from above, very convex, rather strongly compressed laterally, and with a very polished surface. Dissected out and viewed from the side, it is seen to be a semicircular case, with the sides somewhat flattened, and the opening on the straighter margin of the semicircle. This straighter margin is not exactly straight, but, so far as the chitinous portion of it is concerned, is for the basal third straight, then widely concave, and then, for about the apical fourth, gently rounded. Along the straight and concave portions of the margin are (in the dissection) the remains of the membrane by which the capsule is attached, the apical fourth being free. It is difficult to make out and to describe the structure of the apparatus contained in the capsule. From the apex often protrudes a long, very narrow, gradually attenuating process, which, when not protruded, is curled up within the capsule. In *wüllerstorffi* the capsule is about ·52 mm. long by ·3 mm. broad, and the process, so far as protruded, nearly 1 mm. in length. In *sericeus* the capsule is rather smaller.

The Genital Segments of the Female.

Above and below, three segments are visible.

The first is, above, like the preceding abdominal segment, but not so broad. Below it is much longer than it is above, and subequal in length to three or more of the abdominal ventral segments. In shape it is transversely oblong. On the lateral line the dorsal and ventral parts of the plate are posteriorly not continuous for a greater or less length. In dissected examples may be seen a long process (triangular at the base), extending from the front margin forwards within the sixth and fifth abdominal segments.

The second segment is, above, similar to the first, but rather shorter and much narrower. Below, it consists of two triangular plates, whose edges meet or overlap in the longitudinal mesial line (Pl. I. fig. 7, ♀ *ab. b.*). (In some cases the first genital segment more or less completely covers the second below.) Within the genital fissure thus formed, but usually quite concealed, is situated the ovipositor, &c. The ovipositor appears to consist of four valves. Two, which lie somewhat externally to the other two, are sublanceolate in shape, with the inner apical margin slightly recurved upwards and outwards, and fringed with long hairs. The two inner valves are rather shorter and narrowly lanceolate, with their inner edges also fringed with long hairs.

The third segment terminates the body, and is altogether, in form and structure, like the conical apex of the abdomen of the male.

THE LEGS.

The Front Legs.

These are very short in comparison with the others, but are relatively stouter. In addition to subserving locomotion, they are (without being raptorial) fitted for grasping, and, for the greater part of their length, lie well in advance of the body.

The Acetabula have been already described.

The Coxa (Pl. I. fig. 8, *ac.*) is stout, and for the most part immersed in the acetabulum. It can best be seen on the inner side, where it presents a somewhat triangular outline. In colour it is usually somewhat paler than the rest of the leg.

The Trochanter (Pl. I. fig. 8, *ac.*) is large, about twice as long as broad, narrow at the base, and increasing gradually in breadth upwards. It is curved abruptly at the base, and the broad apex is cut obliquely forwards to articulate with the femur.

The Femur is joined to the anterior apical face of the trochanter, the base being curved somewhat downwards and backwards. It is usually stout, but varies in stoutness and shape in different species. The greatest thickness is usually a little above the base, and it is gradually attenuated upwards from about the middle. The anterior edge is nearly straight from the bend at the base to beyond the middle, and thence slightly curved convexly to the apex. The basal half of the posterior edge is either subparallel to the anterior edge or slightly convex, while the apical half is more or less (varying in different species) strongly curved concavely. Near the apex on the posterior edge is a notch, often nearly obsolete, but whose position is then marked in microscopical specimens by a thickening of the integument. The apex itself, which is sometimes very slightly incrassate, presents, when viewed from above (that is, between the anterior and posterior edges), an irregularly oblique outline; nearest the anterior edge it is straight, followed by a semicircular notch, and thence to the hind margin obliquely concave. The femur is more or less pubescent, the hairs on the lower posterior side being more numerous and longer, especially towards the base. The margin of the apex is fringed with long hairs. In most, if not in all the species, the femur is armed with a series of five or more long black hair-like spines, not quite erect, but pointing down the limb, and inserted a little above the posterior edge. The spines are longest and strongest near the base, and the series is not in all cases continued to the apex.

The Tibia is usually a little shorter than the femur, and much less stout. For the greater part of its length it is of equal thickness, but the extreme base is narrower, and the apex dilated and bifurcate. The upper branch of the bifurcation is a continuation of the long axis of the tibia, while the lower and posterior branch is subtriangular in outline, the basal side being curved, and the apical side slightly angular and at right angles to the anterior branch. The dilated portion varies in size and shape in different species. On the under side the anterior branch is somewhat flattened, and between it and the posterior branch is an oblique furrow. To the apex of the anterior branch, which is obtusely angular, the tarsus is articulated. On the outer side of the apex of the other branch is an oval patch (varying in size and shape in different species) of peculiar hairs. (Pl. III. figs. 9 and 10). These hairs are very short (in *wüllerstorffi* about ·025 mm., and in *sericeus* about ·024 mm. long), set so close together that they touch each other at the base and for some distance above it, and are gradually narrowed upwards to the rather blunt apex (Pl. III. fig. 11).

The patch is to be found only in the male; in the female, at the same spot, is a small tuft of short, almost straight hairs, not so closely set together.

The tibia is more or less pubescent, the pubescence being stronger and thicker on the under side of the dilated portion. The tibia is also armed with a series of spines similar to those of the femur, but less strong, and inserted a little below the posterior edge.

The Tarsus is two-jointed, and usually a little shorter than the tibia, and rather less stout.

The relative length of the joints one to the other varies in the different species, and often affords a good point of distinction.

The first joint may be equal to, or longer, or shorter than the second. In form it is cylindrical, and the base has a narrow neck. The outer side is clothed with strong hairs, which spring, as in other parts of the leg, from flat circular tubercles. On the inner side some of the hairs are arranged in a regular series, and the general pubescence is finer.

The second joint has also a neck at base, above which it is cylindrical, and with pubescence similar to that of the first joint.

At about the middle of its length the joint is cleft longitudinally into two unequal parts (Pl. III. fig. 13). The upper and outer part (which may be looked upon as the joint itself, while the lower and inner part may be called a process) is twice or three times the length of the other part, but is only about half as thick as the basal half of the joint. On the outer side it is rounded, but on the side facing the process it is flat or slightly channeled, and destitute of pubescence. The hairs on the outer side are rather coarse and adpressed, but towards the apex a few stronger, less adpressed hairs are mixed with the others, and in some species at least two or three long stout hairs, with curved extremities arise some way before the apex, and reach to or beyond it.

The process, or shorter part of the cleft joint, is parallel to the other part. It is somewhat triangular in outline, with a blunt apex, the outer side rounded and clothed with rather long semi-adpressed hairs; the inner face furrowed and destitute of pubescence. The fissure between the two parts is wider on the under side of the joint than on the upper.

At the bottom of the cleft are inserted the two curved sharp pointed claws (Pl. III. fig. 14), which are about double the length of the shorter division or process of the joint. Each claw is rather broad, somewhat angularly keeled on the posterior surface, and slightly concave on the other. At the base it is suddenly dilated posteriorly, the dilatation being triangular in outline. In one species (*wüllerstorffi*) the claws are about ·23 mm. long, in another (*sericeus*), they are about ·17 mm. From between and a little behind the claws arises a thin ribbon-like process about as long, but only half as broad, as the claws, curved backwards, equally wide and thin throughout, and truncate at the apex (Pl. III. figs. 13 and 14). The use of this process is unknown.

The Middle Legs.

The Acetabulum has been already described.

The Coxa is cylindrical, much broader than long; the apex is truncate, and fringed with rather long hairs, which curve inwards; it is hollowed to receive the expanded base of the trochanter.

The Trochanter (Pl. III. fig. 15, *tr.*) is about three times as long as broad. Its base is a somewhat flattened ball, which fits into the hollowed apex of the coxa. Above the base is a very short neck, above which the trochanter suddenly widens, and curves upwards and inwards; it is then for half the length somewhat cylindrical, while the apical half narrows to a point above, and below is triangularly cleft to receive the femur. The trochanter is more or less pubescent, and is sometimes armed on the inner side with small teeth or spines.

The Femur (Pl. III. fig. 15, *f.*) is much the longest joint. It is somewhat incrassate at the base, and becomes gradually thinner to about the middle, after which it is for a little way of equal thickness, and then is gradually and slightly incrassated to the apex. It is more or less pubescent, and is usually armed with small spines or teeth pointing backwards, and arranged in a series on the inner side from base to apex; more rarely the spines are irregularly scattered.

The Tibia (Pl. III. figs. 15 and 16, *ti.*) is shorter and less stout than the femur, cylindrical, and slightly and gradually attenuate from base to apex. It may be armed like the femur, or be unarmed. On the inner edge is one or more series of flattened circular tubercles, from which arise hairs (usually more or less curved at the apex), increasing in number and length towards the apex of the joint. From out of this line of curved hairs springs a fringe of very long hairs, many times longer than the diameter of the tibia, and naturally straight but easily bent. At the base of the joint these hairs are few, but their number and their length increase towards the apex.

The Tarsus (Pl. III. figs. 15 and 16, *ta.*) is two-jointed, the first joint being longer than the second, but varying in its relative length in the different species. The first joint (Pl. III. fig. 16, *ta.* 1) is cylindrical, and a little incrassate at the base. Its inner edge is furnished with hairs similar to those on the inner edge of the tibia; towards the apex of the joint these hairs diminish in length (Pl. III. fig. 17). Approximate measurements of this joint (taken about the middle) give (in *wüllerstorffi*) the diameter of the joint ·08 mm.; length of the hairs on the inner side ·035 mm.; of the curved short fringe ·05 mm.; and of the long fringe ·4 mm. In *sericeus* the corresponding measurements are ·05 mm.; ·025 mm.; ·05 mm. and ·4 mm. The second joint (Pl. III. figs. 15 and 16, *ta.* 2) is cylindrical, and bears on its inner side a line of short curved hairs, similar to that on the first joint, but without the long hairs. Not far from the apex on the inner side is a notch or excavation, from which to the apex runs a furrow, in which lie two straight claws. Arising from between the claws is a ribbon-like process similar to that on the front tarsus. Between the notch and the apex the joint is thinner than before the notch, and on its outer side arises, some way before the tip, one or two long stout hairs, more or less abruptly bent at the apex, and extending beyond the end of the joint. The length of the claws is, in *wüllerstorffi*, about ·085 mm., and of the longest hair on the opposite side of the joint ·2 mm. (the ordinary hairs there being ·05 mm.). In *sericeus* the claws are ·08 mm. long.

The Hind Legs.

In general form these resemble the middle legs, but are somewhat shorter and less stout.

The Acetabulum has been already described.

The Coxa is three or more times as long as broad, slightly curved outwards, and slightly incrassate at the apex.

The Trochanter is shorter and thinner than the middle trochanter.

The Femur shorter and thinner than the middle femur.

The Tibia has not the fringe of hairs on the inner side.

The Tarsus (Pl. III. figs. 18 and 19) is one-jointed. The joint is similar to the second joint of the middle legs, but has not the fringe of hairs on the inner side, and the excavation for the claws is rather more distant from the tip. Like the middle tarsus there is, on the side of the joint opposite to the claws, one to three long hairs inserted at different places, and reaching to or beyond the apex of the joint. The ribbon-like process from between the claws is also present. The claws measure in *wüllerstorffi* about ·15 mm., and in *sericeus* ·12 mm.

RESPIRATORY SYSTEM.

As in most other insects, air is admitted to the tracheal system by means of spiracles. I have failed to find any trace of prothoracic spiracles. The large mesothoracic spiracles have already been noticed (p. 30). The remaining spiracles are nearly circular in outline, and the first pair of these are inserted near the posterior end of the thorax (though possibly abdominal), and more or less near the sides of the body is one pair, and in the abdomen six pairs can without much difficulty be made out; and possibly others may exist, but may be concealed by the legs. Those that can be seen are as follows:—One pair on the first segment, usually covered by the thorax; one pair on each of the last three segments situated nearer the side of the body than those on the first segment; one pair on the first genital segment; and one pair on the second genital segment, situated at the posterior angles in the male, and about the middle of the side in the female. Measurements of the various circular spiracles give an average of, in *wüllerstorffi*, ·035, and in *sericeus*, ·025 mm. for the long diameter.

In the last two segments of the larva no spiracles exist.

I regret very much that want of material has prevented me from examining the internal anatomy more completely.

DESCRIPTION OF THE SPECIES.

The number of species of *Halobates* (in the restricted sense) already described is five, viz. :—

Halobates micans, Esch.
„ *sericeus*, Esch.
„ *flaviventris*, Esch.
„ *streatfieldanus*, Templ.
„ *wüllerstorffi*, Frauenf.

To these I am able to add six, namely :—

Halobates princeps.
„ *hayanus.*
„ *proavus.*
Halobates germanus.
„ *sobrinus.*
„ *frauenfeldanus.*

Key to the Species.[1]

1 The last three joints of the antennæ of equal length, . . . *frauenfeldanus.*
The last three joints not all of equal length, ... 2
2 Front femora more or less distinctly steel-blue in colour, ... 3
Front femora not blue, ... 4
3 Antennæ with the second and third joints equally long, ... *micans.*
Antennæ with the second joint one-fourth longer than the third joint, . *wüllerstorffi.*
4 Front tarsus with the first joint nearly twice as long as the second joint, . *princeps.*
Front tarsus with the first joint never more than equal in length to the second joint, 5
5 Antennæ with second joint equal to, or a little longer than, the fourth joint, . 6
Antennæ with the second joint distinctly shorter than the fourth joint, . . 8
6 Front tarsus with the first joint almost as long as the second, . . *flaviventris.*
Front tarsus with the first joint distinctly shorter than the second joint, . . 7
7 Front tarsus with the first joint one-half shorter than the second joint; antennæ with the second and fourth joints subequal in length, . . . *hayanus*
Front tarsus with the first joint one-third shorter than the second; antennæ with the second joint rather longer than the fourth joint, . . . *proavus.*
8 Front tarsus with the joints subequal in length, ... *streatfieldanus.*
Front tarsus with the first joint shorter than the second joint, . . . 9
9 Middle tarsus with the first joint seven times longer than the second joint, . *sericeus.*
Middle tarsus with the first joint not more than five times longer than the second joint, 10
10 Base of antennæ narrowly rufous ochreous; front tarsus with first joint a little more than half the length of the second joint, ... *germanus.*
Base of antennæ concolourous; front tarsus joint about one-fourth shorter than the second joint, ... *sobrinus.*

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[1] The "key" must be used with caution. More than one or two points have to be taken into consideration in discriminating the more closely allied species.

1. *Halobates wüllerstorffi*, Frauenf. (Pl. I. fig. 1).

Halobates wüllerstorffi, Frauenfeld, Verhandl. der. k. k. zool. bot. Gesellschaft in Wien, Band xvii. p. 453, Taf. xii. figs. 1, 2, 6, 8, and 10, 1867.

Oval, widest behind the middle. Whitish ash grey, paler on the sides and below. Back of the head with two very indistinct reddish spots. First two joints of the antennæ (indistinctly), coxæ, trochanters, and femora, and in a less degree the tibiæ more or less shining steely blue. Second joint of antennæ nearly one-fourth shorter than the fourth, and about one-fourth longer than the third. Front tarsus with first joint rather shorter than the second. Middle tarsus first joint more than three and a half times the length of the second.

♂. Length 4·25, breadth 2·3, middle femur 5, hind femur 3·25 mm.

♀. Length 3·5, breadth 2·5, middle femur 4, hind femur 2·5 mm.

Habitat.—The most widely diffused of all the species, but most common in the North Atlantic, between the tropic of Cancer and the equator. Less common in the North Atlantic, north of the tropics; in the South Atlantic, within the tropics; in the Indian Ocean; in the North-West Pacific, at about lat. 10° N., and in the South Pacific at about the tropic. There are no records of its occurrence in the Eastern Pacific.

In the Atlantic specimens have been taken between about lat. 43° N. and 20° S. In the Pacific between about lat. 10° N. and 25° S. In the Pacific specimens have not been taken east of long. 175° E.

The following are the localities of the specimens seen by me:—

Challenger Specimens.

North Atlantic, localities:—Station 98, Aug. 14, 1873, lat. 9° 21′ N., long. 18° 28′ W.; between Teneriffe and St. Thomas, West Indies, February and March 1873; about lat. 18° N., long. 28° W., April 28, 1876; Station 62, June 18, 1873, lat. 35° 7′ N., long. 52° 32′ W.

South Atlantic:—Off Rio de Janeiro, June 18, 1873.

North Pacific:—North of the Admiralty Islands, March 1875 (about lat. 12° N., long. 142° E.).

Specimens from other Sources.

North Atlantic localities:—Cape Finisterre (*Oxford Museum*); lat. 10° N. (*Stockholm Museum*); lat. 9° 20′ N.—5° N., long. 26° 30′ W.—26° 50′ W. (*Liverpool Museum*); Sargasso Sea (*Liverpool Museum*); lat. 5° N., long. 25° W. (*Liverpool Museum*); lat. 2° 30′ N., long. 28° 30′ W., January 31, 1865 (*Liverpool Museum*); Atlantic near equator (*Stockholm Museum*).

South Atlantic localities:—Near St. Helena (*Berlin Museum*); South Atlantic (*Liverpool Museum*).

Indian Ocean localities :—Just south of Mauritius, lat. 25° S. (*Collingwood*); Sunda Straits (*Turin Museum*); lat. 2° S., long. 84° 20′ E. (*Westwood*).

Pacific localities :—Near Norfolk Island (*Berlin Museum*); Guinea (*Signoret*).

♂. Oval, widest before the middle (Pl. I. fig. 1 ♂). Whitish ash grey, paler on the sides and below; sometimes with slightly brassy reflections. The two reddish spots at the back of the head more or less ill-defined. Eyes dark brown. Rostrum shining black, apex fulvous brown. Claws of the legs fulvous brown. Antennæ black, with, especially on the last two joints, greyish pubescence; the first two joints with an indistinct bluish tinge. Legs black; coxæ, trochanters, and femora, especially of the middle and hind legs, and in a less degree the tibiæ, more or less shining steel-blue. Front legs with grey hairs, the other legs with black or dark grey hairs. Underside of abdomen towards the middle at the sides more or less indistinctly reddish ochreous. Genital segments more or less shining bluish-black, but usually covered with greyish pubescence which is easily denuded.

Head rather strongly convex, slightly elevated on the mesial longitudinal line. *Antennæ* (Pl. I. fig. 1, *a.*) three-fifths the length of the body; first joint rather shorter than the other three taken together, slightly curved, very slightly thinner upwards, and apex slightly incrassate; second joint almost one-third the length of the first, slender, thinnest in the middle, then slightly incrassate to apex; third joint rather stout, cylindrical, thickest towards the apex, about three-fourths the length of the second; fourth joint nearly one-fourth longer than the second, thickest at the base, then gradually and slightly attenuate upwards.

Pronotum with front and hind margins nearly equally concave; disk slightly convex, with two transverse foveæ on each side, of which the posterior are the largest. *Mesonotum* widest about the middle, disk very convex.

Front Legs: Femora stout, thickest near the base, thence equally thick to the middle, and then slightly and gradually attenuate to the apex; slightly notched on the inner side just before the apex. The usual hairlike spines are frequently absent. Tibia nearly four-fifths the length of the femur, apex strongly dilated. Tarsus (Pl. I. fig. 1, *f.t.*) about four-fifths the length of the tibia; second joint longer than the first, cleft about the middle.

Middle Legs: Femora about one-eighth shorter than the tibia and tarsus taken together; scarcely incrassate at the apex, and rarely and obscurely armed with spines. Tibia (Pl. I. fig. 1, *m.t.*) rather more than one-half the length of the femur, rarely and obscurely armed. Tarsus subequal to, or slightly shorter than, the tibia, the first joint more than three and a half times the length of the second.

Hind Legs: Femur subequal in length to the tibia and tarsus taken together, rarely and obscurely armed with spines. Tibia about one-fourth shorter than the femur. Tarsus more than one-fourth the length of the tibia, cleft at about two-thirds the length from the base.

Abdomen: Sixth ventral segment nearly as long as the other five, the disk rather flatly depressed posteriorly.

Genital Segments: ♂ First below nearly as long as all the abdominal segments taken together, nearly as long as broad, hind margin straight, posterior angles rounded. Second below only visible at the sides; the right horn reaching nearly to the apex of the next segment (below); the left horn bent just above the base, and directed outwards and a little upwards (Pl. III. fig. 22). The horns (Pl. III. fig. 23) have thickened margins; the outer margin and the surface generally are covered with slight tubercles tipped with hairs; the apical margin is smooth; the inner is fringed at the base with long hairs, and from near the base to the apex is armed with tubercle-like teeth, arranged in several series on the thickened part, and pointing downwards. The hairs on the surface also point downwards. The posterior angles of this segment are prolonged into a broad tubercle-like process. The third segment above (Pl. I. fig. 1 *g*, and 1 *ga*) has the lateral angles somewhat produced.[1] The third segment below has apparently thickened margins.

♀. (Pl. I. fig. 1, ♀.) Similar in appearance to the male, but differs in the following particulars:—

Form more widely oval; femora of front legs and first joint of antennæ more distinctly steel-blue. Front femora less stout. Hind margins of ventral segments and apex of third genital segment indistinctly brownish-red. Below, the first genital segment about covers the second.

Halobates wüllerstorffi has been found from January to April, from June to August, and in October, and the larvæ from January to April, so that it probably occurs throughout the whole year.

The only note that I can find regarding the life history is in Dr. Cuthbert Collingwood's Rambles of a Naturalist, p. 358. The specimens referred to were given by him to Mr. J. W. Douglas, and by Mr. Douglas to me, and appertain to this species. "A notable circumstance occurred in the Indian Ocean, in lat. 25° S., just south of the Mauritius. For several days in succession the net produced *Halobates*, glass-crabs, *Velellæ*, and the beautiful oceanic shell *Janthina*, of a rich deep violet colour." A footnote is added as follows:—"The occurrence of this singular Hemipterous insect at sea is at least very remarkable. There appear to be several species, of which I met with two, one on the coast of China, and the other some 500 miles from the land, in the South Indian Ocean. That they are veritable marine insects I think cannot admit of a doubt, though how they exist in the open ocean is a mystery. They are of a deep bluish-black, with six legs, the two hindermost furnished with a delicate brush on the inner side of the tarsus. The abdomen is remarkably undeveloped. Although taken occasionally in the

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[1] For the form of this segment in the present and succeeding species, the student is referred to the figures, which will give a much better idea of the shape than any description could do.

towing-net, I did not find them common, and never observed any movement after capture, owing to their delicate soft bodies being injured by the passage of water and other things through the net."

2. *Halobates micans*, Esch. (Pl. I. fig. 2).

Halobates micans, Esch., Entomographien, i. p. 107, No. 786, Taf. ii. fig. 3, 1822.
Burmeister, Handbuch der Entomologie, vol. ii. p. 208, No. 1, 1835.
Blanchard, Hist. Natur. des Insectes, vol. iii. p. 98, No. 1, 1840.
Herrich-Schäffer, Die wanzenartigen Insecten, vol. viii. p. 110, 1848.
Frauenfeld, Verhandl. der k. k. zool. bot. Gesellsch. in Wien, p. 458, Taf. xii. fig. 5, 1867.

Widely oval, widest behind the middle. Hoary ash grey, lighter below. Antennæ and legs black, front femora bluish. Antennæ with second and third joints equal in length.

♀. Length 4, breadth 2·25, middle femur 4·6 mm.

Habitat.—Reported by Eschscholtz from the South Pacific and South Atlantic Oceans, and by Frauenfeld from the Indian Ocean, near Ceylon (lat. 3° N.).

I have not seen this species, and the above diagnosis and the following description are drawn up from the writings of Eschscholtz and Frauenfeld. Both these writers say that they have seen males only, but they confused the sexes—Eschscholtz's figure representing a female.

♀. Closely allied to *Halobates wüllerstorffi*. Widely oval or conical. Hoary ash grey or blackish-grey, somewhat shining, brighter coloured below. With (according to Eschscholtz) brassy reflections, which, however, Frauenfeld denies. Eyes black. Antennæ and legs black, the front femora bluish. Abdomen whitish-grey. Antennæ (Pl. I. fig. 2, *a*.) rather slender, rather longer than half the body, first joint as long as the other three together; second and third equal in length; fourth joint longer than the third. Pronotum strongly concave in front, nearly straight behind; disk with two rather long foveæ anteriorly. Mesonotum strongly convex anteriorly.

According to Frauenfeld, *micans* differs from *wüllerstorffi* in the slenderer antennæ, with longer first joint, and second and third joints equal in length; legs more slender, and, except the front femora, without any bluish tinge.

Dr. Rogenhofer kindly measured, at my request, some of Frauenfeld's specimens in the Vienna Museum, and states the proportions of the joints of the tarsi to be as follows:—First joint of front tarsus very little shorter than the second joint; middle tarsus one-sixth shorter than the middle tibia; first joint of middle tarsus less than three times the length of the second.

As Frauenfeld was acquainted with both species, there can be no doubt that *micans* exists as a species distinct from *wüllerstorffi*, but whether all the specimens that

Eschscholtz saw, and on the strength of which he gives as localities the South Atlantic and South Pacific Oceans, are really referable to *micans*, seems to me open to doubt.

3. *Halobates princeps*, n. sp. (Pl. I. fig. 3).

Oblong oval, widest behind the middle. Somewhat shining, silvery ash grey, especially on the sides and below. A reddish-yellow oblique mark on each side of the head posteriorly. Middle acetabula, with the inferior margins, inner edge of suture, and the adjacent part of the hind margin of mesosternum, as well as the hind margins of the ventral segments, fuscous ochreous. Antennæ and front legs black. Middle and hind legs brownish-black. Antennæ with second joint subequal in length to fourth, less than twice as long as third. Front tarsus with first joint a little less than twice as long as second. Middle tarsus with first joint more than three and a half times the length of second.

♀. Length 5·5, breadth 2·3, middle femur 7, hind femur 5 mm.

Habitat.—Celebes Sea. February 6th, 1875. One specimen. (Challenger.)

Somewhat like *Halobates wüllerstorffi*, but distinguished from that and other species by its larger size and longer middle and hind legs, as well as by the long first joint of the middle tarsus.

♀. Oblong oval, widest behind the middle. Slightly shining silvery ash grey, brighter at the sides and below. Back of the head with an oblique, not very well-defined reddish-yellow spot on each side. Antennæ and front legs black, with greyish pubescence. The other legs brownish-black; coxæ and trochanters with silvery grey hairs, the other joints with fuscous hairs. Eyes brown. Rostrum black. Margins of the middle acetabula below, the adjacent part of the hind margin of the mesosternum, the inner edge of the middle acetabular suture, and the hind margins of the ventral abdominal segments fuscous ochreous.

Antennæ (Pl. I. fig. 3, *a*.) about three-fourths the length of the body; first joint slender, subequal in length to the other three joints taken together; second joint slender, about one-third the length of the first; third joint more than one-half the length of the second; fourth subequal in length to second, stout and slightly attenuate upwards.

Pronotum with front margin strongly and hind margin slightly concave; disk with a wide transverse fovea on each side anteriorly.

Mesonotum widest behind the middle.

Front legs with stout femora, thickest about the middle; tibia subequal in length to femur; tarsus (Pl. I. fig. 3, *f.t.*) subequal in length to the tibia, first joint a little less than twice as long as the second, which is cleft between the base and the middle.

Middle legs: trochanter armed with spines; femora as long as the tibia and tarsus taken together, armed with very fine spines; tibia more than one-half the length of the femur, the basal one-third armed with fine spines; tarsus (Pl. I. fig. 3, *m.t.*) one-fifth shorter than the tibia, first joint more than three and a half times the length of the second.

Hind legs: femur, about two-thirds the length of the middle femur, one-fifth longer than the tibia and tarsus taken together, armed with fine spines; tibia about half as long as the femur, armed with fine spines; tarsus about five-eighths of the length of the tibia, cleft a little beyond the middle.

Abdomen: fourth dorsal segment with two obscure short transverse impressions on each side of the middle.

Genital segments; first below longer than all the ventral abdominal segments taken together, strongly transversely convex, hind margin straight. Second segment below concealed by the first.

4. *Halobates streatfieldanus*, Templn. (Pl. I. fig. 4).

Halobates streatfieldana, Templeton, Trans. Entom. Soc. of London, vol. i. p. 230, pl. xxii. fig. A, 1836.

Broadly ovate, widest behind the middle. Brilliant black above, brownish-black below. Two small spots at the back of the head, and the sides and hind margins of the fourth and fifth abdominal segments above rufous. Abdomen below with the first five segments yellowish, with hind margins rufous. Antennæ: second joint longer than the third, but shorter than the fourth. Front tarsus with the joints subequal in length.

♀. Length, 0·13 inch (3·3 mm.).

Habitat.—Atlantic Ocean, nearly midway between Africa and America south of the equator.

I have not seen this species. The above diagnosis and the following description are compiled from Templeton's paper.

♀. Broadly ovate or lozenge-shaped. Brilliant black above, brownish-black below; sides when dry somewhat hoary. Head with a rufous spot on each side of the middle at the hind margin. Eyes rufous. Abdomen above with the sides and hind margins of the fourth and fifth segments rufous; below with the first five segments yellowish, with rufous hind margins.

Antennæ (Pl. I. fig. 4, *a.*) about two-thirds the length of the body; first joint slender, not so long as the other three taken together; second longer than the third; fourth longer than the second, attenuating upwards.

Pronotum gently channeled into three subequal divisions, scarcely visible in the dried specimen.

Front legs (Pl. I. fig. 4, *f.l.*) : tarsus (Pl. I. fig. 4, *f.t.*) with the joints subequal, the second cleft about the middle.

Templeton's full description, as also the account of the capture of the specimen, will be found in the first part of this paper.

5. *Halobates sobrinus*, n. sp. (Pl. I. fig. 5).

Long oval, widest behind middle (♂), or oval, widest about the middle (♀). Ashy grey (♂), or dark grey (♀), paler below. Head with two ill-defined rufous spots posteriorly. Antennæ and legs dull fuscous black. Abdomen: hind margin of fourth dorsal segment rusty brown, genital segments dull fuscous black (♂); or ventral segments dull brownish, hind margins broadly ochreous, first and second genital segments brownish below, middle acetabula below from the suture inwardly rather broadly ochreous (♀). Antennæ: third joint rather more than one-fourth shorter than the second, which is one-fourth shorter than the fourth. Front tarsus: first joint about one-quarter of the length shorter than the second. Middle tarsus: second joint rather more than one-quarter of the length of first.

♂. Length 4, breadth 1·75, middle femur 5, hind femur 4·5 mm.

♀. Length 4, breadth 2, middle femur 4, hind femur 3 mm.

Habitat.—Tahiti (*Stockholm Museum*).

♂. Long oval, widest behind the middle. Ashy grey, somewhat paler below. Head with the usual ill-defined rufous spots. Antennæ, legs, first genital segment below, and genital segments above, dull fuscous black, with more or less sparse grey pubescence.

Head with the hind margin very slightly elevated on each side of the middle. *Antennæ* (Pl. I. fig. 5, *a.*) about three-fifths the length of the body; first joint shorter than the other three taken together; second joint about one-half the length of the first; third about three-quarters the length of the second; fourth about one-quarter longer than the second, attenuate from the middle upwards.

Pronotum: front margin rather strongly concave, hind margin slightly concave; disk slightly convex, with a very fine impressed longitudinal central line, on each side of which is an anterior transverse fovea. *Mesonotum* gradually widened to beyond middle; disk convex, with a very fine percurrent longitudinal central line.

Front legs: femora rather stout; tibia subequal in length to femur; tarsus (Pl. I. fig. 5, *f.t.*) about two-thirds as long as tibia, first joint about one-fourth shorter than the second, which is cleft before the middle.

Middle legs: femur subequal in length to tibia and tarsus together, armed with a series of small teeth, as is the tibia; tibia about three-fourths of the femur in length; tarsus (Pl. I. fig. 5, *m.t.*) about three-fourths of the tibia in length, second joint rather longer than one-fourth of the first, cleft near apex.

Hind legs: femur and tibia armed like the middle legs, the femur about one-third longer than the tibia and tarsus taken together; tarsus about one-third the length of the tibia, cleft beyond the middle.

Abdomen (which appears to be a little distorted—in drying—in the specimen described) with the sixth ventral segment a little longer than the fifth.

Genital segments: first below subequal in length to all the abdominal ventral segments, hind margin very slightly concave, sides oblique. Second segment with horns reaching nearly to the apex of third below: exterior to the base of each horn is a spine-like tubercle. Third segment (Pl. I. fig. 5, *g.*) above with the lateral angles much produced outwardly.

♀. Oval, broadest about the middle. Darker in colour than the male; middle acetabula below, from the suture inwardly, rather broadly ochreous, shading into brown. Abdomen above with the hind margins of the uncovered segments, especially the fourth and fifth, rusty brown (possibly, however, this is the membrane between the segments, more visible than usual); ventral segments (2nd to 6th) dull brown, with the hind margins broadly ochreous. Genital segments; first fuscous brown; second below brown; third below black.

Head more convex than in male, the hind margin not elevated. *Antennæ* with the fourth joint quite as long as half the first, and about one-fourth longer than the second.

Abdomen: hind margins of ventral segments rather elevated and thickened.

It is not improbable that fresher examples of this species may be greyer in general colour.

6. *Halobates sericeus*, Esch. (Pl. I. fig. 7).

Halobates sericeus, Esch., Entomographien, i. p. 108, No. 79, Taf. ii. fig. 4, 1822.
Burmeister, Handb. d. Entomol., ii. p. 209, No. 2, 1835.
Blanchard, Hist. Nat., vol. iii. p. 98, No. 2, 1840.
Amyot and Serville, Hémipt., p. 412, No. 2, 1843.
Herrich-Schäffer, Die wanzenartigen Insecten, vol. viii. p. 110, Tab. cclxxxvi. fig. 880 ♀, 881 ♂, 1848.

Ovate, widest a little before (♂) or about (♀) the middle. Ashy grey. Head with the usual ill-defined reddish marks at the hind margin. Antennæ, legs, rostrum at base, and genital segments, fuscous black, clothed more or less with grey pubescence. Hind margins of the ventral abdominal segments sometimes obscurely luteous. Antennæ: third joint shorter than the second; fourth subequal in length to the second and third taken together. Front tarsus with first joint less than one-half (two-fifths) the length of the second. Middle tarsus with first joint seven times longer than the second.

♂. Length 3, breadth 1·75, middle femur 3·25, hind femur 2·5 mm.

♀. Length 3, breadth 2, middle femur 3, hind femur 2·25 mm.

Habitat.—Next to *Halobates wüllerstorffi*, the most abundant species, but almost confined to the North Pacific Ocean, over which, within or near the tropics, it is widely diffused. Less abundant in the South Pacific. Two specimens, which seem inseparable from *sericeus*, were taken by the Challenger in the North Atlantic, near the Cape de Verde Islands. Amyot and Serville record its occurrence near the Cape of Good Hope, and Fairmaire from near Madagascar; but I have not seen specimens from either locality, and it is possible that these were not correctly determined, since any small grey *Halobates* was always referred to *sericeus*.

The specimens I have examined are from the following sources:—

Challenger Specimens.

North Pacific localities:—Many stations on the voyage from the Admiralty Islands to Japan, and from Japan to Honolulu (or—in other words—common between the equator and lat. 38° N., and between long. 137° E. and 154° W., thus ranging considerably north of the tropics).

South Pacific:—Lat. 23° 46′ S., and long. 149° 59′ W.

North Atlantic:—About lat. 11° N., long. 32° W.

Specimens from other Sources.

Pacific between Cape Horn and San Francisco (*Liverpool Museum*). "Ocean Austral" (*Berlin Museum*). "Pacific.—Lat. 24°–34°, long. 120°–115°" (*Stockholm Museum*).

♂. Ovate, widest a little before the middle. Ashy grey. Antennæ, rostrum, legs, and genital segments fuscous black, clothed more or less with grey pubescence. Head with an ill-defined reddish oblong transverse blotch on each side at the hind margin. Eyes brown or, more rarely, yellowish. Rostrum for apical half, front femora, and last genital segment below more or less shining black. Abdomen with the ventral hind margins sometimes very obscurely reddish luteous.

Antennæ (Pl. I. fig. 7, *a*.) comparatively stout, about half as long as the body; first joint more than one-third shorter than the other three joints taken together; second incrassate upwards, about two-fifths the length of first; third cylindrical, shorter than the second; fourth stout, slightly and gradually incrassate upwards, subequal in length to the second and third taken together.

Pronotum of the usual form, disk somewhat flat, rather hollowed in the middle posteriorly, and with a transverse fovea on each side anteriorly. *Mesonotum* widest a little behind the front margin, disk very convex. *Mesosternum* with a very indistinct percurrent longitudinal mesial line.

Front legs: femora very stout (comparatively), nearly equally thick to middle, then narrowing to apex; tibia about four-fifths the length of the femur; tarsus (Pl. I. fig. 7, *f.t.*) about three-fifths the length of the tibia, first joint two-fifths the length of the second, which is cleft about the middle.

Middle legs: trochanters armed on inner side with short spines, as is the femur; femur rather shorter than the tibia and tarsus taken together; tibia a little shorter than the tarsus; tarsus (Pl. I. fig. 7, *m.t.*) first joint seven times as long as second joint.

Hind legs: femur armed as middle femur, about one-fifth longer than the tibia and tarsus together; tibia armed on all sides with scattered small spines; tarsus cleft at about two-thirds of the length.

Abdomen: peculiarities of the connexivum have been noticed in the generic description.

Genital segments: first below as long as four of the abdominal ventral segments, transversely convex, sides parallel. Second with the horns reaching about three-fourths the length of the third below; the margins of the horn (Pl. III. fig. 24) are not thickened, and on the basal half are a few long hairs pointing inwards, and arising from the disk; apical half of the disk set with short, stout, outward-pointing teeth; near the base of the horn, and between it and the posterior angle of the segment, is a tubercle. Third segment above (Pl. I. fig. 7, *g.*), with the lateral angles moderately produced; on each side below is a patch of sharp spines pointing forwards.

♀. Ovate, widest at about the middle. Hind margins of the ventral abdominal segments sometimes luteous.

Head and *mesothorax* more convex than in the male.

Front tibia nearly as long as femur.

Middle legs: trochanters unarmed, femora less strongly armed. Sometimes the middle and hind legs are scarcely armed.

Abdomen below (Pl. I. fig. 7, ♀ *ab. b.*): segments 1st to 5th, each rather elevated in transverse middle line; sixth with a suboblique transverse furrow not quite reaching the middle.

Genital segments: first below as long as three of the ventral abdominal segments together, transversely convex, sides tumid, hind margin straight in the middle, each side somewhat oblique.

Halobates sericeus has been found in March, April, June, July, and October, but probably occurs all the year round. The larva resembles the adult, with the exception of the differences to be noted in the description of the metamorphoses.

7. *Halobates germanus*, n. sp. (Pl. I. fig. 6).

Long oval (♂) or shortly ovate (♀), widest behind the middle. Dark ashy grey paler on the sides (♂), or silvery ashy grey (♀). Head with an obscure transverse rufous yellow mark on each side at the hind margin. Antennæ and legs fuscous black above, dark fuscous brown below, clothed sparsely with grey pubescence. Base of antennæ narrowly rufous ochreous. Front legs with coxæ, trochanters more especially on inner side, and base of femora below; middle legs with a spot on the acetabula below (broader and more distinct in the female) trochanters, and base of femora below; hind legs with trochanters and base of femora, more or less indistinctly fuscous ochreous brown. Abdomen with hind margins of ventral segments fuscous ochreous. Genital segments: first below on disk and posteriorly, second above, and apex of third above, fuscous brown; second below, especially at apex of horns, and most of third below, fuscous rufous brown. Antennæ: third joint shorter and fourth joint longer than the second. Front tarsus: first joint rather more than half the length of second. Middle tarsus: first joint about five times as long as second.

♂. Length 3·5, breadth 2, middle femur 4, hind femur (?) mm.
♀. Length 3, breadth 2·25, middle femur 4, hind femur 3 mm.

Habitat.—North Pacific Ocean and Celebes Sea (Challenger); China Sea (Giglioli).

♂. Long oval, widest behind the middle. Dark ashy grey, paler on the sides. Antennæ and legs fuscous black above, dark fuscous brown below, more or less sparsely clothed with grey pubescence. Rostrum with the apical three-fourths shining black. Eyes dark brown. Antennæ at the extreme base rufous ochreous. Head with an ill-defined transverse rufous yellow mark on each side near the hind margin. Front legs with the coxæ, trochanters (more especially on the inner side) and base of femora; middle legs with a blotch on under side of acetabula, trochanters, and femora at base below; hind legs with trochanters and base of femora, more or less indistinctly fuscous ochreous brown. Abdomen with the hind margins of the ventral segments fuscous ochreous. Genital segments with the second above and apex of the third above, as well as the disk and hinder part of the first below, fuscous brown; the second below, especially at the tips of the horns, and the third below, especially towards the base, fuscous rufous brown.

Head with hind margin slightly elevated on each side of the middle, the elevation neither reaching the middle nor the eyes. *Antennæ* (Pl. I. fig. 6, *a*.) more than half the length of the body, rather slender; first joint rather more than three-fourths of the length of the other three together; second joint less than one-half the length of the first; third one-fourth shorter than the second; fourth nearly one-quarter longer than the second, slightly attenuate from the middle upwards.

Pronotum of usual shape with the usual anterior foveæ, disk rather flat. *Mesonotum* widest behind the middle, disk convex.

Front legs: femur rather stout, equally thick to beyond middle; tibia about one-fifth shorter than femur; tarsus (Pl. I. fig. 6, *f.t.*), more than one-half length of tibia, first joint rather more than half (nearly five-eighths) the length of the second, which is cleft about the middle.

Middle legs: trochanters and femora armed with short teeth; femur rather shorter than tibia and tarsus together; tibia about one-fifth longer than tarsus; tarsus (Pl. I. fig. 6, *m.t.*) second joint about one-fifth the length of the first joint.

Hind legs (from the ♀): trochanters and femora with fine teeth; femur about two-fifths longer than the tibia and tarsus together; tibia four and a half or five times longer than the tarsus; tarsus cleft a little beyond the middle.

Abdomen: sixth ventral segment a little longer than the fifth.

Genital segments (Pl. I. fig. 6, *g.*): first below nearly as long as all the ventral abdominal segments together; disk sloping forwards anteriorly, posteriorly flat, with an oblique-sided hollow (from shrinking in drying ?), hind margin straight. Second below with horns reaching four-fifths the length of the third below and with a tubercle near the base of each.

♀. Shortly ovate, widest behind the middle. Silvery ashy grey. Coxæ, trochanters, and base of femora below paler than in the male. Middle acetabula below more widely and distinctly ochreous or rufo-ochreous, which colour spreads to the adjoining part of the hind margin of the mesosternum. First genital segment paler below.

Head more convex.

Pronotum more convex in middle, with two transverse foveæ on each side, the anterior larger and deeper.

First *genital segment* below almost as long as all the ventral abdominal segments together, tumidly convex in centre posteriorly, hind margin narrowly straight in middle, the sides somewhat obliquely rounded at the base.

This species might readily be mistaken for *sericeus*, from which, however, it seems to be structurally distinct. I have seen only three specimens (unfortunately not in the best condition) from the following sources:—

Celebes Sea, February 6 and 7, 1875, and between the Admiralty Islands and Japan, March and April, 1875 (Challenger); "Mare della China" (Turin Museum).

One specimen shows a curious abnormality of the right antenna (the left is broken), which is only two-jointed, the first joint very small and almost ring-like, the second about as long as the normal fourth joint.

8. *Halobates hayanus*, n. sp. (Pl. I. fig. 8).

Oval, widest about (♂) or behind (♀) the middle. Silvery grey above, paler on the sides, and silvery white below. Antennæ and legs blackish, with grey pubescence. Head with an oblique, wedge-shaped, reddish-yellow spot on each side between the eyes, the spots meeting by their narrower ends at the middle of the hind margin.

♂. Antennæ at the base, prosternum (except the sides), front legs with coxæ and trochanters, a spot at base and a smaller spot at apex of front femora; middle and hind legs with under side of coxæ and trochanters, sternum with a somewhat obsolete longitudinal posterior central line, a large triangular blotch on the under side of the middle acetabula, a large spot on the outer side of all the acetabula, third genital segment above with the margins, as well as the abdomen and genital segments below, more or less yellowish ochreous. Second genital segment above reddish-brown, tips of the horns blackish-brown. Antennæ: third joint about four-fifths the length of the second, fourth joint subequal in length to the second. Front tarsus: first joint about one-half the length of the second. Middle tarsus: first joint quite three times the length of the second.

♀. Similar in colour to the male, but front femora with a yellow-ochreous band above from base to near apex, and another more distinct one on the inner under side. Under side of the body mostly yellowish ochreous, sides of the head, and sides of the sternum, especially anteriorly and on the front margin of the mesosternum, fuscous brown.

♂. Length 3·5, breadth 1·5, middle femur 4, hind femur 3·5 mm.

♀. Length 3·5, breadth 2·25, middle femur 4·5, hind femur 3·5 mm.

Habitat.—Red Sea, near Aden (Dr. George Hay).

♂. Oval, widest behind the middle. Silvery grey above, more silvery on the sides, and silvery white below. Antennæ and legs fuscous black, with grey pubescence. Head with two oblique transverse, wedge-shaped reddish-yellow spots, which meet by their narrow ends at the middle of the hind margin. Sides of the head with longer silvery white pubescence. Jointlet between the second and third joints of the antennæ reddish-yellow. Antennæ with the base; prosternum except the sides; front legs with the coxæ and trochanters, and a spot at base and a smaller spot at apex of femora; middle and hind legs with under sides of coxæ and trochanters; mesosternum with a rather obsolete posterior central longitudinal line, and a large triangular blotch reaching from the apex of the middle acetabula nearly half-way to the front margin of the mesosternum; all the acetabula with a large spot exteriorly; third genital segment above with the margins, as well as the abdomen below and genital segments below, more or less yellowish ochreous, tinged in some places with reddish. Pale markings of the trochanters and coxæ with small black or fuscous spots and blotches varying in intensity of colour. Eyes brownish-black; rostrum piceous black. Tubercle at the base of the abdomen fuscous black. Front tarsus fuscous brown. Second genital segment above reddish-brown, the tips of the horns blackish-brown.

Head very convex in middle of vertex. *Antennæ* (Pl. I. fig. 8, *a.*) more than three-fourths the length of the body, rather slender; first joint subequal in length to the other three together; second rather more than one-third (about two-fifths) the length of first; third thicker than the second, and about one-fifth shorter; fourth joint subequal in length to the second, rather incrassate upwards to near the tip, then attenuate; several of the joints have a few spines.

Pronotum of usual form, rather flat, with an anterior transverse fovea on each side. *Mesonotum* gradually widened to the middle, then gradually narrowing; disk convex, with a very faint impressed longitudinal central line.

Front legs: femora rather stout, equally thick to middle; tibia about three-fourths the length of the femur; tarsus (Pl. I. fig. 8, *f.t.*) about three-fourths the length of tibia, first joint rather stout, about one-half the length of the second, which is cleft at the middle.

Middle legs: femur armed on inner side with fine spines, about one-third shorter than the tibia and tarsus taken together; tibia about three-fourths the length of the femur; tarsus (Pl. I. fig. 8, *m.t.*) rather more than one-fourth shorter than the tibia, first joint quite three times the length of the second.

Hind legs: femur about one-fourth longer than the tibia and tarsus together; tibia nearly four times as long as the tarsus, armed with fine spines; tarsus cleft beyond the middle.

Abdomen (Pl. I. fig. 8, ♂ *ab.h.*): first ventral segment rather the longest, the hind margins of the second to the fifth slightly produced in the centre; sixth nearly concealed in the middle by the fifth.

Genital segments (Pl. I. fig. 8, *g.*): first below nearly as long as all the ventral abdominal ones together, hind margin concave, sides oblique. Second with horns reaching nearly to apex of the third segment below, with a small conical tubercle near the base of each.

♀. Ovate, widest behind the middle. Colour and markings as in the male, but the front femora have a yellow ochreous band above from the base to near the apex, and another more distinct one on the under inner side. Sometimes the whole femur below, except at the apex and most of the first joint of the antennæ below, is more or less pale, but this may be from immaturity. Head with the sides and sternum on the sides, especially anteriorly, as well as the front margin of the mesosternum, fuscous brown.

Front femora less stout than in the male.

Genital segments: first below longer than all the ventral abdominal segments together, hind margin concave, posterior angles obliquely rounded. Second below with the edges of the valves overlapping each other a little.

The larva is similar to the adult (with the usual differences), but with the bases of the front femora and antennæ, as well as the under side of the body more widely pale, and the leathery parts of the integuments above reddish-brown. The species occurs in large "schools" on the surface of the sea near Aden, and the larvæ, which seem to dislike the wind more than the adults, take shelter in the lee of piers.

9. *Halobates proavus*, n. sp. (Pl. II. fig. 1).

Oblong, rather wider behind the middle. Slaty grey above and below. Head with an oblique transverse reddish-yellow spot on each side, nearly forming a band on the hind margin. Antennæ and legs fuscous brown. Gula, front acetabula at the margins, and front coxæ at the apex; most of middle coxæ; sternum posteriorly, at least sometimes; a large triangular brown-edged blotch on the under outer side of the middle acetabula, and the adjacent hind margin of mesosternum, as well as the greater part of the abdomen below, yellow ochreous. Abdomen with first and second ventral segments in part, the sixth at the sides, a spot at the base on each side of the first genital below, and the tips of the horns of the second genital, more or less fuscous brown. Trochanters at the apex, front femora with a long streak on the under side, middle femora with a spot at the base below, as well as sometimes the disk posteriorly of the mesosternum, brownish ochreous. Antennæ: third joint about two-thirds the length of the second, fourth joint subequal in length to second. Front tarsus: first joint nearly two-thirds the length of the second.

♂. Length 4, breadth 1·5, middle femur 4·25 mm.

Habitat.—Gilolo (British Museum and Brussels Museum).

♂. Oblong, rather wider behind the middle. Slaty grey above and below. Head with an oblique transverse reddish-yellow spot on each side at the hind margin, nearly forming a band there. Antennæ and legs fuscous brown. Eyes reddish-brown. Rostrum shining black. Gula, sternum posteriorly, at least sometimes, margins of front acetabula and apex of front coxæ, a large triangular brown-edged spot on the under and outer side of the middle acetabula, and the hind margin of mesosternum adjacent thereto, most of the middle coxæ, and most of the abdomen below, as well as genital segments below, yellowish ochreous. Abdomen with the first and second ventral segments in part, the sides of the sixth, a spot at the base of the first genital segment below, and the tips of the horns of the second genital segment, more or less fuscous brown. Front femora with a long streak on the under side, the trochanters at their apex, a spot at the base of the middle femora, as well as sometimes the disk posteriorly of the mesosternum, brownish ochreous.

Antennæ (Pl. II. fig. 1, *a.*) slender, about three-fourths the length of the body; first joint shorter (about one-sixth) than the other three together; second less than half the length of the first; third about two-thirds the length of the second; fourth slightly shorter than the second, stouter, attenuate from the middle upwards.

Pronotum with an impressed longitudinal central line. *Mesonotum* slightly and gradually widening to about the middle, disk rather flat, with a fine impressed longitudinal percurrent central line.

Front legs: femora not very stout, thickened about the middle; tibia about four-fifths the length of the femur; tarsus (Pl. II. fig. 1, *f.t.*), about half as long as the tibia, first joint nearly two-thirds the length of the second, second cleft before the middle.

Middle legs: trochanter armed with spines; femur with scattered spines all round, shorter than the tibia and tarsus taken together; tibia about four-fifths the length of the femur, with a series of spines on the inner side; tarsus (Pl. II. fig. 1, *m.t.*) about two-thirds the length of the tibia, first joint three times the length of the second.

Hind legs: femur about two-fifths longer than tibia and tarsus together.

Abdomen: sixth ventral rather longer than any of the preceding segments, hind margin straight, with a narrow transverse depression.

Genital segments: first below, about as long as any three ventral segments, except the sixth, hind margin straight, sides oblique; second with horns reaching nearly to apex of third below; third (Pl. II. fig. 1, *g.*) above with the lateral angles rounded.

Closely resembling *Halobates hayanus*, but differs, *inter alia*, by the greater length of the first joint of front tarsus, more spiny middle femora, more strongly impressed line on the thorax, &c. I have seen the male only.

10. *Halobates flaviventris*, Esch. (Pl. II. fig. 2).

Halobates flaviventris, Esch., Entomographien, i. p. 109, No. 80, Taf. ii. fig. 5, 1822.
„ „ Burmeister, Handb. d. Entom., vol. ii. p. 209, No. 3, 1835.
„ „ Herrich-Schäffer, Die wanzenartigen Insecten, vol. viii. p. 110, 1848.

Oblong, widest in the middle. Slaty grey, silvery white on the sides and below. Head with an oblique transverse reddish-yellow mark (nearly joining at the middle of the hind margin) on each side posteriorly. Antennæ and legs brownish-black. Front acetabula with outer rim very narrowly; a long triangular blotch in front of the middle acetabula below; hind acetabula with a spot on the outer side; abdomen below (except the sides narrowly); genital segments, disk of the first below and under side of the horns of the second, ochreous yellow. Third genital segment above and below brownish-black, the disk of the third below and apex reddish-yellow. Antennæ: third joint about two-thirds the length of the second, fourth a little shorter than the second. Front tarsus: first joint about one-fifth shorter than the second, which is cleft before the middle. Middle tarsus: first joint two and one-half times the length of the second.

♂. Length 5, breadth 2, middle femur 6, hind femur 4.5 mm.

Habitat.—North Atlantic, near St. Helena (*Berlin Museum*). Indian Ocean, near Ceylon (*Oxford Museum*). Eschscholtz gives the South Atlantic as the locality of his specimens, and Fairmaire determined some of Coquerel's *Halobates* taken near Madagascar as belonging to this species.

♂. Oblong, widest in the middle, then becoming slightly and gradually narrower to each end. Greyish-black in old examples (when fresh "blue-grey, as if covered with bloom"), silvery white on the sides and below. As in the allied species, the usual red spots on the head are very distinct, oblique and transverse, and nearly meet at the middle of the hind margin. Antennæ and legs brownish or fuscous black. Rostrum shining black. Eyes dark brown. Outer rim of the front acetabula very narrowly, a long triangular black-edged blotch on, and extending in front of, the middle acetabula below, a spot on the outer side of the hind acetabula, the ventral segments of the abdomen (except at the sides, especially of the sixth), the disk of the first genital below, and the under side of the horns of the second genital, ochreous yellow. The third genital segment above brownish-black; third below brownish-black, with the disk and apex reddish-yellow.

Head moderately convex, the edge of the hind margin distinctly elevated, except near the eyes. *Antennæ* (Pl. II. fig. 2, *a.*) slender, about one-half the length of the body; first joint subequal in length to the three others taken together; second about one-third the length of the first; third about two-thirds the length of the second; fourth subequal to the second, cylindrical, slightly attenuate upwards.

Pronotum of the usual shape, disk nearly flat, slightly longitudinally convex in middle, with a very slight hollow on each side of the middle. *Mesonotum* slightly widened to the middle, disk rather flat.

Front legs: femora moderately thick, thickest a little above base; tibia about four-fifths the length of the femur; tarsus (Pl. II. fig. 2, *f.t.*) more than one-half the length of the tibia, first joint about one-fifth shorter than the second, which is cleft before the middle.

Middle legs: femur shorter than the tibia and tarsus taken together, armed with fine spines; tibia three-fourths the length of the femur, armed like the femur; tarsus (Pl. II. fig. 2, *m.t.*) about one-half the length of the tibia, first joint about two and one-half times the length of the second.

Hind legs: femur not quite twice as long as the tibia and tarsus together, armed below with fine spines; tibia with spines all round; tarsus less than one-fourth the length of tibia, cleft at about two-thirds of the length.

Abdomen: sixth ventral segment a little longer than the preceding ones, hind margin straight.

Genital segments: first below as long as all the ventral abdominal segments together, disk slightly convex, hind margin straight, sides oblique; second with horns reaching three-fourths the length of the third below; near the base of each horn, and exterior to it, is a conspicuous obtuse tubercle. Third above (Pl. II. fig. 2, *g.*) with the lateral angles acuminately produced.

This seems to be a scarce species. Eschscholtz saw the male only (which he calls the female). I have seen two specimens, both males. The female has not been discovered. The Oxford Museum specimen was captured on September 12, 1834.

11. *Halobates frauenfeldanus* (Pl. II. fig. 3).

Halobates flaviventris, Frauenfeld (*nec* Eschscholtz), Verhandl. der k. k. zool.-bot. Gesellsch. in Wien, vol. xvii. p. 459, Taf. xii. figs. 3, 4, 7, and 9, 1867.

Oval, widest behind the middle (♀). Pale hoary ash grey above. Head with a brownish-yellow spot on each side posteriorly, united to a narrow line of the same colour on the hind margin. Antennæ with the basal halves of the joints; prosternum; mesosternum with a central longitudinal line broadest behind and narrower in front (absent in the ♀); ventral segments of the abdomen; a spot near the insertion of each of the legs; the front femora below, and a more or less extensive spot at the base above, as well as the under side of the coxæ of the middle and hind legs, yellow. Front femora black above. Antennæ: second, third, and fourth joints equal in length. Front tarsus with first joint about one-third shorter than the second joint. Middle tarsus with first joint two and one-half times the length of the second.

♂. Length 4·1, breadth 1·9, middle femur 5·1 mm.

♀. Length 4·2, breadth 2·4, middle femur 5 mm.

Habitat.—Indian Ocean near the Nicobar Islands (Frauenfeld).

I have not seen this species, and have compiled the diagnosis and description from Frauenfeld's paper. The latter author's description is a little confusing, as he sometimes uses the sign ♂ (both in the text and in the plate) when he evidently intended to write ♀. He has made the same mistake as to the sex as Eschscholtz and other writers have done. Moreover, he gives two different measurements for the female (his male). Frauenfeld's description applies chiefly to the female, for, as he thought, the male had already been described by Eschscholtz. I am indebted to Dr. Rogenhofer for measurements of the front and middle tarsi of specimens in the Vienna Museum.

Oval, widest behind the middle (♀), pale hoary ash grey above; the usual spots at the back of the head distinct, brownish-yellow, and united to a narrow line of the same colour on the hind margin. Front femora, middle and hind legs black. Eyes clear, or brown. Antennæ with the basal halves of the joints, the prosternum, a central longitudinal line (in the female) wide posteriorly and narrowed anteriorly on the mesosternum, the ventral abdominal segments, a spot near the insertion of the legs, the front femora below and more or less extensively at the base above, as well as all the coxæ below, yellow.

Antennæ (Pl. II. fig. 3, *a*.) about as long as three-fourths of the body, slender; first joint shorter than the other three taken together; the second, third, and fourth of equal length.

Front femora stout; front tarsus with the first joint about two-thirds the length of the second.

Middle legs: tibia about one-third longer than the tarsus; tarsus first joint two and one-half times the length of the second.

The larva has the plates hoary ash grey, the leathery part of the integuments brown, the sides, under side, &c., yellow.

Frauenfeld lays much stress upon the absence of a jointlet between the second and third joints of the antennæ. I have not seen adult specimens, but find that in the larvæ (some of Frauenfeld's own specimens, lent me by the Vienna Museum) this jointlet does exist, and therefore, judging from what is the case in other species, suspect that it is also present in the adult.

HALOBATODES, n. g.

Body oval or oblong.

Head (with eyes) semicircular.

Antennæ four-jointed, with two intermediate jointlets.

Rostrum four-jointed, first and second joints very short, the latter ring-like; third joint the longest.

Eyes large, situated at the back of the head and resting partly on the pronotum.

Ocelli, none.

Prothorax, transverse, much broader than long, distinct from the mesothorax.

Mesothorax and metathorax together cylindrical, coalesced, the boundary between them scarcely distinguishable; no scutellum nor scutellar process.

Elytra and wings wanting.

Front legs short, rather stout; tibia with a straight or nearly straight process at the apex. Tarsus two-jointed, first joint very small, second joint with claws inserted beyond or about the middle.

Middle and hind legs long and slender, inserted at the sides of the posterior end of the thorax, the hind legs inserted above the middle legs. Middle legs without a fringe of long hairs. Tarsus two-jointed, second joint clawed before the tip. Hind legs with two-jointed tarsus, the second joint clawed before the tip.

Abdomen short; sides furnished with a conspicuous connexivum. Apex of the abdomen in the male without a conspicuous rhomboidal appendage.

Type of genus: *Halobates lituratus*, Stål.

In general form resembling *Halobates*, but with a different facies, and easily distinguished by the shape and structure of the head and front tibia, the two-jointed hind tarsus, differently constructed abdomen and genital segments, and much less pubescent integuments, as well as by the more variegated coloration.

DETAILS OF STRUCTURE.

THE HEAD AND ITS APPENDAGES.

The Head (with the eyes) presents, when viewed from above, a somewhat semicircular outline. Without the eyes it is oblong, the front and hind margins slightly rounded, and the sides slightly concave. The vertex is more or less convex; the face perpendicular; the middle lobe larger than the side lobes, widest at the apex, which is truncate; and the side lobes triangular. The *Eyes*, viewed from above, are subtriangular in outline, with the outer margin rounded; the inner margin nearly straight; and the hind margin concave, resting on the sides of the pronotum. Seen from below, the eye is subtriangular in outline. There are no ocelli nor ocellus-like spots.

The Antennæ (Pl. II. figs. 4 *a.*, 5 *a.*, 6 *a.*) are four-jointed, the first joint being the longest, slightly curved, and usually thinnest in the middle. The second joint is slightly incrassate upwards, and between the second and third joints is a distinct jointlet. Between the third and fourth is also a minute jointlet. The fourth joint is usually fusiform. The antenniferous tubercles are situated between and close to the eyes and side lobes of the face, and form cups to receive the antennæ, the inner side of the rim being incised as in *Halobates*.

The Rostrum reaches to the front margin of the mesosternum, and is four-jointed. The first joint is stout, and about as broad as long. The second is ring-like; the third is the longest; and the fourth is shorter than the third, and thinner.

The Thorax.

As in *Halobates*, the thorax forms by far the largest part of the body, and increases in width more or less from the front to beyond the middle. In a similar manner two only of the three segments which compose it can be made out, the posterior two being coalesced.

The Prothorax is much broader than long, and narrower than the head with the eyes. The Pronotum has the front margin concave between the eyes, then obliquely rounded to the posterior angles; the anterior angles excavated to receive the eyes; the sides rounded and convex; the posterior margin slightly concave; and the disk rather flat. The Prosternum is in the middle third rather flat or longitudinally convex, and the outer third on each side is occupied by the large acetabula.

The Mesonotum is a little wider in front than the prothorax, and widens gradually backwards; the front margin is slightly convex in the middle, and then slopes slightly concavely forwards; the sides are rounded and convex; and the disk is also convex. The Mesosternum has the disk rather flat, anteriorly sloping to the prosternum.

Between the *mesonotum* and *metanotum* no suture is apparent. The metanotum slopes backwards between the ridges leading to the hind legs. No part of the metathorax is visible below. The hind margin of the *mesosternum* is widely concave.

The Abdomen.

The structure of the abdomen is rather difficult to make out as regards the exact point above where the thorax ends and the abdomen begins, or whether any of the abdominal segments are covered by the integuments of the thorax.

The Abdomen of the Male.

On the dorsal surface in the male (Pl. II. fig. 4 ♂ *ab. a.*, 6 ♂ *ab. a.*) one segment appears to be covered, as its front margin is obscure. The front margin of the second segment is angulated, the hind margin slightly concave, and the length in the middle is three times the length at the sides. The third to the sixth segments have nearly straight hind margins, the third segment being the longest of these. All the segments have a conspicuous connexivum, which is erect, and perpendicular to the segments. It is widest opposite the third segment, and thence decreases in width anteriorly and posteriorly. The abdomen itself slopes backwards to the end of the fourth segment, and is then subhorizontal. Below, the male abdomen (Pl. II. fig. 4 ♂ *ab. b.*, 6 ♂ *ab. b.*) is convex, with six ring-like segments, whose hind margins are concave. The first segment has the sides mostly hidden by the mesosternum, and has in the middle a conspicuous perforated tubercle as in *Halobates*.

The Abdomen of the Female.

The abdomen of the female (Pl. II. fig. 4 ♀ *ab. a.*, 4 ♀ *ab. b.*, 5 ♀ *ab. b.*) is on the whole similar to that of the male.

The Genital Segments of the Male.

The first segment above is similar to the sixth abdominal segment, but narrower and longer; like it it is provided with an erect connexivum. Below it is ring-like, but nearly as long as all the ventral abdominal segments together; the hind margin is concave.

The second is, below, longer than the first, the hind margin concave, the sides prolonged and sloping upwards and backwards to the upper surface, where they form a convex oblong plate (with hairy margins) nearly concealing the third above.

The third below is a convex roundish plate; above is a small conical tubercle like the podical plates in *Halobates*, nearly concealed, and embraced by the third segment below. There is therefore reason to believe that the third segment above and the third below are not to be considered as the same segment. I have had no opportunity of making dissections.

The Genital Segments of the Female.

Three segments are visible above, but only one below. The first and second above resemble the sixth abdominal above, but are somewhat shorter and narrower. The third above is a conical tubercle.

The only segment visible below is triangularly convex, with the apex truncate, the sides sloping upwards and embracing the sides of the three segments above, forming, as it were, a continuation of the erect connexivum of the abdominal segments.

THE LEGS.

The Front Legs.

As in *Halobates*, these are very short in comparison with the others, and for the greater part of their length lie well in advance of the body.

The Acetabulum (Pl. II. fig. 5, *ac.*) is very large, occupying the outer third on each side of the prosternum, and extending from the front to the hind margin. Its opening is circular, and looks backwards and downwards; on the middle line in front is a suture or slit reaching from the rim to the base, but not triangularly emarginate as in *Halobates*.

The Coxa is nearly altogether immersed in the acetabulum, appearing merely as a ring above the opening.

The Trochanter is large; viewed from the inner side it is subtriangular, and attached to the coxa by a small narrow neck at the anterior lower angle; viewed from the outer side it is subrhomboidal, with the femur inserted on the upper anterior side.

The Femur (Pl. II. fig. 4 ♂ *f.l.*, 4 ♀ *f.l.*, 6 *f.l.*) is moderately stout, and varies somewhat in shape in different species and sexes.

The Tibia (Pl. II. fig. 4 ♂ *f.l.*, 4 ♀ *f.l.*, 6 *f.l.*) is nearly as long as the femur, and slightly incrassate from base to apex. Above it is crossed near the apex by a furrow running obliquely towards the base from the hind to the front margin. The hind margin itself is prolonged into a short nearly straight process which extends a little beyond the apex.

The Tarsus (Pl. II. fig. 4 ♂ *f.l.*, 4 ♀ *f.l.*, 6 *f.l.*) is attached to the anterior part of the apex of the tibia, and is two-jointed, with the first joint very small. The second joint is fusiform, and cleft and clawed beyond the middle, the claws being furnished with the ribbon-like process already described in *Halobates*.

The Middle Legs.

These limbs are inserted at the lower posterior angles of the thorax.

The Acetabulum is large and cylindrical, with the opening slightly oblique and circular. The middle line below has a long longitudinal suture or slit.

The Coxa is ring-like, and much broader than long.

The Trochanter has a ball-like base lying in the hollowed apex of the coxa; viewed from the inside it is lanceolate, attached by a slightly curved neck to the ball-like base.

The Femur is inserted on the under side of the trochanter, and gradually narrows from the base to about the middle, being very slightly incrassate at the apex.

The Tibia gradually narrows from the base to before the middle, and has somewhat longer hairs on the inner side, but is not furnished with a long fringe as in *Halobates*.

The Tarsus (Pl. II. fig. 5, *m.t.*) is two-jointed. The first joint is rather thicker at the base, where also it has longer hairs (but not a long fringe) on the inner side. The second joint is cleft and clawed near the tip, and furnished on the outer side with one or two long hairs, as in *Halobates*.

The Hind Legs.

These are inserted above the middle legs at the upper posterior angles of the thorax.

The Acetabulum is large and cylindrical. Each slightly approaches the other posteriorly, and the opening is slightly oblique and circular. Viewed from the side, the acetabulum shows an impression on the under side for about half of its length posteriorly, in which impression the middle coxa lies. Between the hind and middle acetabula is a deep narrow furrow, anteriorly forked, the upper branch nearly perpendicular, but sloping slightly forwards; the lower and shorter branch horizontal, and occupied for all or most of its length by the longitudinal opening of the mesothoracic spiracle. On the inner side the acetabulum is bounded by the erect connexivum, which at its commencement has its edge slightly but acutely folded over to the outer side.

The Coxa is similar to the middle coxa, but rather longer.

The Trochanter is similar to the middle trochanter.

The Femur is also similar to the middle femur, and nearly as long or longer, but less stout.

The Tibia is similar to the middle tibia, but without longer hairs on the inner side.

The Tarsus (Pl. II. fig. 5, *h.t.*) is two-jointed, with the second joint cleft and clawed before the apex.

DESCRIPTION OF THE SPECIES.

In the following pages four species of *Halobatodes* are described, namely:—

Halobatodes lituratus, Stål.
„ *histrio*, n. sp.
„ *compar*, n. sp.
„ *ståli*, Dohrn.

Of these the first three are before me, and are certainly congeneric. The fourth, which was described as *Halobates ståli*, I have not seen, and as the original description does not give any of the details of structure, it is perhaps not rightly located in this genus. From the description of the coloration, however, it seems to be probably a *Halobatodes*.

Key to the Species.

Owing to insufficiency of material, colour differences have to be employed in the following key (as well as in the diagnoses of the species) more than structural differences.

1.	Ground colour yellow testaceous; markings black or brownish-black, . .	2
	Ground colour dull black; markings yellow testaceous, ...	3
2.	The central longitudinal black line of the thorax continued to the abdomen,	*lituratus.*
	The central longitudinal black line of the thorax not reaching the abdomen, .	*histrio.*
3.	Under side of body dull black, ...	*compar.*
	Under side of body yellow testaceous, ...	*ståli.*

1. *Halobatodes lituratus*, Stål (Pl. II. fig. 4).

Halobates lituratus, Stål, Öfv. af K. Vet.-Ak. Förhandl., p. 238, 1854.
" " Stål, Eugenies Resa. Insekter, p. 264, 124, 1858.
" " Mayr, Novara-Expedition Zool., Bd. ii. p. 177, 1866.

Ovate, widest behind the middle. Dirty yellowish testaceous, with sparse fuscous pubescence. Head, thorax, and abdomen above with brown or blackish-brown lines and spots, of which the central longitudinal line of the thorax reaches the abdomen. Dirty ochreous below. Genital segment below of the female, with a notch at the middle of the sides.

♂. Length 6, breadth 2·5, middle femur 6·5, hind femur 5 mm.

♀. Length 4·5, breadth 2·5 mm.

Habitat.—The Chinese Seas. I have only seen two specimens, one from the Stockholm Museum, the other from Dr. Signoret's collection, and received by him from Stål. Unfortunately the male is not perfect, and so the following description is not so complete as it might be.

♂. Ovate, widest behind the middle. Dirty yellowish testaceous, with sparse fuscous pubescence. Head with an obscure double mark between the eyes; clypeus towards the apex, and a triangular spot at base of the rostrum; antenniferous tubercles; pronotum with a short line on each side; mesonotum with a large oblique spot on each side of the centre, brown or fuscous brown. Pronotum with the front margin and a central longitudinal line; mesonotum with middle of front margin, a central percurrent longitudinal line, a short rather indistinct line on each side of the central line, and joining the oblique brown spot; a short line leaving front margin on a level with the eyes; a transverse line (wider exteriorly) crossing the central line posteriorly, in front of which a large spot (united to the central line by a slender line) gives rise to an oblique line running forwards and outwards, and forming (about the middle of the side) a loop from which it runs irregularly back along the side to the base of the middle legs, the ends of the above mentioned transverse line turned forwards, and meeting or nearly meeting the looped line, as well as a longitudinal line on the sides abbreviated at each end; sternum with a short slightly oblique streak on each side, more or less brownish or fuscous black. Abdomen above blackish, with pale golden pubescence, and a more or less wide transverse band on each segment yellowish testaceous. Last genital segment yellowish testaceous, fuscous black at base and apex. Under side of thorax and abdomen dirty ochreous. Rostrum ochreous, apex of the third and all of the fourth joint shining piceous black. Legs yellowish testaceous, with fuscous pubescence. Front legs with a small spot on outside of coxæ, femora with the base exteriorly very narrowly, a wide streak on the outer side not reaching base or apex, a shorter streak on the inner side, which reaches (by a prolongation below) the apex, as well as the apex itself, piceous black; tibia and tarsus fuscous black. Middle legs: upper margin of acetabula, a streak on the outer side of coxæ, femora with two spots at the base and the apex, fuscous black; tibiæ brownish, with black hairs, apex fuscous. Hind legs: upper rim of acetabula, and a streak in front, coxæ with a longitudinal streak continued on to the trochanters, femora with the base, an exterior spot near it and the apex, fuscous black; tibiæ and tarsi fuscous brown with black hairs.

Head moderately convex above, rather strongly convex in front. Rostrum: third joint about three times as long as the first and second together; fourth about one-third the length of third.

Front legs (Pl. II. fig. 4. ♂ *f.l.*): femora stout, slightly curved, tapering towards base and apex, posterior side with a rounded blunt tubercle at about the middle, a slight notch near the apex, and a small tubercle between the notch and the apex; apex fringed with strong hairs. Tibia as long as femur; tarsus more than one-third the length of the tibia.

Middle legs: femur rather stout, unarmed; tibia about one-fifth shorter than the femur, armed below with a few fine spines.

Hind legs: femur very slightly shorter than the middle femur; tibia about two-thirds the length of the femur, armed below with fine spines; tarsus about one-fifth the length of the tibia, joints subequal in length, the second cleft about the middle.

Abdomen (Pl. II. fig. 4 ♂ *ab. a.*, and 4 ♂ *ab. b.*): sixth segment below nearly as long as all the other ventral segments taken together, hind margin concave, fringed, slightly emarginate in the middle.

Genital segments: above one is visible, about as long as broad, very convex, hind margin angularly emarginate. Below, the first, which is part of the first above, is nearly as long in the middle as all the ventral abdominal segments taken together, hind margin concave, sides sloping backwards and upwards. The second segment below is a very convex plate surrounded by the first segment; hind margin rounded, and forming with the hind margin of the first above a crescent-shaped aperture at the end of the body.

♀. Widely ovate, widening to the middle, then parallel-sided. Colours brighter and markings more distinct than in the male. Head with a large blackish spot, prolonged anteriorly, between the eyes; clypeus and antenniferous tubercles more suffused. Pronotum more strongly marked, and with a large brown spot joined to the front margin on each side of the middle line. Mesonotum much more distinctly marked: front margin narrowly blackish-brown; a central longitudinal line widening backwards, and widest behind the middle; on each side of central line a slender line, first going slightly obliquely outwards, forming an angle and running sharply obliquely inwards, and having from the angle to the end a large reddish-brown oblong blotch joined to it; more external to the last-mentioned line a slender line, curved inwards and nearly reaching the oblong blotch external to the latter line, another starting from the front margin below the level of the eye, runs along the side of the base of the middle legs; from the base of the middle legs another line runs forward along the side to about the middle, forms a loop upwards and backwards, and joins an oval blotch on the disk behind the reddish-brown blotch; from the oval blotch a short straight line joins the longitudinal central line at right angles; more posteriorly to this another transverse line crosses the longitudinal line and connects the anterior ends of the connexivum, and from each end a slender curved line runs forwards and outwards to the looped line. The above-mentioned markings are black or fuscous black. Abdomen more or less black, posterior segments with the angles of the connexivum, and genital segments with the centres, dirty testaceous. Antennæ (which are broken in the male) yellowish testaceous, gradually suffused upwards with fuscous brown, more especially on the under and outer side; second and third joints fuscous brown, the jointlet reddish-brown, fourth joint dirty testaceous suffused with fuscous. Front legs less strongly marked than in the male.

Antennæ (Pl. II. fig. 4 *a.*) (broken in the male) about three-fourths the length of the body; first joint slender, furnished at the upper and inner side with fine rather long spine-like hairs; second joint about half as long as the first, also with spine-like hairs; third joint subequal in length to second, but more slender; fourth about three-fourths the length of third, and slightly thicker.

Front legs (Pl. II. fig. 4 ♀ *f.l.*) not so stout as in the male; femur without the central tubercle, and with the notch at apex sub-obsolete, armed below with a few long hair-like spines.

Abdomen (Pl. II. fig. 4 ♀ *ab. a.*, and 4 ♀ *ab. b.*): sixth segment below as long as the two preceding segments, sides a little produced.

Genital segments; two visible above; first ring-like and resembling the last abdominal segment; second small, transversely convex, broader than long, hind margin straight. One visible below, longer than all the abdominal ventral segments taken together, convex, triangular, apex slightly concave; at the middle of each side with a notch from which a fold curves inwards and then forwards. The side margins, which are continuous with the connexivum, embrace the sides of the two segments above.

2. *Halobatodes histrio*, n. sp. (Pl. II. fig. 5).

Halobates histrio, De Haan, MS.

Widely ovate, widest about the middle, then parallel-sided. Dull yellowish testaceous above, with black or brownish-black lines and spots, of which the central longitudinal line on the thorax does not reach the abdomen. Dirty ochreous below. Genital segment below of the female without a notch at the middle of the sides.

♀. Length 6, breadth 3·5, middle femur 6·5, hind femur 6·5 mm.

Habitat.—Japan (*Berlin Museum*).

Very similar to *Halobatodes lituratus* in form and colour, but differs in its rather larger size, in the somewhat different arrangement of the markings, and in the form of the genital segment below of the female. I have seen two females only, and possibly the male may show greater differences than the female does.

♀. Widely ovate, widening to the middle, then parallel-sided. Dull yellowish testaceous, with very sparse fuscous pubescence. Markings black or brownish-black, as follows:—Head with an oblong mark between the eyes, slightly split behind and united to a line on the inner side of each orbit by a short slender line. Pronotum: front margin broadly between the eyes, joined on each side to a short thick line running backwards and then curved outwards; a small spot behind each eye, and a percurrent central line tapering to a sharp point on the hind margin. Mesonotum: front margin between the shoulders; a central percurrent line not reaching the abdomen; a thick short line on each side of the centre; a slender short line curved inwards from each shoulder; a slender line on the side not reaching the base or apex; on the disk an obliquely transverse line with curved ends embracing the short thick line, and sometimes joining the slender curved line that rises from the front margin; posterior to this a blotch on each side, united by a straight transverse line to the central longitudinal line, gives rise to a line which, running outwards and forwards, is looped backwards and divides, one branch going to the connexivum, the other to near the base of the middle legs; a short thick line in front of the hind legs but reaching the rim of the acetabulum. The anterior ends of the connexivum joined by a broad transverse line in which the central longitudinal line ends; posterior to this another transverse line.

Clypeus and apex of antenniferous tubercles fuscous. Eyes black. Antennæ fuscous brown, first joint ochreous at base above and for a little way beyond base below; jointlet reddish-brown. Rostrum pale ochreous with a brown spot at the base, apex of the third and all of the fourth joint shining black. Front legs: outer side of acetabula with a pale brown small spot; coxæ pale ochreous with a blackish spot near the apex; trochanters pale ochreous, with a few blackish spots at the apex; femora ochreous with the base exteriorly, a short streak in the middle above and to the inside, and a longer streak in the middle below and to the outside, as well as the apex, brown or brownish-black; tibia and tarsus fuscous black. Middle legs: acetabula with the rim above, a streak from it above, and a spot on the outer side brownish-black; coxæ dirty ochreous, base and apex brownish-black; femora dirty testaceous with fuscous pubescence, outer side with a brownish-black streak from base to apex; tibia and tarsus fuscous black. Hind legs: somewhat similar in colour to the middle legs. Abdomen above black, hind margins of the segments yellowish testaceous or pale fulvous in the middle, the pale markings on the posterior segments becoming triangular in shape. Second genital segment fulvous with apex black. Connexivum fulvous yellow, front and hind margins more or less broadly blackish-brown. Under side of the body dirty ochreous, with a slender fuscous streak on each side before the middle legs, and a brownish spot on the mesosternum behind the front legs.

General form similar to that of *lituratus*. Spine-like hairs of the antennæ absent or broken off.

Middle legs: femur longer than the tibia and tarsus together; tibia about one-fifth shorter than the femur; tarsus (Pl. II. fig. 5, *m.t.*) less than half the length of the tibia, second joint about one-sixth the length of the first.

Hind legs: femur subequal in length to the middle femur, about one-fifth longer than the tibia and tarsus together; tibia more than four times the length of the tarsus; tarsus joints (Pl. II. fig. 5, *h.t.*) subequal, second cleft about the middle.

Abdomen and *genital segments* as in *lituratus*, but the genital segment below (♀), has not the notch in the sides (Pl. II. fig. 5 ♀ *ab. b.*).

3. *Halobatodes compar*, n. sp. (Pl. II. fig. 6).

Oblong oval, widest behind the middle. Dull black with yellowish testaceous lines and spots. Under side of body dull black. Front femora of male without a tubercle near the centre and no notch near the apex.

♂. Length 6·5, breadth 2·5, middle femur 7, hind femur 7 mm.

♀. Length 6, breadth 3, middle femur 7, hind femur 7·5 mm.

Habitat.—India (*Professor Westwood's Collection*).

♂. Oblong oval, widest behind the middle. Dull black with sparse greyish pubescence and dirty yellow-testaceous markings, as follows:—The head (except a large oblong spot on the vertex, a spot at the apex of the face, apex of the antenniferous tubercles, some streaks and spots on the rostrum, and the gula, which are dull black or brownish-black). The anterior angles, a large semicircular mark on each side, and most of the perpendicular sides of the pronotum. Mesonotum with two short longitudinal parallel lines, the posterior end of each of which joins a comma-shaped mark extending forwards on each side of the disk; a semicircular mark on each side posteriorly; a small triangular mark at each hinder angle; a wavy line along the sides; a streak above and another below on the acetabula of the hind legs. Sternum with a longitudinal line on each side, joined about the middle by a short transverse line to an irregular spot on each side of the middle of the disk; and a spot on the inferior margin of the middle acetabula, sometimes joined to the wavy line along the sides. The sides and hind margin broadly of the first genital segment above; and the hind margin of the first and the whole of the second and third below. Base of the antennæ (except at the very extreme base, which is shining piceous). Front legs: most of the under side of the acetabula except a large square spot, coxæ, trochanters, femora at base below, and a streak above reaching from the base to near the apex, and with less distinctly a streak below reaching nearly to the apex, and a short streak on the posterior side near the apex. Middle legs: coxæ except some spots at the apex, trochanters except a brownish spot in the middle and a long streak on each side of the femora. Hind legs: similar to the middle legs but duskier in colour, and base and inner side of coxæ sometimes brownish.

General colour of legs and of abdomen below dull fuscous brown. Rostrum with last joint shining black. Antennæ with blackish hairs.

Antennæ (Pl. II. fig. 6, *a.*) slender, first joint subequal in length to the other three together; second joint about half the length of the first; third joint rather shorter than the second; fourth about three-fourths the length of the third.

Front legs (Pl. II. fig. 6, *f. l.*): femur not very thick, thickest about the middle, slightly curved; tibia rather shorter than femur, hind margin with brownish hairs; tarsus about half the length of tibia; second joint cleft about one-fourth the length from the apex.

Middle legs: femur shorter than the tibia and tarsus together; tibia about four-fifths the length of the femur; tarsus half the length of the tibia, first joint about six times longer than the second.

Hind legs: femur about one-fifth longer than the tibia and tarsus together, as long as the middle femur; tarsus less than one-sixth the length of the tibia, second joint cleft beyond the middle.

Genital segments (Pl. II. fig. 6 ♂ *ab. a.*, and 6 ♂ *ab. b.*): first above like the preceding abdominal segment, but twice as long; below as long as three of the abdominal ventral segments, hind margin concave. Second above nearly square, but a little wider posteriorly, convex, the hind margin fringed with long coarse hairs, especially towards the sides; below rather longer than the first below, the sides sloping obliquely backwards. Third above, a slightly convex tubercle, nearly embraced by the second, and bearing on each side of the base an erect, stout, recurved tooth; below a very convex oval plate, slightly raised in the middle line posteriorly, embracing the third above, margins fringed with long coarse hairs.

♀. Similar to the male, but colours rather brighter and markings more distinct. Front femora with the markings much more distinct. Abdomen with the hind margins of the ventral segments, except the first and the genital segments, yellowish ochreous. Antennæ and front legs more slender. Genital segments too much distorted in the only specimen to permit of the structure being made out clearly.

4. *Halobatodes* (?) *stäli*, Dohrn.

Halobates stäli, Dohrn, Stett. Ent. Zeit., vol. xxi. p. 408, No. 103, 1860.

Dull black above, with yellow testaceous lines and spots; yellow testaceous below.

Length, 7 mm.

Habitat.—Ceylon.

I have not seen this species, though Dr. C. A. Dohrn kindly looked for the type in the collection of his son, Dr. Anton Dohrn (the well-known director of the zoological station at Naples), with a view of sending it to me. From the description it appears to belong to this genus, and to be closely allied to *Halobatodes compar*, from which the different colour of the under side of the body distinguishes it.

The following description is compiled from the original description, which will be found in the introductory part of this paper.

Opaque black above, with the following yellowish testaceous markings:—The head (except a large black central spot, and three smaller ones in front which are black). Thorax: in front two semicircular spots; behind, in the middle two parallel longitudinal spots, one on each side, shaped like a comma, another on each side transverse and semicircular, a third smaller spot on each side at the apex of the disk; more posteriorly one transverse, two longitudinal and three smaller apical spots. Front coxæ except a black spot above, and femora except three more or less broad black lines. Sides and body below yellow testaceous, the sides with longitudinal black streaks. Antennæ, middle and hind legs, and front tibiæ blackish. Rostrum yellowish testaceous, apex black. Eyes fuscous fulvous, with black spots.

III. LIFE HISTORY AND HABITS.

METAMORPHOSES.

HALOBATES.

The Egg.—The only account that has been given of the egg of *Halobates* is by M. Léon Fairmaire, whose note on the subject is reproduced in the part of this memoir relating to the literature of the subject. I am able to add to our scanty knowledge, by describing the egg of *Halobates wüllerstorffi*, of which there is before me one of about twenty-five found (in a Challenger specimen of *wüllerstorffi*) by Mr. John Campbell, the optician to whom I am indebted for the preparation of the microscopic specimens which I have used in examining the minuter anatomical structure of these insects.

The egg is very large in comparison with the size of the animal. Consequently the small abdomen is not sufficiently spacious to contain even so few as twenty-five or thirty, and part of the cavity of the thorax is employed to hold them. The egg of *wüllerstorffi* (Pl. III. fig. 30) is long oval in outline, measuring 1·2 mm. long by ·8 mm. broad, and the integuments do not show any particular markings or structure. The contents were rather coarse amorphous particles of coagulated albumen. The eggs found by M. Fairmaire are described as oblong in shape, and the species furnishing them were *sericeus* or *flavicentris*,—whether rightly determined or not, it is now impossible to say, as M. Fairmaire informs me that he gave away the specimens long ago.

No observations have been made as to when and where the eggs are deposited. The statement[1] that the female carries them about, attached to the abdomen, after they have been extruded, Professor Moseley informs me is a mistake.

The Larva and Pupa.—These two stages will be considered together, for in this as in other ametabolous groups of insects it is not easy to say where the one ends and the other begins, the more especially as we do not yet know how many times the young *Halobates* changes its skin.

While resembling in general form the adult animal, the larva has several important structural differences.

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[1] Moseley, Notes by a Naturalist on the Challenger, p. 572.

The integuments are leathery, with isolated plates of chitin, of which the following are the principal:—A large central triangular plate on the head (the apex of the triangle being posterior), with a rather ill-defined long narrow plate on each side, leading from the back of the head to the antennæ; the margins of the orbits; two transversely oval plates on the pronotum; two large longitudinal oval plates on the mesonotum; two transverse reniform plates on the metanotum; a rather ill-defined narrow transverse plate on each side of the mesial line of each abdominal dorsal segment (Pl. III. fig. 29). In the abdomen the chitinization of each segment begins at the front margin and spreads backwards.

In dried specimens the number of abdominal segments cannot be made out from the shrinking of the integuments, but in two microscopical specimens ten rings can be distinguished behind the reniform plates of the metanotum, while in a third example nine rings only can be made out. This difference in the number may possibly be due to sex, and would seem to indicate that the male has, as its structure suggests, really four genital segments. The podical plates which terminate the body of the adult are present in the larva, but no trace can be found of the peculiar lozenge-shaped plate which precedes them in the adult male. One specimen, which from the rest of its structure must be regarded as not yet having undergone its final moult, presents all the external genital characteristics of the adult female.

The antennæ are stouter than in the adult and proportionately shorter. The jointlet between the second and third joints is rudimentary, and that between the third and fourth joints is not visible.

The peculiar tubercles which we have considered to be possibly ocelli are not visible or are more or less rudimentary, according to the age.

In like manner the dilatation of the apex of the front tibia is more or less undeveloped according to the age.

The front tarsus (Pl. I. fig. 1, *f.t.a*) has only one joint, which is cleft and furnished with claws beyond the middle. The other legs are relatively shorter and stouter than in the adult.

The coloration of the larva is somewhat similar to that of the adult, but the leathery portion of the integuments is often brown or reddish-brown.

HALOBATODES.

No observations of the metamorphoses have been made.

HABITS.

HALOBATES.

Except for the sake of calling attention to the necessity of observations, it is almost unnecessary to devote any space to this part of the subject, so little is known about it. The little that has been recorded about individual species has been noticed under each.

Mr. Murray writes to me as follows :—

"I have looked through my Challenger journals carefully for notes about *Halobates*, and find that I have noted its occurrence in the Atlantic 21 times between the latitudes 35° N. and 20° S., and 38 times in the Pacific between lats. 37° N. and 23° S. It would thus seem that these insects are confined to the warmer waters of the ocean, as we have no note of their occurrence north or south of these latitudes during our cruise.

"While the Challenger was engaged in dredging in the open ocean, a boat was lowered for the use of the naturalists whenever the weather permitted, and when away on such occasions *Halobates* was frequently observed. When the boat during calm weather was rowed near a dead *Porpita*, *Physalia*, *Salpa*, or fragment of some other creature floating on the surface, three or four *Halobates* would occasionally be observed to start out from it, and skim away over the surface in different directions. At first I thought that the insects were merely resting on the floating objects, but latterly I came to believe that they were feeding on them.

"The majority of the specimens taken by the tow-net were dead when brought on board, but we frequently took them alive, and observed them skimming over the surface of the water in our globes.

"We captured them both during the day and during the night ; but most frequently when the ship was steaming during a calm, and the tow-net was kept dipping at the surface of the water. When the net was dragged beneath the surface, we did not, of course, expect to capture creatures scudding about on the surface ; and nine-tenths of our tow-net observations were made by sinking the net beneath the surface. Hence on these occasions no specimens of *Halobates* were captured.

"On one occasion only have I observed *Halobates* dive. This was on 31st March 1875, on the passage from New Guinea to Japan, when a specimen having been captured alive, was seen to dive in the globe. Our assistant, Mr. Pearcey, says he remembers the circumstance distinctly."

As a corroboration of this observation of the diving powers of *Halobates*, the following note[1] by Mr. J. J. Walker, of H.M.S. "Kingfisher," may be quoted :—"I saw a good many specimens of the oceanic bug, *Halobates*, sp. ? on November 26, about 400 miles from the nearest land (on the voyage between San Francisco and Callao), and caught a few for Dr. Buchanan White. They are curious little ivory-legged fellows, resembling our

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[1] *Entomologist's Monthly Magazine*, vol. xix. p. 278, May 1883.

familiar "*Gerris*" in structure and habits, and they skip about in the net when caught in just the same manner. They are apterous, and covered with silky bluish-white down, which carries down a supply of air to serve them when they dive beneath the surface, which they do very readily on the approach of the net. They are only seen when the sea is perfectly calm. I tried to keep two or three in a large bottle of sea-water, but they very soon died."

That all the species do not avail themselves frequently of this power of diving (if indeed they possess it) seems evident from the fact that it was only on one occasion that Mr. Murray had an opportunity of seeing it, and that Dr. Hay, who at my request observed the habits of *Halobates hayanus*, and kept specimens in captivity, never saw them dive.

From these notes it would seem that the habits of *Halobates* are probably much the same as those of the allied genera so frequently seen on the surface of fresh water in this and other countries, which, like *Halobates*, may often be seen congregated round any small recently dead animal (such as a fly) floating on the surface. The attraction is of course the juices of the animal, which they obtain by first piercing its integuments with the aid of their mandibles, and then sucking the fluid by means of the maxillæ.[1]

Some of the species occur close to the shore, but others are found in mid-ocean many hundred miles from land. In both situations they are gregarious to a greater or less extent. Their mode of progression is probably the same as that of the more closely allied fresh-water genera, which by means chiefly of the long middle and hind legs run rapidly (skim or scud) on the surface of the water, or when alarmed, progress by long jumps. These fresh-water species are said to be able to dive, but I do not think that this can be a common habit, for I have never seen it done by any of the thousands of specimens that have come under my observation. Some of the fresh-water species (*Gerris*) are said to be able to swim,[2] but this seems open to question. On the other hand, the long fringe on the middle tibia and tarsus of *Halobates* seems to be intended for something more than merely to support the animal on the surface. This supposition is strengthened by the fact that it is the middle and *undermost* legs that are provided with the fringe. It may be that the use of the fringe is not wholly, nor even mainly, for swimming, but for enabling its possessor to resist the action of the wind, by taking hold of the water, which it would do by submerging these legs. The fringe is often seven or eight times longer than the breadth of the tarsus, and the hairs which compose it are fine and flexible. At their base is a shorter fringe of stouter hairs, curved at the apex. It is possible that the animal can exercise some control over the position of the fringe, keeping it adpressed to the limb, so as not to impede its progress, when scudding over the surface; or extending it at right angles to the limb when this is immersed. The shorter fringe

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[1] They also catch and kill living insects.

[2] Kirby and Spence, Entomology, p. 479.

may be part of the mechanism employed.[1] Observations are however very desirable on these points.

The absence of elytra and wings seems to be constant in *Halobates*, and on this account some authors formerly thought that the known specimens had not reached the adult condition. M. Fairmaire's discovery of eggs proved that this theory was erroneous, but an examination of the genital segments would have shown the same. The absence of wings and elytra is not unfrequent in many species of allied genera which live on the surface of fresh water;[2] and in their case the advantage, to the species, of the possession of these organs is intelligible, especially when they inhabit, as is often the case, small pools or marshes liable to be dried up in summer, or capable of supporting a limited number only of individuals. But to species which dwell on a practically inexhaustible surface as the sea the possession of wings would seem unnecessary, if not positively a disadvantage, as making their possessors and users liable to be carried off by the wind, and, if not blown to some inhospitable spot, separated at least from their companions, a probable disadvantage to gregarious species as the *Halobates* are.

Unless it has been derived from a fresh-water progenitor,—which is of course possible, but in view of its structure perhaps not very probable,—it seems likely that *Halobates* has never possessed wings. On the whole, there are good grounds for thinking that *Halobates*, if not the actual ancestor of its fresh-water allies, is much less differentiated from the common ancestor than they are. The small or *apparently* rudimentary condition of the abdomen which gives the adult *Halobates* so strong a resemblance to the immature *Gerris*, must not be lost sight of in this connection.

Amongst many points which require investigation in the life history, especial attention should be directed to the following:—

1. The food, and the manner in which it is seized and retained.
2. The manner of locomotion, and especially whether all the species have the power of diving beneath the water. Experiments may also be made as to the effect of compulsory submersion. As several writers have mentioned that specimens obtained by the tow-net have always been dead, it is probable that submersion means, in some cases, death by drowning.
3. What enemies they have; if they are eaten by any other animals; and what means of defence they have.
4. The use of the several peculiar organs or structures, such as the ocelli-like tubercles of the head; the perforated tubercle at the base of the ventral surface of the abdomen; the ribbon-like process connected with the claws of the tarsi,

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[1] Though I am not yet quite certain, I think that in the species whose usual locality is the open sea the long fringe is longer than in those which dwell near the shore. The material at hand is not sufficient to clear up this point. If it be the case, the reason for it seems obvious.

[2] It is to be noted that this absence of wings is not necessarily due to an aquatic life, for most, if not all, of the Hydrocorisa have well-developed wings, which they not unfrequently use for aërial flight.

and the long curved hairs near the tips of the tarsi. It is probable that the latter are organs of touch, and intended to warn the animal of the approach of any enemy, as from their situation at the outer side of the extremities of the legs, it seems likely that any object approaching their possessor would come in contact with them first, and thus give notice of its approach. The curved tips of the hairs are perhaps to preserve them from being so readily broken as if they were straight.

HALOBATODES.

Of the habits of *Halobatodes* nothing has been recorded. Whether all the species inhabit the sea is uncertain. In fact it is not improbable that three of them are fresh-water species, and it is only because Frauenfeld has stated that he found one in the Chinese Seas that the genus has been included in this monograph, where, however, it deserves a place on account of the close resemblance in structure to *Halobates*.

IV. GEOGRAPHICAL DISTRIBUTION.

Though the details of the distribution have already been given under each species, it is desirable that a few lines should be devoted to a consideration of (1) the distribution of the genus, and of the relations of the species, so far as regards their distribution, to each other; and (2) the factors that have caused, or at least aided, in bringing about the distribution.

HALOBATES.

Wüllerstorffi is the most widely diffused species. It is pre-eminently *the* species of the North Atlantic, and occurs also in the South Atlantic, Indian, and West Pacific Oceans.

Micans is reported from the Atlantic, Indian, and Pacific Oceans, but seems to be very rare, and it is possible that some confusion exists in the records, and that *wüllerstorffi* has in some cases been confounded with *micans*.

Sericeus is a species that seems very abundantly represented by individuals, but it is almost confined to the Pacific, especially the North Pacific, of which it is pre-eminently *the* species. It has been recorded as occurring near the Cape and near Madagascar, but this is possibly an error of determination. I have before me two specimens (from the Challenger) from the North Atlantic. I cannot think that there is a mistake about the locality of these, but still, corroboration is very desirable.

Flaviventris is a rare species. I have seen specimens from near St. Helena, and from near Ceylon, and it has also been reported from near Madagascar.

All the remaining species are, so far as we yet know, very limited in their distribution. *Streatfieldanus* has only once been taken in the South Atlantic; *hayanus* occurs at Aden; *frauenfeldanus* at the Nicobars; *proavus* near Gilolo; *princeps* in the Celebes Sea; and *germanus* and *sobrinus* in one or two localities in the Pacific.

To sum up, five species occur in the Atlantic, but one only is (so far as we know) restricted to that ocean, though the headquarters of another appear to be there.

Six species, of which two are peculiar, occur in the Indian Ocean, west of long. 100° E., while to the east of long. 100° E., and chiefly in the West Pacific, eight species occur, of which four are restricted to that region. But if we take the Indian Ocean and West Pacific together, we find that nine out of the eleven known species occur there, and five nowhere else. It would seem, therefore, that the region between the eastern part of the Indian Ocean and the West Pacific is the metropolis of the genus, and it does not seem to demand too much from the imagination if we suppose that the genus originated there, and has spread thence to other parts of the world.

So far as some of the species are concerned, this seems almost certain. The two species *proavus* and *hayanus* are, while distinct enough, extremely closely allied and very similar in general appearance. The first occurs near Gilolo, the second in the Red Sea. Now Professor Semper[1] has pointed out the close alliance between the mollusca, crustacea, fishes, &c., of the Red Sea and Indian Ocean and those of the Philippines and Western Pacific, and has suggested that this alliance is due to the currents. He also states that a strong superficial current enters the Red Sea, and, while taking many species in, prevents the return of those which dwell on or near the surface. From this it seems not improbable that *hayanus* has been developed from emigrant individuals of *proavus*.

So far as general appearance and coloration go, two other species—*flaviventris* and *frauenfeldanus*—also resemble *proavus*, but structurally they present far greater differences, and indeed if *frauenfeldanus*, which I have not seen, be correctly described,[2] it would seem almost to deserve generic separation. *Frauenfeldanus* occurs at the Nicobar Islands, *flaviventris* near Ceylon, Madagascar, and St. Helena, and it does not seem impossible that they have in *proavus* their common ancestor, or at least have had with that species and *hayanus* a progenitor less remote than the common ancestor of the genus.

Wüllerstorffi, *micans*, and *princeps* are three other species somewhat closely allied. The headquarters of *wüllerstorffi* certainly appear to be the Atlantic, but notwithstanding this it probably came originally from the Western Pacific, for by the arrangement of ocean currents it seems scarcely possible that it should have spread in the opposite direction.

In like manner *sericeus*, if it occurs elsewhere than the Pacific, has probably been carried thence by the currents.

Of the distribution of the remaining species we know too little to make it worth discussion. To conclude, it seems probable that the genus originated in the region of the West Pacific, and that the species, or their ancestral forms, have been distributed by the ocean currents.

HALOBATODES.

Halobatodes lituratus is reported as occurring in the Chinese Sea, between Manilla and Hong Kong. The locality of the closely allied *histrio* is "Japan," but whether it is marine or fresh-water is not stated. *Compar* is an Indian species, and *ståli* comes from Ceylon.

This distribution is interesting, when it is remembered that the metropolis of the species of *Halobates* is the region between the Indian Ocean and Western Pacific, and that *Halobatodes* has probably been derived from *Halobates*.

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[1] The Natural Conditions of Existence, p. 279, 1881.

[2] See however the description, *antéa*, p. 57.

APPENDIX.

The Ventral Tubercle.

Since the description of the "ventral tubercle" was printed (pp. 31 and 32) it has occurred to me that this peculiar structure may possibly be the orifice of the canals leading from the odoriferous glands. These orifices are usually situated on each side of the metasternum near the posterior coxæ. If this be the case, it is possible that what we have considered to be the first abdominal ventral segment may be the metasternum, though this seems very improbable.

Excluded Species.

1. *Halobates albinervus*, Am. et Serv. (Hist. Nat. des Insectes, Hémiptères, p. 412, 1843), is a fresh-water Brazilian species, for which Mayr (Verh. zool. bot. Ges., 1865, p. 445; and Reise d. Freg. Novara, Zool., Band ii., Abth. 1, p. 177, 1866) founded the genus *Brachymetra*. It is to be noted that some authors write the specific name *albinervis*, but the original is *albinervus*.

2. *Halobates pictus*, Germ. (Herrich-Schäffer, Die wanzenart. Insecten, Band viii. p. 108, 1848), is another fresh-water North American species, which we take as the type of the new genus *Stephania*.[1] A winged form of this is said to have

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[1] *Stephania*, n. g. Body oval, moderately pubescent. Head (with eyes) subtriangular. Antennæ four-jointed, with two intermediate jointlets. Eyes large, situated at the back of the head, and resting partly on the pronotum. Ocelli absent. Prothorax transverse, broader than long, distinct from the mesothorax. Mesothorax and metathorax together cylindrical, subcoalesced, the suture between them distinct on the upper surface. Mesonotum with a narrow free process (scutellar), posteriorly overlapping the base of the abdomen. Metasternum not visible. Elytra and wings? Front legs short, rather slender: tibia without an apical process; tarsus two-jointed, the second joint excavated beyond the middle, but without a process, furnished with claws. Middle and hind legs rather long and slender, inserted at the posterior end of the thorax; the hind legs inserted above the middle legs. Middle legs without a fringe of long hairs; tarsus? Hind legs with one-jointed tarsus clawed before the tip. Abdomen short, sides furnished with a conspicuous connexivum; apex of male abdomen without a conspicuous rhomboidal appendage.

Type.—*Halobates pictus*, Germ. *Halobates platensis*, Berg., also probably belongs to this genus, but I have seen larvæ only, and they have not the scutellar process of the mesonotum, which serves at once to separate this genus from *Halobates*. I have also seen but one specimen of *Stephania picta*, and that a female, and not quite perfect, so that the generic diagnosis is not so complete as it might be. *Metrocoris*, Mayr (with a single species, *Metrocoris brevis*, Mayr, found in Ceylon and India), is in many ways closely allied to *Stephania* and *Halobates*. So also is *Platygerris*, mihi (with a single species—*Platygerris depressa*, mihi—from Mexico).

been found, but very rarely. Though Germar is cited as the author of this species, it was described by Herrich-Schäffer.

3. *Halobates platensis*, Berg. (Hemiptera Argentina, p. 183, No. 220, 1879), is a fresh-water species from the Argentine Republic, probably congeneric with *Stephania picta*.
4. *Halobates* (?) *orientalis*, Distant (Trans. Ent. Soc. Lond., p. 126, 1879), is an Indian fresh-water species, which the author now admits (Scientific Results of the Second Yarkand Expedition, Rhynchota, p. 13, No. 38, 1879) does not belong to *Halobates* though allied thereto.

I may mention that Mr. Murray has shown me drawings and description (made by Sir J. D. Hooker) of a *Halobates* taken during Sir James Ross's Antarctic Voyage. The species figured appears to belong to an undescribed form, but as Sir J. D. Hooker tells me that the specimens have unfortunately been lost, nothing more can be said about it.

Halobates princeps ♂.

At the moment of going to press, I have received, through the kindness of Professor Bogdanow of the Moscow Museum, the loan of two specimens of the species referred to in Professor Semper's note (p. 22). They seem to be males of my *Halobates princeps*. The third genital segment above is comparatively narrow, six-sided, and with the usually prominent lateral angles truncate, so that the segment is parallel-sided in the middle.

INDEX.

The figures in dark type indicate the page where the Genus or Species is fully described.

PLATE I.

Fig. 1.—*Halobates wüllerstorffi*, Frauenf.

1 ♂.	Male, upper side.
1 *a.*	Antenna.
1 *f.t.*	Front tarsus.
1 *f.t. a.*	Front tarsus of the larva.
1 *m.t.*	Middle tibia and tarsus.
1 *g.*	Genital segments of the male from above.
1 *g. a.*	Genital segments of the male in profile.
1 ♀.	Outline of the body of the female.

Fig. 2.—*Halobates micans*, Esch.

2 ♀.	Female, upper side (after Eschscholtz).[1]
2 *a.*	Antenna (after Frauenfeld).

Fig. 3.—*Halobates princeps*, n. sp.

3 ♀.	Female, upper side.
3 *a.*	Antenna.
3 *f.t.*	Front tarsus.
3 *m.t.*	Middle tibia and tarsus.

Fig. 4.—*Halobates streatfieldanus*, Templn.

4 ♀.	Female, upper side (after Templeton).
4 *a.*	Antenna ,,
4 *f.l.*	Front leg (after Templeton).
4 *f.t.*	Front tarsus. ,,

Fig. 5.—*Halobates sobrinus*, n. sp.

5 ♂.	Male, upper side.
5 ♀.	Female, upper side.
5 ♀ *a.*	Female, under side.
5 *a.*	Antenna.
5 *f.t.*	Front tarsus.
5 *m.t.*	Middle tibia and tarsus.
5 *g.*	Genital segments of the male from above.

Fig. 6.—*Halobates germanus*, n. sp.

6 ♂.	Male, upper side.
6 ♂ *a.*	Male, under side.
6 ♀.	Female, upper side.
6 *a.*	Antenna.
6 *f.t.*	Front tarsus.
6 *m.t.*	Middle tibia and tarsus.
6 *g.*	Genital segments of the male from above.

Fig. 7.—*Halobates sericeus*, Esch.

7 ♂.	Male, upper side.
7 ♂ *a.*	Male, under side.
7 ♀.	Female, upper side.
7 ♀ *ab.b.*	Female, under side of abdomen.
7 *a.*	Antenna.
7 *f.t.*	Front tarsus.
7 *m.t.*	Middle tibia and tarsus.
7 *g.*	Genital segments of the male from above.

Fig. 8.—*Halobates hayanus*, n. sp.

8 ♂.	Male, upper side.
8 ♂ *a.*	Male, under side.
8 ♂ *β.*	Male, outline of body.
8 ♂ *γ.*	Male, outline of body from the side.
8 ♂ *ab.b.*	Male, under side of abdomen.
8 ♀.	Female, upper side.
8 ♀ *a.*	Female, under side.
8 *a.*	Antenna.
8 *a.c.*	Anterior acetabulum, coxa and trochanter.
8 *f.t.*	Front tarsus.
8 *m.t.*	Middle tarsus.
8 *g.*	Genital segments of the male from above.

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[1] The size has been reduced, and position of the legs a little altered. It is to be noted that the middle and hind legs are, as in Eschscholtz' other drawings of *Halobates*, out of proportion to the length of the body.

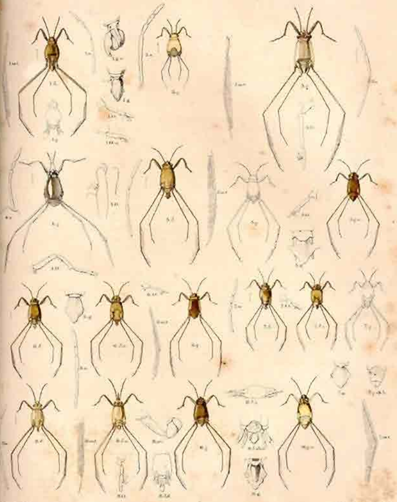


PLATE I.

PLATE II.

Fig. 1.—*Halobates proavus*, n. sp.

1 ♂.	Male, upper side.
1 ♂ *a*.	Male, under side.
1 *a*.	Antenna.
1 *f.t.*	Front tarsus.
1 *m.t.*	Middle tarsus.
1 *g*.	Genital segments of the male from above.

Fig. 2.—*Halobates flaviventris*, Esch.

2 ♂.	Male, upper side.
2 ♂ *a*.	Male, under side.
2 *a*.	Antenna.
2 *f.t.*	Front tarsus.
2 *m.t.*	Middle tibia and tarsus.
2 *g*.	Genital segments of the male from above.

Fig. 3.—*Halobates frauenfeldanus*, n. sp.

3 ♀.	Female, upper side (after Frauenfeld).
3 *a*.	Antenna (after Frauenfeld).

Fig. 4.—*Halobatodes lituratus*, Stål.

4 ♂.	Male, upper side.
4 ♂ *a*.	Male, under side.
4 ♂ *ab.a.*	Upper side of male abdomen.
4 ♂ *ab.b.*	Under side of male abdomen.
4 ♂ *f.l.*	Front leg of male.
4 ♀ *ab.a.*	Upper side of female abdomen.
4 ♀ *ab.b.*	Under side of female abdomen.
4 ♀ *f.l.*	Front leg of female.
4 *a*.	Antenna.

Fig. 5.—*Halobatodes histrio*, n. sp.

5 ♀.	Female, upper side.
5 ♀ *a*.	Female, under side.
5 ♀ *β*.	Female, body from the side.
5 ♀ *ab.b.*	Under side of female abdomen.
5 *a*.	Antenna.
5 *a.c.*	Anterior acetabulum, coxa, and trochanter.
5 *m.t.*	Middle tarsus.
5 *h.t.*	Hind tarsus.

Fig. 6.—*Halobatodes compar*, n. sp.

6 ♂.	Male, upper side.
6 ♂ *a*.	Male, under side.
6 ♂ *ab.a.*	Upper side of male abdomen.
6 ♂ *ab.b.*	Under side of male abdomen.
6 *a*.	Antenna.
6 *f.l.*	Front leg.

The Voyage of H.M.S. Challenger

Pelagic Hemiptera Pl. II.

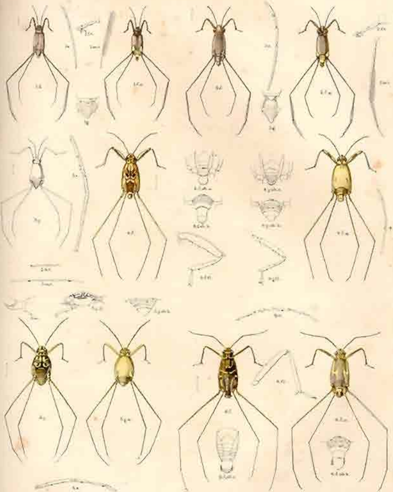
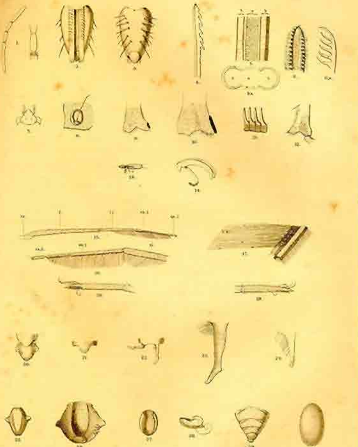


PLATE II.

PLATE III.



F. Buchanan White del. et lith.

PLATE III.

THE

VOYAGE OF H.M.S. CHALLENGER.

ZOOLOGY.

REPORT on the HYDROIDA dredged by H.M.S. Challenger during the years 1873–76. By Professor G. J. ALLMAN, M.D., LL.D., F.R.C.S.I., F.R.SS.L. & E., M.R.I.A., C.M.Z.S., &c.

PART I.—PLUMULARIDÆ.

INTRODUCTION.

IN the descriptive zoology of the Plumularidæ a considerable amount of literature already exists. The British species have, in more recent times, been studied by several observers, and more especially by Hincks,[1] whose valuable History of the British Hydroid Zoophytes has greatly facilitated the labours of such zoologists as have since worked at species from other seas. Among the more important recent contributions to our knowledge of foreign forms must be mentioned the descriptions given by Busk,[2] of the species collected during the exploratory expedition of the "Rattlesnake"; the memoirs by Kirchenpauer,[3] in which a large number of new species contained in various continental collections has been described and figured; and that by G. Ossian Sars,[4] in which we find descriptions and figures of many new and interesting Plumularidæ from

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[1] A History of the British Hydroid Zoophytes, by Thomas Hincks, London, Van Voorst, 1868.

[2] Narrative of the Voyage of H.M.S. "Rattlesnake," London, 1852. Account of the Polyzoa and Sertularian Zoophytes, by George Busk, Appendix, vol. i.

[3] Kirchenpauer, Ueber die Hydroidenfamilie Plumularidæ. *Abhandl. aus der Gebiete der Naturwiss. von dem naturwiss. Verein in Hamburg*, Bd. v., vi., 1872 and 1876.

[4] G. O. Sars, Bidrag til Kundskaben om Norges Hydroider. *Forhandl. Vidensk. Selsk. i Christiania*, Aar 1873.

the North Atlantic. Heller[1] has described several new Plumularidæ from the Adriatic. To Professor Millen Coughtrey,[2] of Otago, we owe descriptions of New Zealand species, and to Surgeon James Armstrong,[3] of the Indian Medical Department, descriptions of species collected by him on the eastern shores of India.

Besides the expedition of the Challenger, other recent exploratory expeditions have largely added to our knowledge of this group. The exploration of the Gulf Stream, by the United States Coast Survey,[4] has brought to light many new and beautiful forms, the voyages of the "Porcupine"[5] have made us acquainted with new species from the North Atlantic, and the explorations by the United States Coast Survey Steamer "Blake" in the Carribbean Sea and along the Atlantic Coast of the United States have brought to our knowledge the occurrence in those regions of a rich plumularian fauna, among which are several new and highly interesting forms.[6]

To the number of species thus determined and described the collection of hydroids brought home by the Challenger makes a large and valuable addition. Of this collection the family of the Plumularidæ forms a considerable proportion. Among these, four species, namely, *Acanthella effusa*, *Acanthocladium huxleyi*, *Aglaophenia macgillivrayi*, and *Lytocarpus longicornis* had been already described by Busk from the voyage of the "Rattlesnake," and one, namely, *Lytocarpus secundus*, by Kirchenpauer, from specimens brought home by Semper from the Pelew Islands. The Challenger also obtained from dredgings off Bermuda a species (*Aglaophenia ramosa*) already described in the Report on the Hydroida of the United States exploration of the Gulf Stream.

The only form which can be identified with a species occurring in the European seas is *Cladocarpus formosus*. This species was dredged by the "Porcupine" from the seas lying to the north of Scotland, and by the Challenger from the seas of Japan. The species is a well-marked one, and the great distance between the Atlantic and Pacific stations without any intermediate station having been discovered, is a remarkable and significant fact.

But by far the greater part of the Plumularidæ brought home by the Challenger consists of species new to science, while among these a considerable number must be assigned to

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[1] Prof. C. Heller, Die Zoophyten und Echinodermen des adriatischen Meeres, Wien, 1868.

[2] Millen Coughtrey, Notes on the New Zealand Hydroida. *Journal of the New Zealand Institute*, vol. vii. 1874.

[3] Description of some new species of Hydroid Zoophytes from the Indian Coasts and Seas, by Surgeon James Armstrong, Marine Survey Department. *Journal of the Asiatic Society of Bengal*, vol. xlviii., 1879.

[4] Geo. J. Allman, Report on the Hydroida collected during the exploration of the Gulf Stream, by L. F. De Pourtalès, United States Coast Survey. *Mem. of Mus. Comp. Zool. at Harvard College*, vol. v., No. 2, 1877.

[5] Geo. J. Allman, Report on the Hydroida collected during the expeditions of H.M.S. "Porcupine." *Trans. Zool. Soc. Lond.*, 1873.

[6] Reports on the results of dredging under the supervision of Alexander Agassiz in the Caribbean Sea in 1878-79, and along the Atlantic Coast of the United States during the summer of 1880, by the U.S. Coast Survey Steamer "Blake," Commander J. R. Bartlett, U.S.N., commanding. Report on the Acalephæ by J. Walter Fewkes. *Bull. Mus. Comp. Zool. at Harvard College*, vol. viii. p. 127.

genera now specially constituted for their reception. Many are of great interest in the light they throw on the external morphology of the group, and in the aid which they afford towards a philosophic conception of the significance of parts otherwise enigmatical.

I believe, therefore, that the value of the collection will be enhanced, and its instructiveness made more available if the technical description of the species be preceded by a few introductory remarks on the general morphology of the Plumularidæ, more especially on such points as receive important illustration from the species described in the present Report.

GENERAL MORPHOLOGY OF THE PLUMULARIDÆ.

The Plumularidæ constitute a very natural section of the Calyptoblastic Hydroids. Their hydrothecæ are always sessile, and are carried on one side only of the supporting ramulus. Nematophores of a definite form, and with a definite arrangement, are always present. The gonangia are either fully exposed and destitute of any special protective apparatus, or they are enclosed or otherwise protected by more or less modified portions of the hydrocaulus.[1]

The Plumularidæ admit of division into two primary sections, characterised by the condition of the nematophores. In one—the Eleutheroplea (Pls. I., II., &c.),—the nematophores are attached only by their proximal end, and in almost every case are to a certain extent moveable on their point of attachment. In a very few instances the moveable nematophores are associated with nematophores of the fixed type (Pl. VIII. figs. 1–3).

In another section—the Statoplea (Pls. XI., XII., XIII., &c.)—the nematophores are adnate to the chitinous periderm for a greater or less portion of their length, or are fixed by a base too wide to admit of movement on the surface of attachment. No nematophores of the moveable type ever occur in this section.

Each of these sections admits of a further division into two main groups—the Phylactocarpa (Pls. XI., XII., XIII., &c.),[2] in which the hydrocaulus has become modified so as to form a more or less complete protection for the gonangia, and the Gymnocarpa (Pls. II., III., IV., &c., and Pl. VIII. and Pl. XIX. figs. 1–3), in which no protective apparatus is present.

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[1] For definitions of the terms here used see p. 17.

[2] The collection contains no example of the phylactocarpal Eleutheroplea. For our knowledge of the occurrence of phylactocarpal forms among the Eleutheroplean Plumularidæ, we are indebted to Mr. J. Walter Fewkes, who detected the presence of this condition in two Hydroids, *Hippurella annulata* and *Callicarpa gracilis*, obtained by the dredge of the U.S. Coast Survey Steamer "Blake." *Bull. Mus. Comp. Zool.*, *loc. cit.*

In accordance with these differences, the great leading groups of the Plumularidæ may be systematically arranged as in the following scheme :—

PLUMULARIDÆ	Moveable nematophores always present,	ELEUTHEROPLEA.	Gonangia with special protective apparatus,	ELEUTHEROPLEA PHYLACTOCARPA.
			Gonangia destitute of special protective apparatus,	ELEUTHEROPLEA GYMNOCARPA.
	Moveable nematophores never present,	STATOPLEA.	Gonangia with special protective apparatus,	STATOPLEA PHYLACTOCARPA.
			Gonangia destitute of special protective apparatus,	STATOPLEA GYMNOCARPA.

The opportunities of examining the Hydroida in a living state, or even in dead specimens which have the soft parts sufficiently well preserved, are so comparatively few, that the systematist is compelled to have recourse to the chitinous periderm, as affording almost the only available grounds for determination and classification.

This chitinous external skeleton, however, presents so many points of high morphological interest, that the classification thus based upon it is by no means an arbitrary and artificial one.

A correct idea of the morphology of the chitinous skeleton in the Plumularidæ will be best obtained by comparing with one another the modifications of form which it presents when examined in the various parts of the colony or hydrophyton in the different groups.

Morphology of the Trophosome.

Hydrocaulus.—The hydrocaulus of the Plumularidæ, both in the Eleutheroplea and the Statoplea, may be formed either of a single tube (monosiphonic) or it may be fascicled or polysiphonic. The fascicled condition may exist in the main stem and in the principal branches, but the ultimate ramuli or hydrocladia are always monosiphonic. The polysiphonic condition gradually gives place to the monosiphonic in passing from the proximal to the distal parts of the colony, the fascicled stem sending off bundles of tubes to form the branches, and these again throwing off smaller bundles to form secondary branches, until finally, in the distal parts of the colony, the fasciculation has become exhausted, and a monosiphonic condition has taken its place.

The tubes which compose the fascicled portions of the hydrocaulus communicate laterally with one another. In *Aglaophenia coarctata* (Pl. XIX. figs. 7–9) this communication is plainly seen to be effected by very short tubular processes which are given off from the component tubes, those of two juxtaposed tubes meeting one another and inosculating in such a way as to suggest the conjugation of a Zygnema (fig. 1).

Hydrothecæ.—In all the Plumularidæ hydrothecæ are borne on special ramuli, which are usually disposed in pinnæ, and for which the convenient term *hydrocladium*, as proposed by Kirchenpauer, may be adopted. In a few species (Pl. IV. figs. 3, 4) hydrothecæ are also carried directly by the stem.

In the Eleutheroplea the margin of the hydrotheca is, with, so far as I know, only one exception,[1] invariably destitute of all trace of serration. The peculiar ridge which I have termed the "intrathecal ridge," and which constitutes a characteristic feature in the Statoplea, is never present in the Eleutheroplea.

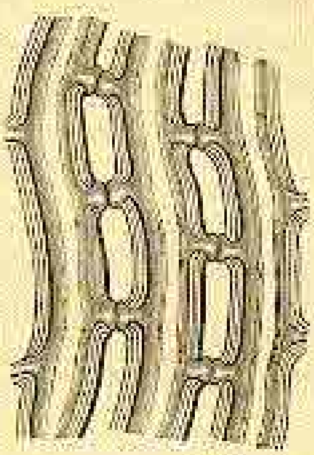

Fig. 1.—Longitudinal section of the polysiphonic stem of *Aglaophenia coarctata*, showing the lateral offsets through which the component tubes communicate with each other.

In the Statoplea the margin of the hydrotheca is in most instances deeply serrated (Pl. XI., &c.). In a few it presents only an indistinct crenation (Pl. XIV.), while in a few it is quite entire (Pl. XVII.). In almost every case there is present in the hydrotheca of the Statoplea a slightly projecting chitinous ridge (Pl. XI., &c.), which runs on the inner surface of the walls transversely from behind forwards, but with a more or less oblique direction, and which more or less completely encircles the cavity of the hydrotheca, thus forming an imperfect septum, which divides the hydrotheca into a proximal and a distal portion. This is the intrathecal ridge, which, as just said, is never present in the Eleutheroplea. In some species of Statoplea, what has the appearance of a similar ridge running from before backwards may be seen in the anterior portion of the hydrotheca (Pls. XV. and XVIII.). This, however, is only the optical expression of a fold in the walls of the hydrotheca.

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[1] The exception here referred to is found in an Eleutheroplean Plumularidan not yet described. For an opportunity of examining it I am indebted to Miss Gatty. Among other very exceptional characters, the margin of the hydrotheca is here provided with a strong anterior mesial tooth, and with a strong lateral tooth on each side.

In one remarkable genus of Statoplea contained in the Challenger collection (*Diplocheilus* (Pl. VIII. figs. 4-7), the hydrotheca presents a double margin formed by the development of an external chitinous sheath round the upper third of the hydrotheca.

Nematophores.—The presence of nematophores, whether fixed or moveable, constitutes the most characteristic feature in the Plumularidæ. The nematophores are hollow chitinous bodies, more or less cup-shaped or tubular, and having their cavity in communication with that of various parts either of the trophosome or of the gonosome. Their contents consist of protoplasm, in which thread-cells are often immersed, and which has the faculty of emitting pseudopodial prolongations which often attain great development.

Those nematophores which belong to the fixed type are usually blunt spine-like bodies, with a continuous cavity and a terminal orifice, and with one or sometimes two lateral orifices. The terminal orifice is usually oblique or deeply emarginate.

The nematophores of the moveable type are more constant in form. They are funnel- or trumpet-shaped, and never provided with lateral orifices. They are mostly bi-thalamic, their cavity being divided into a proximal narrow chamber and a distal wide cup-shaped chamber, separated from one another by a transverse perforated septum. The distal chamber opens by a wide terminal orifice, which is usually deeply emarginate on one side.

Nematophores are either hydrocladial, hydrocauline, or gonosomal, according to the special part of the colony with which they are in immediate connection. An accurate knowledge of their arrangement and modifications will be best acquired by examining them separately in the two great Plumularian sections.[1]

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[1] Bodies resembling the nematophores of the Plumularidæ have, however, been found in other Hydroids. Hincks (*loc. cit.*, p. 230, pls. i. iv. fig. 2) has constituted the genus *Ophiodes* for a remarkable Hydroid closely allied to *Halecium*, in which he had discovered certain singular bodies in the form of long cylindrical, very contractile tentacula-like appendages, each protected at its base by a small chitinous cup, through which it communicates with the cœnosarc of the colony, and terminating distally in a spherical capitulum, loaded with thread-cells. They occur here and there on the stem, at a slight distance below the hydrothecæ, but are chiefly found scattered on the creeping stolon.

Bodies closely resembling these have been found by G. O. Sars (*loc. cit.*, p. 109, pl. iv. figs. 5-8) in a Hydroid which he refers to the genus *Ophiodes* of Hincks, under the name of *Ophiodes parasitica*. This determination is not accepted by Hincks, who proposes for Sars's Hydroid the new generic name of *Ophionema*, believing it to belong to the Plumularidæ instead of regarding it with Sars as a near ally of *Halecium*. Notwithstanding, however, the resemblance of Sars's figures to a Plumularian, it is plain to me that the affinities of his *Ophiodes parasitica* are really with *Halecium*, and that the Norwegian zoologist had a true conception of its nature when he referred it to Hincks's genus *Ophiodes*. The tentacula-like organs in *Ophiodes* would seem to take the place of the nematophores of the Eleutheroplean Plumularidæ. They appear, however, to stand on a much higher grade of development than true nematophores, and to have passed out of the condition of mere protoplasm into that of a multi-cellular organ. If this be so we should not be justified in assigning to both the same significance.

Belonging apparently to the same group of appendages are certain minute bodies which occur in *Oplorhiza parvula*, a little Hydroid allied to *Lafoëa*, obtained during the United States exploration of the Gulf Stream. They are here in the form of tubular receptacles, which are developed on the hydrorhizal network, and enclose a granular fleshy column, which supports a cluster of thread-cells (Hydroids of Gulf Stream, p. 14, pl. vii. figs. 1-3). In a nearly allied form, *Lafoëina tenuis*, Sars, from the Norwegian seas, the hydrorhiza supports appendages which would seem to be essentially of the same kind (G. O. Sars, *loc. cit.*, p. 119, pl. v. figs. 1-5). Minute fleshy processes of doubtful significance have also

Nematophores in the Statoplea.

a. *Hydrocladial nematophores.*—These are arranged in two sets on every internode of the hydrocladium, and consist of an azygous or mesial nematophore and a pair of lateral nematophores. The mesial nematophore is in the form of a tubular process springing from a point of the hydrotheca-bearing internode immediately below the hydrotheca, to the front wall of which it becomes in almost every instance adnate for a greater or less extent of its length. In a very few cases the mesial nematophore of the Statoplean Plumularidæ, while fixed immovably by its base, remains free for the rest of its course, having no adhesion to the hydrotheca (Pl. XVI. figs 1–3). In a single instance (*Aglaophenia bispinosa* of the Gulf Stream Report[1]) a second mesial nematophore is developed in a longitudinal line behind the first.

The mesial nematophore communicates through its base with the cavity of the internode, just below the hydrotheca. In that portion of it which is adnate to the front of the hydrotheca it communicates by means of a longitudinal slit-like aperture with the cavity of the latter. It is always open at its distal extremity, where an aperture, usually very oblique, allows of the projection of its protoplasmic contents in the form of free pseudopodia. Besides the terminal and the longitudinal slit-like aperture there is also in many cases an aperture on its inner or hydrothecal side (Pl. XV.), just beyond the point where its distal portion becomes free from the walls of the hydrotheca. Occasionally an imperfect transverse septum exists in some part of its course (Pl. XX. figs. 4, 5).

The mesial nematophore is in a few cases adnate to the walls of the hydrotheca for its entire length. In most cases, however, its distal extremity is continued for some distance as a free process. This free distal portion of the mesial nematophore varies much in length. In *Aglaophenia* proper it is generally quite short, but in some other genera it attains a great length, being developed in the form of a long curved horn (Pl. XVIII.).

The lateral nematophores in the Statoplea are tubular, cup-shaped, or crescentic bodies, always two in number, situated symmetrically one on either side of the hydrotheca, nearly on a level with its orifice or thecostome. They spring from the hydrothecal internode with the cavity of which they communicate by their base. They terminate distally by

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been described by G. O. Sars (*loc. cit.*, p. 112, pl. iv. fig. 10) as developed below the hydrothecæ in his *Halecium gorgonoide*.

Mr. Busk, in a letter which I have recently had from him, describes from a specimen in his collection but from an unknown locality a Hydroid whose affinities are with the Sertularidæ rather than with the Plumularidæ, and which yet carries on the front of every hydrotheca a small sessile nematophore-like body. Whether this is to be regarded as a true nematophore or not, can scarcely be asserted with confidence from the examination of a dried specimen. Its peculiar position, lying as it does on the front wall of the hydrotheca, without any apparently direct communication with the hydrocaulus, is certainly against placing it in the same category with the true nematophores. The Hydroid is also very exceptional in other respects, and Mr. Busk regards it as the type of a new genus, for which he proposes the name of *Greenia*.

[1] Hydroids of the Gulf Stream, p. 46, pls. xxvii. xxviii.

an open orifice which is usually very oblique. In some very rare cases (Pl. VIII. figs. 4–7, and Pl. XIX. figs. 1–3) the lateral nematophores are absent.

In a singular and beautiful species (*Acanthocladium huxleyi*, Pl. IX.) contained in the Challenger collection, the hydrocladia become towards the dorsal extremities of the branches atrophied, lose their hydrothecæ, and are converted into spine-like appendages, which carry from base to apex two longitudinal alternate series of minute cup-shaped nematophores (Pl. XX. fig. 3).

b. *Cauline nematophores.*—These are usually small, cup-shaped bodies, situated on various parts of the hydrocaulus, with the cavity of which they communicate. They are generally disposed in linear series (Pl. XVII.) on the main stem and principal branches, and often form definite symmetrical groups of two at the points where the hydrocladia spring from the stem. Though quite different from the moveable nematophores of the Eleutheroplea,—being seated on a wide base which fixes them to the stem,—they would seem to be in many cases easily detached.

c. *Gonosomal nematophores.*—The system of nematophores attains in the gonosome of the Phylactocarpal Statoplea a remarkable development. The characteristic denticles which are found on the margins of the leaflets, which combine to form the walls of the corbula (Pls. XI. and XII.) in *Aglaophenia*, are only slightly modified nematophores. These denticles are tubular with a terminal orifice, and their cavity is in communication with that of the leaflet, while this opens into the common basal rachis of the corbula. In most cases a nematophore is specially developed at the base of each leaflet in the form of a spur. In one remarkable form (Pl. XX. fig. 6) branching chitinous ridges are developed on the walls of the corbula, and enclose cup-shaped nematophores in bifurcations of their branches.

But nematophores are largely developed not only in the corbula, but in the other forms of Phylactocarp, where they constitute a very characteristic feature. They occur in such cases along the branches of the Phylactocarp, or along the common basal rachis, and are usually present in the form of denticles or cup-shaped bodies, arranged in two opposite or alternate series. In *Lytocarpus spectabilis* (Pl. XV.) they are in the form of a pair of stout opposite spines on every internode of the phylactocarpal rachis, and are each provided with a terminal aperture and also with a lateral aperture close to the base (fig. 5). In *Lytocarpus racemifera* (Pl. XIII.) there is, in addition to the pair of opposite spine-like nematophores on each internode, an azygous spine on the front of the internode (figs. 4–6). A similar azygous spine-like nematophore is in *Lytocarpus spectabilis* carried by that internode of the rachis which supports a gonangium (fig. 2, p. 44).

Nematophores in the Eleutheroplea.

The nematophores here belong, in almost every instance, exclusively to the moveable type. In very rare cases (Pl. VIII. figs. 1–3) the moveable nematophore is associated with a fixed nematophore developed in other parts of the same colony.

a. *Hydrocladial nematophores.*—The hydrocladial nematophores in the Eleutheroplea are, as in the Statoplea, disposed in two sets—mesial and lateral. The mesial nematophore is never, as in the Statoplea, adnate to the front of the hydrotheca, and is almost always removed to a point at some distance from the hydrotheca at its proximal side. It is this azygous nematophore which in very rare cases differs from the others in being immovable. In one instance, that of *Schizotricha multifurcata* (Pl. VII. figs. 4, 5), the single mesial nematophore is replaced by a pair of nematophores, one on each side of the internode. In some cases an azygous nematophore is also found on the hydrothecal internode at the distal side of the hydrotheca, while in *Plumularia armata* (Pl. IV. figs. 3, 4) this part of the internode supports, instead of a single mesial nematophore, a pair of lateral nematophores.

In every case the hydrothecæ of the Eleutheroplea are flanked, as in the Statoplea, by a pair of lateral nematophores.[1] Each of these is usually borne on the summit of a hollow chitinous process, which springs from the internode at either side of the hydrotheca. The process varies much in length, and is sometimes obsolete.

The hydrocladia of the Eleutheroplea differ from those of the Statoplea in being very often provided with internodes which do not carry hydrothecæ (Pl. I. figs. 1–4). The internodes thus destitute of hydrothecæ carry nematophores which are either solitary or are disposed in a longitudinal series on the front of the internode.

b. *Cauline nematophores.*—These are borne, generally in considerable numbers, along the stem and branches, and are often disposed in pairs close to the points from which the ultimate ramuli or hydrocladia spring (Pl. V.).

c. *Gonosomal nematophores.*—When these are present in the gymnocarpal Eleutheroplea they spring from the gonangium, where they are usually disposed in a symmetrical pair on its proximal end, and are here in connection with the base of the blastostyle (Pl. IV. figs. 2, 6). In some cases they are connected with other parts of the blastostyle, which is then pushed out of the axis of the gonangium, and lies in contact with its wall (Pl. IV. fig. 4). In such cases the wall of the gonangium is perforated along the course of the blastostyle, and the contents of the nematophores, which are developed externally, communicate through the perforations with the blastostyle.

In another very remarkable form (*Sciurella indivisa*, Pl. V.) the blastostyle is extensively ramified, and the ends of the ramification impinge on definite points sym-

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[1] In the rare cases in which these lateral nematophores are stated to be absent, I believe that they have either been overlooked in consequence of their minuteness, or have fallen away from their points of attachment.

metrically disposed on the walls of the gonangium. Over each of these points a nematophore is developed externally, while a perforation in the chitinous walls allows of the free communication of the contents of the nematophore with the subjacent branch of the blastostyle.

In the only two known species of phylactocarpal Eleutheroplea the nematophores are developed in abundance along the sides of the appendages, which combine to form the peculiar phylactocarps of these Hydroids.[1]

That the nematophores play a very important part in the economy of the Plumularidæ would appear from the fact of their early appearance and of their persistence. In the development of the trophosome they are in many cases, if not in all, the first zooids of the colony to make their appearance, preceding the hydranths and hydrothecæ; while, as we shall afterwards see, they remain behind in certain cases in which the hydranth and hydrotheca, which would normally belong to them, have become entirely suppressed.

I have endeavoured to show elsewhere[2] that their phylogenetic or palæontological significance is scarcely less important, for I believe we have good grounds for maintaining that the ancient graptolites represent hydroid organisms, in which the nematophores were the only zooids of the trophosome which had been developed.

Morphology of the Gonosome in the Phylactocarpal Plumularidæ.

The gonosome in the phylactocarpal forms of the Plumularidæ is full of interest, presenting as it does some significant morphological facts, and affording instructive examples of the extent to which variation of form may exist consistently with the retention of homological identity.

The term *phylactocarp* may be used as a sufficiently convenient general expression for the various forms under which the apparatus destined for the protection of the gonangia shows itself in the phylactocarpal Plumularidæ. This apparatus is referrible to one or other of two types; it consists either of one or more variously modified hydrocladia, or of a separate appendage to the hydrocladium quite distinct from the hydrocladium itself.

The commonest and longest known form of phylactocarp is the corbula of *Aglaophenia* (Pls. XI. and XII.). This consists of a peculiarly modified hydrocladium, which supports on each side a row of ribs or costæ in the form of flattened leaf-like appendages, and between these two rows a row of gonangia. The leaflets of each side arch over the gonangia, and enclose them in a basket-shaped receptacle. They are furnished with numerous short teeth-like nematophores on one or both edges, recalling somewhat the

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[1] See J. W. Fewkes, *Bull. Mus. Comp. Zool.*, *loc. cit.*

[2] Gymnoblastic Hydroids, p. 179.

serrated margin of a leaf, and they are here usually adnate to one another, so as to form a completely closed case (Pl. XI. fig. 4, and Pl. XII. figs. 4 and 8). In other instances they contract no adhesion by their edges, and the corbula is then open (Pl. XI. figs. 5 and 9).

That the corbula is a modified hydrocladium there can be no doubt. It takes exactly the place of a hydrocladium, while its proximal end is in the form of a short peduncle, which holds it to the stem, and which still retains the normal condition of the ramulus, and carries a scarcely modified hydrotheca. The floor or rachis of the corbula is a simple continuation of this peduncle, with the hydrothecæ entirely suppressed.

In determining the morphological significance of the corbula, the meaning of the costæ or leaflet-like ribs becomes an element of primary importance. Now the key to this will be found in certain other forms of the protective apparatus, and I believe we shall be justified in regarding the costæ as the greatly modified mesial nematophores of the suppressed hydrothecæ, complicated by the development on them of secondary nematophores, and thrown alternately to the right and left in accordance with their new protective function. This will become apparent after an examination of the phylactocarpal apparatus in other genera.

The form of phylactocarp referrible to the type found in the *Lytocarpus* (*Aglaophenia*) *myriophyllum* of the European coasts, affords the means of clearing up this point in a way which will scarcely admit of doubt. Two beautiful species, *Lytocarpus* (*Aglaophenia*) *distans*, and *Lytocarpus* (*Aglaophenia*) *bispinosa*, obtained during the exploration of the Gulf Stream by the United States Survey,[1] are especially significant in the light they throw on the morphology of the corbula, while another beautiful species, *Acanthocladium huxleyi*, occurring in the Challenger collection (Pl. X., and Pl. XX. fig. 1), is scarcely less instructive.

In all these, as well as in *Lytocarpus myriophyllum*, the phylactocarp is, as in the true corbula, an obviously modified hydrocladium. After retaining for some distance from its point of origin the normal character of the hydrocladium, and supporting one or more hydrothecæ, each with its usual mesial and lateral nematophores, it is continued in an altered form, and develops a double series of long ribs, which carry numerous small nematophores along one or both edges, remain quite distinct from one another, and form the walls of an open basket or cage (Pl. XX. fig. 1), along whose floor the gonangia are distributed from the proximal to the distal end. Now, in this continuation of the hydrocladium the hydrothecæ are not, as in the true corbula, suppressed. We find, on the contrary, that every rib carries a hydrotheca at its base, the rib with its basal hydrotheca being raised on a peduncle from the rachis or floor of the cage. The pair of lateral nematophores belonging to each of these hydrothecæ may be recognised in nearly its usual condition, while the mesial nematophore, though holding its normal position with

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[1] Hydroids of the Gulf Stream, pp. 44 and 46, pl. xxvi. figs. 1-8, and pls. xxvii. and xxviii.

regard to the hydrotheca, becomes much elongated and transformed into the great protective rib.

The whole morphology of the corbula thus becomes beautifully distinct. We have only to complete the transformation by supposing the costal hydrothecæ, with their peduncle and lateral nematophores to become suppressed, and the ribs to become confluent by their edges, in order to convert the curious open cage of *Lytocarpus myriophyllum*, and of the Gulf Stream and Challenger Plumularians, into the ordinary closed Aglaophenian corbula.

In the two species of the Gulf Stream exploration (*Lytocarpus distans* and *Lytocarpus bispinosa*), the hydrocladium, which is to become transformed into a phylactocarp, retains its normal condition for a greater distance than in *Acanthocladium huxleyi* continuing to bear from three to five scarcely altered hydrothecæ before the change begins which results in the formation of a phylactocarp.

An intermediate condition will be found in those instances of an open corbula (*Aglaophenia filicula* and *Aglaophenia attenuata*, Pl. XI. figs. 5 and 9), in which, while the hydrothecæ as in the ordinary closed corbula become suppressed, the leaflets remain distinct from one another.

A very interesting and instructive form of phylactocarp is found in *Lytocarpus racemiferus* (Pl. XIII.). In this beautiful Plumularidan, the hydrocladia on each side for a certain length of the principal branches become, as in the other instances, modified so as to form protective supports for the gonangia (fig. 4). The modification here consists in the entire suppression of the hydrothecæ, while the mesial and lateral nematophores are retained in a scarcely altered form. The hydrothecal internodes also continue distinct, and the places of the suppressed hydrothecæ are taken by the gonangia, which are thus disposed in a single series, one on each internode, from the proximal towards the distal end of the rachis. Near the distal end, however, the suppressed hydrothecæ are not replaced by gonangia, though here, on every internode, we still find the three nematophores, the mesial and the two lateral, of the absent hydrotheca. In this form of phylactocarp there are no rib-like appendages; and the mesial nematophores, which in other forms become converted into ribs, here retain their normal condition.

In *Lytocarpus spectabilis* (Pl. XV.) we have another instructive example of a phylactocarp in which no ribs are developed. Here, as in the instances already cited, the phylactocarps take the places of hydrocladia, of which they are obvious modifications (fig. 4). The proximal internode carries a hydrotheca with its normal mesial and lateral nematophores, but in all the other internodes the hydrothecæ with their mesial nematophores are suppressed, while the lateral nematophores are retained as a pair of strong blunt spines.

In the specimen from which the figures on Pl. XV. had been drawn, no gonangia were developed on the phylactocarps. In another, however, a gonangium (fig. 2, p. 44) was present on the second internode, which was here larger than the others, and carried a mesial as well as a pair of lateral nematophores; while the continuation of the rachis was arched over the gonangium, and had the persistent lateral nematophores of each internode curved backwards so as to be directed towards the convex side of the arch. It would seem to be only on the second internode that a gonangium is borne, and here it takes the place of the hydrotheca, which, had it not been suppressed, would have belonged to this internode, while the mesial and lateral nematophores are retained.

In *Lytocarpus saccarius*, a species from Ceylon,[1] the gonangia are borne near the distal extremity of short ramuli, which are hydrocladia in which the transformation has been less complete than in the cases described above. In the specimens examined these ramuli were composed each of three internodes. The proximal two internodes carried hydrothecæ in all respects like the other hydrothecæ of the colony, but in the distal internode the hydrotheca was suppressed, while its mesial and lateral nematophores remained with but little modification, and the solitary gonangium occupied the place of the suppressed hydrotheca.

In *Lytocarpus secundus* (Pl. XIV.) certain hydrocladia undergo a remarkable modification in order to become converted into phylactocarps. Their internodes, which are reduced to seven or eight in number, lose their hydrothecæ entirely, and carry each a long curved spine-like appendage, which is supported on the end of a short process of the internode, and bears a double row of cup-like nematophores, several nematophores of a similar form being sessile on the internode itself (fig. 5).

Though no gonangia were developed in the specimens examined, it will scarcely admit of doubt that the hydrocladia thus modified are true phylactocarps. Analogy would, perhaps, justify us in regarding the spine-like appendages as the mesial nematophores of the suppressed hydrothecæ, while the lateral nematophores have left no representatives. A comparison of these appendages with the costæ of a true corbula at once suggests itself, nothwithstanding their disposition in a continuous series along the mesial line of the rachis, instead of being thrown alternately to the right and left. In the absence of gonangia, however, the exact relations of the parts of the phylactocarp to the gonangia, which may yet become developed on it, cannot be ascertained with certainty.

In the only known forms of Eleutheroplea in which phylactocarps have been detected these structures appear to be in all essential points modified hydrocladia, a number of which combine to form the phylactocarp. In *Hipparella annulata*, as described by Fewkes, the hydrocladia lose their hydrothecæ, and assume a verticillate disposition, arching over the gonangia, which are borne by the stem near their bases. In *Callicarpa gracilis*, Fewkes, the hydrocladia undergo a similar modification, and, moreover, become dichotomously branched.[2] This dichotomous division of a hydrocladium is not without analogy,

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[1] *Linn. Soc. Journ. Zool.*, vol. xii. p. 277, pl. xxii. The species is there referred to the genus *Halicornaria*.

[2] *Bull. Mus. Comp. Zool.*, *loc. cit.*, p. 134, pls. i., ii.

for it has its representative in the condition of the ordinary hydrocladia in the Eleutheroplean genus *Schizotricha* of the present Report.

In all the instances now described, the phylactocarps must, as we have seen, be regarded as more or less modified hydrocladia. To those which remain for consideration we must assign an entirely different significance, for we now find them to be variously formed appendages, which though specially developed as in the former for the protection of the gonangia, are superadded to the hydrocladia, which retain their normal form.

In *Cladocarpus pectiniferus* (Pl. XVII.) the phylactocarp is a bifurcating branch which springs from the proximal end of a hydrocladium, and supports the gonangia along its sides. It is destitute of hydrothecæ, and carries along its entire length a double series of opposite nematophores, which have assumed the form of long, spine-like processes, giving a pectinated character to the phylactocarpal branches. In *Cladocarpus formosus* of the Challenger and "Porcupine" expeditions (Pl. XVI. figs. 4 and 5), and in *Cladocarpus paradiseus*, *Cladocarpus dolichotheca*, and *Cladocarpus ventricosus*, of the Gulf Stream exploration, we find a branched phylactocarp essentially similar to that just described.

The morphological significance of the phylactocarp in *Cladocarpus* is not so obvious as in that of other Plumularidæ. In *Cladocarpus pectiniferus* (Pl. XVII. fig. 3), *Cladocarpus formosus* (Pl. XVI. fig. 5), and in some other species, the mesial nematophore of the hydrotheca, immediately behind which the phylactocarp springs, is entirely absent; and this fact, supported by the analogy afforded by other forms of phylactocarp, would lead us to regard the phylactocarp here as representing in a greatly modified form the mesial nematophore of the proximal hydrotheca—a view which is scarcely invalidated by the fact that it springs from a point not absolutely in the mesial line of the internode.

There are, however, other cases in which the mesial nematophore of the proximal hydrothecæ is still present, and then we may perhaps regard the phylactocarp as representing the mesial nematophore of a hydrotheca which had been itself totally suppressed—a view which is justified by the analogy of other forms of phylactocarp, to the formation of which, as we have seen, the greatly modified mesial nematophores of suppressed hydrothecæ largely contribute.

In *Pleurocarpa ramosa*, a remarkable Statoplean from St. Vincent, Mr. Fewkes describes the phylactocarp as composed of a series of ribs which take the places of hydrocladia near the proximal end of a branch, the hydrocladia towards its distal end remaining in their normal condition.[1] Though no gonangia appear to have been present in the specimen, there can be no doubt of the structure in question being a true phylactocarp; and then I should regard the ribs as representing the phylactocarpal appendages in *Cladocarpus* with the hydrocladia, which in this genus carry them suppressed. They are described by Mr. Fewkes as carrying along their length long tubular nematophores, and,

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[1] *Bul. Mus. Comp. Zool.*, loc. cit., p. 136, pl. iii. fig. 2.

were it not for their unbranched condition, they would closely resemble the phylactocarpal appendages of *Cladocarpus pectiniferus* of the present Report. I have here taken for granted that the entire structure is, as interpreted by Mr. Fewkes, a modified branch rather than a hydrocladium, though the fact which he mentions of its carrying along its proximal portion, which forms a kind of peduncle for the phylactocarp, a series of hydrothecæ presents a difficulty in the acceptance of this view. Mr. Fewkes does not give a magnified figure, and it is possible that what look like hydrothecæ are really only large cauline nematophores.

Ramification.

The Plumularidæ present considerable differences in the details of their ramification. What may be regarded as the typical ramification in both the great sections of the Plumularidæ shows itself in a simple or branched stem, from two opposite sides of which the ultimate ramuli or hydrocladia are given off. These ramuli are thus disposed in a regularly pinnate manner, and give to the colony the elegantly plumose aspect by which the designation of the typical genus has been suggested. In most species the pinnæ are alternate, but in a few, as in *Plumularia catharina*, for example, they are opposite.

In some rare cases the hydrocladia are confined to one side of the stem (*Monostachas dichotoma* of the Gulf Stream exploration[1]). In *Streptocaulus pulcherrimus* of the Challenger (Pl. XVI. fig. 1), they are disposed in a continuous spiral along a simple stem. Here, however, the hydrocladia really spring from one side only of the stem, and then, by a revolution of the stem round its axis, the lower end remaining fixed, the hydrocladia are thrown into the beautiful spiral characteristic of the genus. In *Antennularia antennina* of the European seas the hydrocladia are disposed in regular verticils round the stem, while in other species of *Antennularia* (Pl. IV. figs. 5, 6), the verticillate arrangement gives place to a scattered one. In *Sciurella indivisa* (Pl. V.) they are in four longitudinal alternating series. In *Hippurella*[2] they are pinnately disposed on the proximal portion of the branches, but distributed on all sides towards the distal extremities. In *Antennella* no proper stem is developed, and the hydrocladia are borne directly by the hydrorhiza.

The main stem may be quite simple, or it may be more or less branched. In the latter case the ramification is usually irregular, but it is sometimes regularly dichotomous (*Monostachas dichotoma*). In some cases, as in *Lytocarpus spectabilis* (Pl. XV.) and *Aglaophenia macgillivrayi* (Pl. X.), the stem gives off branches, which, though destitute of hydrothecæ, are disposed in perfectly regular pinnæ. These primary pinnæ give support to the true hydrotheca-bearing pinnæ, and the ramification thus becomes doubly

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[1] Hydroids of the Gulf Stream, p. 37, pl. xxii. figs. 1–5.

[2] Hydroids of the Gulf Stream, p. 36, pl. xxi. figs. 7, 8.

pinnate. In such forms of ramification the primary pinnæ are almost always opposite, while the ultimate pinnæ or hydrocladia are alternate. Sometimes, however (Pl. XIX. fig. 4), the primary pinnæ are also alternate.

In some rare cases (Pl. I. fig. 5) the hydrothecæ-bearing pinnæ are themselves pinnately branched, the branches also carrying hydrothecæ, like the pinnæ from which they spring.

Definitions of the principal terms used in the descriptive morphology of the Hydroida

Hydrosoma.—The entire hydroid colony.

Ectoderm.—The most external of the three organised layers of which the body of every hydroid is composed.

Endoderm.—The most internal of the three organised layers of which the body of every hydroid is composed.

Mesoderm.—An organised layer which lies between the ectoderm and endoderm. The above are the three embryonic layers which are persistent, and admit of being recognised during the life of the hydroid.

Perisarc.—The unorganised chitinous excretion by which the soft parts are to a greater or less extent invested.

Zooids.—The more or less independent products of non-sexual reproduction, forming by their association the hydroid colony.

Trophosome.—The entire assemblage of such zooids as are destined for the nutrition of the colony.

Gonosome.—The entire assemblage of such zooids as are destined for the sexual reproduction of the colony.

Hydranths.—The proper nutritive zooids, or those which carry the mouth and proper digestive cavity and which are almost always furnished with tentacles.

Hydrothecæ.—The cup-like chitinous receptacles which protect the hydranths in the calyptoblastic genera.

Thecostome.—The external orifice of the hydrotheca, which permits of the extrusion and retraction of the hydranth.

Intrathecal Ridge.—An imperfect septum by which, in many Plumularidæ, the cavity of the hydrotheca is transversely divided into a proximal and a distal portion.

Hydrophyton.—The common basis of the hydrosoma by which its zooids are connected into a single colony.

Hydrorhiza.—The proximal end of the hydrophyton by which the colony fixes itself to other bodies.

Hydrocaulus.—All that portion of the hydrophyton which intervenes between the hydrorhiza and the hydrothecæ or hydranths. It usually consists of a main stem and branches. It is *polysiphonic* or fascicled, when it is composed of several mutually adherent tubes; *monosiphonic* when consisting of a single tube. In some species the cavity of its perisarc is constricted at intervals by annular ridges or imperfect septa—*intracauline ridges*.

HYDROCLADIA.—The hydrotheca-bearing ramuli—almost always the ultimate ramuli—of the hydrocaulus in the Plumularidæ.

RACHIS.—That portion of the hydrocladium which supports the hydrothecæ. That portion of the phylactocarp which supports the costæ or their equivalents.

INTERNODE.—The part of the hydrocaulus which intervenes between any two consecutive joints.

CŒNOSARC.—The common organised fleshy portion of the hydrophyton; the living bond by which the zooids are organically united to one another.

NEMATOPHORES.—Peculiar bodies developed in certain genera from definite points of the hydrosoma, and consisting of a chitinous receptacle with protoplasmic contents, in which thread-cells are usually immersed. They are eminently characteristic of the Plumularidæ.

GONOPHORE.—The ultimate generative zooid which gives origin directly to the generative elements—ova or spermatozoa.

GONANGIUM.—An external chitinous receptacle within which in the calyptoblastic genera the gonophores are developed.

BLASTOSTYLE.—An extension of the cœnosarc through the axis of the gonangium in the form of a fleshy column from whose sides the gonophores are developed as buds.

ACROCYST.—An external sac which in certain hydroids is formed on the summit of the gonangium, where it constitutes a receptacle into which the ova are discharged in order to pass within it through some of the earlier stages of their development.

PHYLACTOCARP.—A part of the gonosome specially modified for the protection of the gonangia in certain genera (phylactocarpal) of the Plumularidæ.

CORBULA.—A form of phylactocarp constituting a basket-shaped receptacle which encloses groups of gonangia in certain phylactocarpal Plumularidæ.

COSTÆ.—Rib-like appendages which form part of the protective arrangement in certain phylactocarps.

GYMNOBLASTIC.—The condition of a hydroid when no external receptacle (hydrotheca or gonangium) invests either nutritive or generative buds.

CALYPTOBLASTIC.—The condition of a hydroid when an external protective receptacle (hydrotheca or gonangium) invests either the nutritive or generative buds.

DESCRIPTION OF GENERA AND SPECIES.

PLUMULARIDÆ.

Sub-family—Eleutheroplea.

Plumularia, Lamk. (in part).

Plumularia, Lamarck, Hist. Nat. des An. sans Vert., 1st ed., 1815.
Aglaophenia, Lamouroux, Hist. des Pol. Coral. flex., 1816.

Plumularia flabellum, n. sp. (Pl. I. figs. 1–4).

Trophosome.—Colony attaining a height of about five inches, stem springing from a dense mass of entangled filaments, much branched, branches pinnately disposed, main stem and principal branches strongly fascicled, hydrocladia alternate, averaging about three-tenths of an inch in length; hydrotheca-bearing internodes separated from one another by a single internode destitute of hydrotheca. Hydrotheca adnate by its entire height to its internode; hydrothecal internode carrying, besides the pair of lateral nematophores, a single mesial nematophore, which springs from a point at some distance below the hydrotheca; intervening internodes carrying a single mesial nematophore.

Gonosome not known.

Plumularia flabellum is a very beautiful Hydroid. Its primary branches, which are of unequal length, and given off at irregular distances, are pinnately disposed and set with hydrocladia, while many of the primary branches also send off pinnately-disposed ramuli, which, like the primary branches, are themselves destitute of hydrothecæ, but carry pinnately-disposed hydrocladia. Hydrocladia are also borne by the main stem in the intervals of the branches. The pinnate disposition of all the branches and ramuli, and the fact of their lying in one and the same plane, confer upon the colony the flabelliform habit which has suggested the specific name.

This fine species was dredged off Marion Island, 26th December 1873, from a depth of 50–75 fathoms.

Plumularia laxa, n. sp. (Pl. I. figs. 5, 6).

Trophosome.—Colony attaining a height of about four inches, stem much and irregularly branched, rooted by a dense mass of entangled filaments, main stem and principal branches fascicled, hydrocladia springing from the branches at distant and irregular intervals, and being themselves set with rather distant, pinnately-disposed alternate hydrocladia. Hydrothecæ campanulate, every internode of the hydrocladia carrying a hydrotheca, which is adnate to the supporting internode for about two-thirds of its height; lateral nematophores very short, cup-shaped, not reaching the margin of the hydrotheca; mesial nematophores like the lateral in form, one borne by every internode at the proximal, and one at the distal side of the hydrotheca.

Gonosome not known.

Plumularia laxa is a very remarkable form, rendered striking by its somewhat diffuse habit, and by the doubly pinnate arrangement of its hydrotheca-bearing ramuli.

In this doubly pinnate condition of the hydrocladia we have a very exceptional character, for though it is not unusual among the Plumularidæ for the ultimate hydrothecal pinnæ to be borne by ramuli also pinnately disposed on the main stem or primary branches, such ramuli rarely carry hydrothecæ. The primary hydrocladia of the present species vary in length from about three-tenths to six-tenths of an inch; the secondary hydrocladia attain a nearly constant length of about two-tenths of an inch.

Dredged in Station 163, April 4, 1874, lat. 36° 56′ S., long. 150° 30′ E.; 120 fathoms.

Plumularia dolichotheca, n. sp. (Pl. I. figs. 7, 8).

Trophosome.—Colony attaining a height of about three inches, stem irregularly branched, monosiphonic, hydrocladia alternate, about two-tenths of an inch in length, divided into internodes of unequal length, each carrying one, two, or three hydrothecæ. Hydrothecæ deep, thimble-shaped, adnate to their internodes by their entire height, and with the lateral nematophores springing from a point close to the margin of the hydrotheca; mesial nematophore sub-calicine only, and found only below the proximal hydrotheca of the internode.

Gonosome not known.

Plumularia dolichotheca presents several very unusual characters. It is, with the exception of *Plumularia frutescens* of the European shores, the only Plumularian with which I am acquainted in which more than one hydrotheca is carried by one and the same internode. While in the present species some of the internodes of a hydrocladium carry as usual only one hydrotheca, others carry two, or even three. When two or more hydrothecæ are carried by a single internode, it is only the proximal hydrotheca which is subtended by a nematophore. This nematophore is supported on a small tubercle-like process of the internode, while the corresponding points below the more distal hydrothecæ show no trace of the tubercle, a fact which affords evidence that the absence of the nematophore is not due to its having been accidentally detached.

Under the name of *Plumularia cylindrica*, Kirchenpauer describes a species—also from anga—which in the form of the hydrothecæ and in the general habit of the colony approaches *Plumularia dolichotheca.* It differs from it, however, in every internode hydrothecal pinnæ carrying only one hydrotheca, and in the opposite instead of ate disposition of these pinnæ.

umularia dolichotheca was dredged off Zamboanga, Philippines, 30th January 1875, depth of 10 fathoms.

umularia insignis, n. sp. (Pl. II.).

ophosome.—Colony attaining a height of about eighteen inches, main stem fascicled, g off in all directions simple jointed branches, along whose entire length the hydro- pinnæ, about two-tenths of an inch in length, are alternately disposed. Hydro- deep conical, adnate by their entire height to the supporting internodes, which are ted from one another by an intervening much shorter internode, destitute of hydro- mesial nematophores situated one on the hydrothecal internode at the proximal side hydrotheca, and one on each of the intervening internodes.

nosome.—Gonangia situated on the hydrocladia-bearing branches, each at the base ydrocladium.

is very beautiful species is rendered especially striking by its large size and its -like ramification. The gonangia present in the specimen seem to be young, and to scarcely yet attained their ultimate form. Several specimens of a little isopodous cean continued to adhere to the stem, and are represented in the drawing.

ation 145, December 27, 1873, lat. 46° 40′ S., long. 37° 50′ E.; depth, 310 and thoms.

lumularia abietina, n. sp. (Pl. III.).

rophosome.—Colony attaining a height of about nine inches, main stem fascicled for distance from its root, and sending off scattered, usually simple jointed branches, carry alternate hydrothecal pinnæ, rather less than two-tenths of an inch in , and commencing from a point at some distance from the origin of the branch. othecæ deep conical, adnate by their entire height to the supporting internodes, which eparated from one another by an intervening much shorter internode, destitute of theca; a single mesial nematophore, borne by the hydrothecal internode at the proxi- ide of the hydrotheca, and another on each of the intervening internodes.

onosome.—Gonangia ovate, borne by the hydrocladia-bearing branches, each close to rigin of a hydrocladium.

he Hydroid here described comes very near to *Plumularia insignis*; indeed, so nearly d are the two forms, that we should almost be justified in regarding the difference een them as merely varietal.

Plumularia insignis, however, is altogether a larger and much more robust form, while the hydrocladia are longer and occupy a greater length of their supporting branches, extending from the distal extremity of these nearly to the base. In *Plumularia abietina*, on the other hand, a considerable portion of the branch towards its proximal end is destitute of hydrocladia.

The specimen had numerous individuals of an Avicula-like fry adhering to it, a feature which has been reproduced in the drawing.

Dredged off Prince Edward's Island, from a depth of 150 fathoms (?).

Plumularia stylifera, n. sp. (Pl. IV. figs. 1, 2).

Trophosome.—Colony attaining a height of about an inch and a half, stem simple monosiphonic, hydrocladia alternate, about one-tenth of an inch in length, and with the hydrotheca-bearing internodes usually separated by an intervening internode which does not carry a hydrotheca. Hydrothecæ rather large, adnate only by their base to the supporting internode, flanked on each side by a long slender process, which springs from the internode and carries a lateral nematophore on its summit; a single mesial nematophore borne by the hydrothecal internode at the proximal side of the hydrotheca, and another by the intervening internode.

Gonosome.—Gonangia springing from the hydrothecal internodes at the proximal side of the hydrotheca, ellipsoidal, with a truncated summit which opens by a lid, and with a pair of nematophores carried near its proximal end.

The great length of the process which supports the lateral nematophore on each side of the hydrotheca presents a striking feature. The present species, however, is not the only one in which this process attains a considerable length. It is nearly as long in the European *Plumularia catharina* and in other species closely allied to the latter, as well as in *Antennularia fascicularis* of the present Report.

Plumularia stylifera has many points of affinity with *Plumularia catharina*, which it resembles not only in the long style-like process which supports the lateral nematophore, but in the presence of a pair of nematophores on the proximal end of the gonangium, and in the general form of the hydrothecæ and their supporting pinnæ. Indeed, it differs from it mainly in its more delicate habit and shorter and more approximated hydrocladia, which are disposed alternately on the stem instead of being opposite, as in *Plumularia catharina*.

Dredged off Nightingale Island, Tristan d'Acunha, Station 135, from a depth of 100–150 fathoms.

Plumularia armata, n. sp. (Pl. IV. figs. 3, 4).

Trophosome.—Colony attaining a height of about two inches; stem monosiphonic irregularly and sparingly branched, divided into internodes, each of which carries a hydrotheca; hydrocladia alternate, rather more than one-tenth of an inch in length, arising one from every internode of the stem close to the base of a hydrotheca. Hydrothecæ deep, conical in front view, cylindrical in profile, adnate by somewhat more than half their height to the supporting internode, flanked on either side by a short tooth-like process, which carries a long lateral nematophore; a single mesial nematophore borne by the hydrothecal internode at the proximal side of the hydrotheca, and another at its distal side in the hydrocladia, while in the stem the single mesial nematophore is replaced in the distal portion of each internode by a pair of lateral nematophores.

Gonosome.—Female gonangia borne along the stem, each springing by a very short peduncle from a point opposite to the origin of a hydrocladium, large, ovate with truncated summit, carrying from base to summit along one side a single linear series of nematophores.

Male gonangia developed in the same colony with the female, and borne exclusively by the internodes of the hydrocladia, springing by a short peduncle from the internode at the proximal side of its hydrotheca, very much smaller than the female, crescentic in form, destitute of nematophores, and with rounded summit curved towards the supporting internode.

Plumularia armata is a small and delicate Hydroid. The condition of the gonosome is very exceptional. The nematophores, which are developed on the outside of the female gonangium, constitute in themselves a very unusual and striking feature. These extend in a continuous series along the course of the blastostyle, with which they communicate through perforations in the chitinous walls of the gonangium. In order to allow of this communication, the blastostyle is thrown out of the axis of the gonangium, and lies against the inner surface of its walls, immediately under the series of nematophores.

In *Sciurella indivisa* of the present Report we also find the gonangium carrying numerous nematophores. Here, however, the nematophores are not arranged in a single series, but form symmetrically disposed groups.

Striking, however, as is the development of gonangial nematophores in these instances, it is only an extreme case of what occurs in several other Eleutheroplean Plumularidæ, as in *Plumularia catharina* and allied species, and in *Antennularia fascicularis*, and the two species of *Schizotricha* described in the present Report. In all these a pair of nematophores is developed from the base of the gonangium, and there communicates with the proximal end of the blastostyle.

Another very exceptional, though by no means unique character, is found in the presence of both male and female gonangia in the same colony. These differ not only in form but in situation. The large ovate female gonangia, with their series of parietal nematophores, are borne exclusively on the stem, which, like the hydrocladia, is composed of a series of hydrotheca-bearing internodes, while the very much smaller crescentic male gonangia are confined to the hydrocladia.

Notwithstanding the many exceptional characters of this curious Plumularian, I believe it will be better to keep it in the genus *Plumularia*, rather than construct for it a new one.

Under the name of *Plumularia obconica*, Kirchenpauer describes a Plumularian from the Gulf of St. Vincent, Australia, which in many respects resembles the present species. Its female gonangium carries, as in this, on the outer surface of its walls, a longitudinal series of nematophores. Like *Plumularia armata*, also, the species is monœcious, carrying male and female gonangia in the same colony, while the main stem is divided into internodes, each carrying a hydrotheca, as in *Plumularia armata*. It differs, however, from *Plumularia armata* in its shallower hydrotheca, with plicated margin, and in the conical roof of its female gonangium, while the stem is unbranched, and carries the hydrocladia in such a way as to give them an obviously secund disposition. Kirchenpauer, moreover, describes the nematophores of the trophosome as monothalamic, those of the gonosome being of the usual bithalamic type. In *Plumularia armata* both sets of nematophores are bithalamic.

The collection contains but a single specimen of *Plumularia armata*. It was dredged at Station 163A, off Port Jackson; depth, 30–35 fathoms; bottom, red clay.

Antennularia, Lamk.

Antennularia, Lamarck, Hist. Nat. des An. sans Vert., 1st ed., 1816.
Nemertesia, Lamouroux, Hist. des Pol. Coral. flex., 1816.

Antennularia fascicularis, n. sp. (Pl. IV. figs. 5, 6).

Trophosome.—Colony attaining a height of upwards of three inches; stem thick, sub-dichotomously branched, formed of a multitude of coalesced tubes, which give off on all sides irregularly scattered hydrocladia, which carry the hydrothecæ on alternate internodes, and are about two-tenths of an inch in length. Hydrothecæ rather large, campanuliform, adnate by their base only to the supporting internode, flanked on each side by a long style-like process, which supports on its summit a lateral nematophore; one mesial nematophore carried by the hydrothecal internode near its proximal end, and three by the intervening internode.

Gonosome.—Gonangia springing laterally from the hydrothecal internodes each at the proximal side of a hydrotheca, obovate, supported on a short stalk and carrying a pair of nematophores close to its proximal end.

A more extended comparison of *Antennularia antennina* of our own shores, in which the hydrocladia are verticillate, with those forms in which they are more or less scattered, has led me to regard this difference as of less systematic importance than I had formerly believed, and has induced me to assign to it a specific rather than a generic value. When, therefore, no other difference of greater importance exists, I believe it will be best to follow the earlier systematists, and combine all such forms under a single genus, of which the well-known *Antennularia antennina* may be taken as the type.

The hydrocladia of *Antennularia fascicularis* spring from the outer tubes of the polysiphonic stem, each hydrocladium being supported on a short process from the tube, and having at its proximal end two short internodes followed by a long one, all three destitute of hydrothecæ. In the deep hydrothecæ, *Antennularia fascicularis* further contrasts with the typical *Antennulariæ*, whose small shallow hydrothecæ are, as a rule, characteristic of the genus; while the position of the gonangia on the hydrothecal internodes, instead of being borne in the axils of the hydrocladia, affords another distinctive feature.

The proximal end of the specimen in the collection had been broken off, so that nothing can be asserted with exactness regarding the height attainable by the colony or the characters of the hydrorhiza.

Antennularia fascicularis is wanting in the graceful habit by which most of the Plumularidæ are characterised, the thick strongly fascicled stem, and the irregularity of the fine hair-like ramuli, giving it a somewhat inelegant habit, which contrasts with the lightness and grace of most other species.

Dredged off Nightingale Island, Tristan d'Acunha, from a depth of 100–150 fathoms.

Sciurella, nov. gen.

Name, a diminutive noun formed from *Sciurus*, a squirrel, in allusion to the squirrel-tail-like disposition of the hydrocladia.

GENERIC CHARACTER. *Trophosome.*—Hydrocladia not disposed in pinnæ, but springing from many points round the circumference of chord-like stems.

Gonosome.—Gonangia situated in the axils of the hydrocladia, provided with symmetrically disposed horn-like processes, and enclosing a ramified blastostyle, whose branches are in connection with moveable nematophores distributed over the surface of the gonangium.

The species on which the genus *Sciurella* has been founded has the general aspect of *Antennularia antennina*. From this, however, it differs not only in the disposition of the hydrotheca-bearing ramuli, but in the much more important character presented by the remarkable gonangia with their ramified blastostyle, their horn-like processes, and the nematophores carried on their walls. These nematophores belong to the ordinary moveable type, and communicate through perforations in the walls of the gonangium with the prolongations of the ramified blastostyle.

Sciurella indivisa, n. sp. (Pl. V.).

Trophosome.—Colony attaining a height of ten inches; stem simple, monosiphonic, springing in clusters from the hydrorhiza; hydrocladia closely set, about two-tenths of an inch in length, arranged in four longitudinal alternating series, which extend from the summit of the stems to within a short distance of the base. Hydrothecæ deep, nearly cylindrical, adnate by their entire height to the supporting internode, every internode of the hydrocladium carrying a hydrotheca, and having, in addition to the lateral nematophores, a single mesial nematophore near its proximal end.

Gonosome.—Gonangia in pairs from the axils of the hydrocladia, urn-shaped in front view, with two symmetrically placed hollow lateral processes near the distal end; gonangial nematophores carried by the lateral processes, by the summit of the gonangium, and by its sides near the base.

As already stated (*see* p. 22), I am not disposed to regard a scattered or multiserial disposition of the hydrocladia as affording sufficient grounds for generic separation from those forms of *Antennularia* in which the hydrocladia are verticillate. While, however, the disposition of the hydrocladia in *Sciurella indivisa* would thus not in itself afford a character by which this species could be generically separated from *Antennularia*, such a character is found in the remarkable form of the gonangia, with their branching blastostyle and the nematophores to which their walls give support.

The general resemblance of *Sciurella indivisa* to *Antennularia antennina* is so close, that, without the aid of a lens, a specimen of one of these hydroids might be easily mistaken for the other. The gonangium, though urn-shaped when viewed in front, is compressed laterally, and when viewed in profile is seen to have its axis curved backwards nearly in a semicircle.

The ramification of the blastostyle in the gonangium presents considerable symmetry, and was similar in every instance examined. A strong branch is sent off on each side into the lateral projections, and each of these branches sends out three short processes and one long one, which all pass directly to the perforations in the walls of the gonangium, in order to communicate with the corresponding nematophores which lie free on the outer surface of the walls. The short processes pass to nematophores which lie near the distal end of the gonangium, while the long processes pass down, one on each side, to communicate with two nematophores situated near the base of the gonangium.

The deep hydrothecæ of *Sciurella indivisa* contrast with the small shallow hydrothecæ by which most species of *Antennularia* are characterised.

Dredged off Somerset Island Cape York, Torres Strait; 5–10 fathoms.

Acanthella, nov. gen.

Name, a diminutive noun formed from ἄκανθα, a thorn, in allusion to the spine-bearing terminations of the branches.

Generic Character. *Trophosome.*—Hydrocladia pinnately disposed; hydrocladia-bearing branches terminating in simple jointed prolongations in which the places of the hydrocladia are taken by spine-like appendages.

Gonosome not known.

The genus *Acanthella*, so far as regards its trophosome, represents among the Eleutheroplean section of the Plumularidæ the genus *Acanthocladium* of the Statoplea. The peculiar terminations of the branches are essentially the same in both, and the lateral spines which these support are in both cases the morphological equivalents of hydrocladia. No part of the gonosome was present in the specimens of the only species referrible to *Acanthella*.

Acanthella effusa, Busk, sp. (Pl. VI.).

Plumularia effusa, Busk, Voyage of the "Rattlesnake," 1852, vol. i. p. 400.

Trophosome.—Colony attaining a height of twelve inches; main stem springing from a dense mass of entangled filaments, monosiphonic, giving off a multitude of scattered subdivided branches, which carry the hydrocladia, every subdivision ending in a spine-like continuation which is composed of numerous internodes, each internode supporting two or more stout blunt spines; hydrocladia one-tenth of an inch in length. Hydrothecæ pitcher-shaped, with entire margin, adnate by their whole height to the rachis; mesial nematophore single, springing from a point close to the base of the hydrotheca, lateral nematophores springing from points close to its margin; hydrocladial internodes separated from one another by a very well-marked joint, and each carrying a hydrotheca.

Gonosome not known.

Acanthella effusa is a remarkable and beautiful species, and, like *Acanthocladium* affords in the curious terminations of its branches an example of the extent to which the hydrocladia may be modified, and yet allow of the recognition of their homological significance.

A very obvious transition may be traced from the simple spines, which occur towards the distal extremity of the branch, backwards into the true hydrotheca-bearing ramuli. In fact some of the posterior or more proximal spines still carry near the base a single hydrotheca, with its mesial and lateral nematophores. These spines are also borne on the summit of a thick process from the internode, while the more distal spines are not only quite destitute of hydrothecæ, but are directly confluent by their base with the internodes which carry them. In the angle between these more distal spines and the supporting internode, two small nematophores of the ordinary Eleutheroplean type are developed.

The close proximity of the mesial nematophore to the base of the hydrotheca, as seen in the present species, is also a very unusual feature in the Eleutheroplea.

Kirchenpauer[1] describes and figures a Plumularian brought by von Martens from the Philippine Islands. He refers it to the *Plumularia effusa* of Busk, a species obtained in Torres Strait during the exploratory voyage of the "Rattlesnake."[2] In the form of the hydrothecæ, and of their supporting pinnæ, and in the form and arrangement of the nematophores, the species figured by Kirchenpauer agrees closely with that here described. No notice, however, is taken of the series of spine-bearing internodes in which the branches of *Acanthella* terminate. Specimens of the present species from the collection of the Challenger have been examined by Mr. Busk, and referred by him to the *Plumularia effusa* of the voyage of the "Rattlesnake," and an opportunity he has given me of comparing the Challenger Hydroid with authentic specimens of his *Plumularia effusa*, has convinced me of the justice of this identification.

Acanthella effusa was dredged off Cape York, Torres Strait, and also from reefs off Zamboanga, at a depth of 10 fathoms.

Schizotricha, nov. gen.

Name from σχίζω, to divide, and θρίξ, a hair, in allusion to the bifurcation of the hydrocladia.

GENERIC CHARACTER. *Trophosome.*—Hydrocladia pinnately disposed, once, twice, or oftener bifurcating.

Gonosome—Gonangia springing from the hydrocladia.

The genus *Schizotricha* is essentially characterised by the bifurcation of its hydrotheca-bearing ramuli. The collection contains two species, in one of which the ramuli bifurcate only once, while in the other, three, four, or probably a greater number of bifurcations are present.

Schizotricha unifurcata, n. sp. (Pl. VII. figs. 1–3).

Trophosome.—Colony attaining a height of about five inches; stem irregularly branched, fascicled, rooted by a dense mass of entangled filaments; hydrocladia alternate, about seven-tenths of an inch in length, dividing each into two similar branches at a short distance from its origin. Hydrothecæ with even margin, rather deep, adnate to the supporting internode by their entire height; besides the pair of lateral nematophores, there is a single mesial nematophore carried by the internode near its proximal end; a hydrotheca without nematophores carried in the angle of the bifurcation.

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[1] Kirchenpauer, *loc. cit.*, Band vi.

[2] Voyage of "Rattlesnake," vol. i. p. 400.

Gonosome.—Gonangia carried by each branch of the hydrocladia near to the bifurcation, pyriform, supported on a short peduncle, and with a basal segment which carries a pair of laterally placed nematophores.

This fine species forms wide flabelliform tufts with rather rigid stems, and with the hydrocladia nearly an inch in length. The hydrocladia are each supported on a short process of the stem; to this is articulated the first segment of the hydrocladium; this segment is very short, is destitute of hydrotheca, and is immediately followed by a long segment in which the bifurcation takes place, and which carries in the angle of bifurcation a hydrotheca without nematophores. One branch of the bifurcation always commences by a short internode destitute of hydrotheca; every other internode of the branches carries a hydrotheca.

Besides the form here described, there occurs also a variety (see fig. 3), in which the hydrothecal ramuli scarcely exceed half the length attained by these ramuli in the typical form.

The typical form was dredged in Christmas Harbour, Kerguelen, from a depth of 100 fathoms. The variety with short hydrocladia was dredged also off Kerguelen Island, from a depth of 10 to 60 fathoms.

Schizotricha multifurcata, n. sp. (Pl. VII. figs. 4, 5).

Trophosome.—Colony attaining a height of about nine inches; stem sparingly branched, fascicled, rooted by a mass of entangled filaments; hydrocladia alternate, attaining about four-tenths of an inch in length, bifurcating three, four, or a greater number of times. Hydrothecæ with even margin adnate to the internode by their entire height, flanked by a pair of lateral nematophores, and also subtended by a similar pair of nematophores on the same internode, a hydrotheca without nematophores carried in the angle of every bifurcation.

Gonosome.—Gonangia carried by the internodes of the hydrocladia, each springing from a point situated laterally, and just below a hydrotheca, pyriform, supported on a very short peduncle, and having a wide basal segment which carries a pair of nematophores.

This is a very graceful species, with flexile stems much longer and less profusely branched, and with shorter hydrocladia than in *Schizotricha unifurcata*. A remarkable feature in the specimen examined consisted in the hydrothecal internodes, carrying at the proximal side of the hydrotheca a pair of laterally situated nematophores, instead of the azygous mesial nematophore usual in the Eleutheroplean Plumularidæ. The gonangia also, besides the two nematophores which were always present on its basal segment, often carried here a third one. This fact, however, scarcely seems to be constant.

In every bifurcation one of the branches is connected with the internode from which it springs, by a short internode destitute of hydrotheca, but carrying a pair of nematophores.

Here, as in *Schizotricha unifurcata*, the first bifurcation takes place in the second segment of the hydrocladium, this segment carrying a hydrotheca without nematophores in the angle of the bifurcation, and being preceded by a very short segment destitute of hydrotheca.

Dredged at Station 151, February 7, 1874, off Heard Island; depth, 75 fathoms; bottom, mud.

Polyplumaria, G. O. Sars.

Polyplumaria, G. O. Sars, Forhandl. Vidensk. Selsk. i. Christiania, 1873.
Diplopteron, Allman, Trans. Zool. Soc. Lond., 1873.

GENERIC CHARACTER. *Trophosome*.—Hydrocladia each with an accessory hydrotheca, bearing ramulus, which springs from its proximal internode.

Gonosome.—Gonangia borne by the basal segment of the primary pinnæ.

In a report on the Hydroids collected during the expeditions of H.M.S. "Porcupine," read at a meeting of the Zoological Society of London in February 1873, I described as a new genus and species, under the name of *Diplopteron insigne*, a very beautiful Plumularian dredged off the north-west coast of Spain, from a depth of 364 fathoms, during one of these expeditions.[1]

G. O. Sars had, however, in the same month, but a few days earlier, described under the generic name of *Polyplumaria*, a Hydroid from the Norwegian Seas, which I believe must be generically associated with the Hydroid of the "Porcupine."[2] The priority of description thus lies with Sars, and though he does not appear to me to have seized on the essential characters of the genus, the name *Diplopteron* must sink into a mere synonym of *Polyplumaria*.

I have here modified the diagnosis of *Diplopteron* as originally given, a diagnosis which, founded as it was on a single species, was too exclusive to admit forms which ought not to be generically separated. In the three species of which the genus *Polyplumaria* now consists, the most striking feature is the accessory ramulus, to which the hydrothecal pinnæ give origin. This ramulus springs from every hydrothecal pinna near to its origin, and is itself composed of internodes which carry hydrothecæ similar to those of the pinna from which it springs.

Sars, it is true, does not describe the accessory ramulus as constant, but as it was never wanting in any of the specimens examined by me, being, on the contrary, always very characteristic, I cannot but regard its absence from some of the branches in Sar's specimens as accidental.

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[1] Report on the Hydroids collected during the expeditions of H.M.S. "Porcupine." *Trans. Zool. Soc. Lond.*, vol. viii. p. 8.

[2] G. O. Sars, Bidrag til Kundskaben om Norges Hydroida. *Forhandl. Vidensk. Selsk. i. Christiania*, 1873.

Polyplumaria pumila, n. sp. (Pl. IV. figs. 7, 8).

Trophosome.—Colony attaining a height of one or possibly two inches; stem strongly fascicled and giving off opposite pinnæ, which do not carry hydrothecæ, and are also fascicled; hydrocladia alternate, scarcely exceeding one-twentieth of an inch in length, borne on the main stem and primary pinnæ, each giving off its accessory ramulus from a point close to the base of the proximal hydrotheca; hydrothecal internodes continuous. Hydrothecæ cylindrical, rather distant, adnate only by their base to the rachis, and with the internodes which support them carrying besides the lateral nematophores a single mesial nematophore at the proximal, and another at the distal side of the hydrotheca.

Gonosome.—Gonangia pyriform, with obliquely truncated summit.

The specimens were fragmentary, and did not afford sufficient evidence of the size attained by the perfect colony; but it is probable that it reaches a height of between one and two inches. It is thus a very much smaller, and altogether more delicate species than the *Diplopteron insigne* of the "Porcupine," which attains a height of about six inches.

The accessory ramuli carry one, two, or three (possibly in some cases more) hydrothecæ, and have a rather long proximal internode, which is always destitute of hydrotheca.

I was unable to find in the present species the second pair of minute lateral nematophores which in *Polyplumaria* (*Diplopteron*) *insignis* is developed at the distal side of the hydrotheca. *Polyplumaria pumila* is further distinguished from *Polyplumaria insignis* by the more cylindrical form of the hydrothecæ, which do not present the slightly everted margin which gives a somewhat campanulate form to the hydrothecæ of *Polyplumaria insignis*. All the known species are doubly pinnate.

The gonangium is borne on a short cylindrical peduncle, and has a truncated summit and a short transverse segment at its very much contracted base.

All the species as yet discovered are inhabitants of the deeper sea zones.

Dredged at Station 75, July 2, 1873; lat. 38° 37′ N., long. 28° 30′ W.; depth, 450 fathoms; bottom, sand.

Heteroplon, nov. gen.

Name, from ἕτερος, dissimilar, and ὅπλον, a weapon, in allusion to the presence of two different kinds of nematophores.

Generic Character. *Trophosome.*—Hydrocladia pinnate; hydrothecal internode with the lateral nematophores moveable, and with a mesial fixed spine-like nematophore below the hydrotheca.

Gonosome not known.

The genus *Heteroplon* combines the characters of the Eleutheroplean with those of the Statoplean Plumularidæ. The hydrothecæ are flanked each by a pair of moveable nematophores of precisely the same kind as in the typical Eleutheroplea, while the mesial nematophore which lies below the hydrotheca is fixed, and resembles that of the ordinary Statoplean genera in all respects, except in the fact of its being quite detached from the hydrotheca, and in the presence of an imperfect septum close to its distal extremity, thus showing a tendency to the bithalamic form of the Eleutheroplean nematophore.

In all other important points the species on which the genus *Heteroplon* has been founded presents the essential features of the Eleutheroplea, with which, notwithstanding the presence of a fixed nematophore, it must be associated.

Heteroplon pluma, n. sp. (Pl. VIII. figs. 1–3).

Trophosome.—Colony attaining a height of about four inches; stems sparingly branched monosiphonic, springing in groups from a creeping stolon; hydrocladia about one-fourth of an inch in length, carrying a hydrotheca on every internode, a hydrotheca also carried by the stem close to the origin of every hydrocladium, stem with groups of two or three short internodes at irregular intervals. Hydrothecæ with entire margin, adnate to the rachis by about three-fourths of their height; lateral nematophores borne each on a short process of the hydrothecal internode; hydrothecal internode also carrying a single moveable nematophore at the distal side of the hydrotheca; mesial fixed nematophore close to the proximal end of the internode, in the form of a short, blunt, somewhat curved spine, with an oblique terminal orifice.

The hydrothecal pinnæ of the present species are closely set along the stem, and the general habit of the colony is more that of an *Aglaophenia* than of a *Plumularia*—a feature which is not without interest when viewed in connection with the presence of the fixed nematophore. Notwithstanding, however, the presence of a fixed nematophore, and the Aglaophenia-like habit of the species, the whole assemblage of characters is so decidedly that of the Eleutheroplean Plumularidæ, that there need be no hesitation in assigning it to this group.

The specimen was dredged at Station 162, April 2, 1874, off East Moncoeur Island, Bass Strait, from a depth of 38 to 40 fathoms; bottom, sandy.

Sub-family—STATOPLEA.

Section—PHYLACTOCARPA.

Acanthocladium, nov. gen.

Name from ἄκανθα, a thorn, and κλάδος, branch, in allusion to the spiny terminations of the branches.

GENERIC CHARACTER. *Trophosome.*—Distal portion of branches destitute of hydrocladia, whose places are taken by a long, spine-like appendage on each internode.

Gonosome.—Phylactocarp replacing a hydrocladium, and consisting of a rachis with two series of pinnately-disposed, alternate, free ribs, each rib carrying near its base a hydrotheca. Gonangia springing from the rachis.

The remarkable mode in which the branches of *Acanthocladium* terminate, recalls the very similar condition presented by the genus *Acanthella*; but while *Acanthocladium* is a Statoplean form, *Acanthella* belongs to the Eleutheroplea. The gonosome of *Acanthella* is unknown, but the specimens of *Acanthocladium huxleyi* the only species of the genus as yet discovered, are, on the contrary, abundantly provided with this important element of the colony. The phylactocarp of *Acanthocladium* belongs to the same type as that of the *Aglaophenia distans* and *Aglaophenia bispinosa* of the Gulf Stream Report,[1] every rib carrying, as in these last, near its base a modified hydrotheca. The distal portion of the rib is in all these cases the greatly modified mesial nematophore of this hydrotheca, while the proximal portion is a peduncle which springs from the rachis and supports the modified hydrotheca and its appendages. (*See* p. 11).

Acanthocladium huxleyi, Busk, sp. (Pls. IX. and XX. figs. 1–3).

Plumularia huxleyi, Busk, Voyage of the "Rattlesnake," vol. i. p. 395, 1852.

Trophosome.—Colony attaining a height of fifteen inches; stem fascicled, springing from a dense cushion of fine entangled tubes, undulated, giving off pinnately-disposed alternate simple branches about two inches in length, which carry the hydrocladia and terminate each in a jointed prolongation which is composed of numerous (twelve to sixteen) internodes, every internode carrying a slightly curved spine, which is supported on the extremity of a short process from alternate sides of the internode, and carries two rows of small cup-shaped nematophores; hydrocladia alternate, short, about one-tenth of an inch in length. Hydrothecæ approximated, wide and rather shallow, with an anterior parietal fold and a very short intrathecal ridge; orifice of hydrotheca with its plane parallel to the axis of the short internode, margin crenate; mesial nematophore adnate to the entire height of the hydrotheca wall, and then continued as a long, free, curved spine which arches over the orifice of the hydrotheca; lateral nematophores short, crescentic.

Gonosome.—Phylactocarps developed in a continuous series on each side of the branches near their middle, every series having the unmodified hydrocladia at its proximal and usually also at its distal side; costæ of phylactocarp twenty-six to thirty in number springing alternately from the sides of the rachis, over which they arch, each carrying a double row of cup-shaped nematophores, and at about one-third of its length from the base, a single small deep hydrotheca. Gonangia ovoid, springing from the rachis, each close to the origin of a costa.

The long flexile undulating stem and simple plume-like branches of *Acanthocladium*

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[1] Allman, Report on the Hydroida collected during the exploration of the Gulf Stream, by L. F. De Pourtalès, United States Coast Survey, 1877, p. 44, pl. xxvi. figs. 1–8, and p. 46, pls. xxvii., xxviii.

huxleyi confer upon this beautiful species an aspect which in gracefulness is perhaps not surpassed by any other Plumularian.

The hydrothecæ are remarkable from the way in which the orifice lies in a plane parallel to the axis of the supporting internode, instead of being, as in most cases, nearly at right angles to it. The internodes are very short, and the hydrothecæ are consequently brought unusually near to one another. The deep serration of the hydrotheca margin usual in the Statoplean section, here gives place to a shallow crenation, and the very long curved continuation of the mesial nematophore beyond the orifice contributes still further to the singular aspect of the hydrotheca. In the front of the hydrotheca is a strong parietal fold, having some resemblance to an anterior intrathecal ridge, while the true intrathecal ridge is nearly obsolete.

The stem and branches, notwithstanding their slenderness, are polysiphonic, the accessory tubes ceasing a little before the distal termination of the branches, which then become monosiphonic for the remainder of their course.

The gonophore can be seen through the walls of the gonangium to be encircled just below its summit by a wreath of refringent spherules, similar to those to which Kirchenpauer first drew attention in the gonophore of his macrorhynchial section of *Aglaophenia*. He believed them to be confined to this group, and incorrectly regarded them as ova.[1]

The phylactocarps are for the most part longer than the hydrocladia, and with the symmetrical arrangement of their parts are objects of great beauty, while they are full of interest in the evidence they afford of the extent to which various parts of an organism may become modified in order to fit them for a change of function.[2]

Mr. Busk has identified the present species with the *Plumularia huxleyi* of the voyage of the "Rattlesnake,"[3] and a comparison of the Challenger Hydroid with authentic specimens from the collection made during that voyage, has enabled me to confirm this determination.

Dredged at Station 188, September 10, 1874, lat. 9° 59′ S., long. 139° 42′ E.; depth, 28 fathoms; bottom, mud. Also at Station 190, September 12, 1874, lat. 8° 56′ S., long. 136° 5′ E.; depth, 49 fathoms; bottom temperature 23°·9 C.; bottom, mud.

Aglaophenia, Lamouroux (in part).

Plumularia, Lamarck, Hist. Nat. des An. sans Vert., 1815.
Aglaophenia, Lamouroux, Hist. des Pol. Coral. flex., 1816.

Aglaophenia macgillivrayi, Busk, sp. (Pls. X. and XX. figs. 4–6).

Plumularia macgillivrayi, Busk, Voyage of the "Rattlesnake," vol. i. p. 400, 1852.

Trophosome.—Colony attaining a height of upwards of fifteen inches; stem fascicled,

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[1] Kirchenpauer, *loc. cit.*, Band v., Ueber die Hydroidenfamilie Plumularidæ, p. 16.

[2] See general remarks on the morphology of the Phylactocarp, p. 10.

[3] Busk, Voyage of the "Rattlesnake," vol. i. p. 395.

sending off closely-set opposite primary pinnæ, which are destitute of hydrothecæ, but carry from end to end the proper hydrotheca-bearing pinnæ, which are about one-tenth of an inch in length, alternately disposed, and borne also by the main stem in the intervals of the primary pinnæ. Hydrothecæ closely approximated, rather deep, with a well-marked intrathecal ridge, margin entire, sigmoidally curved; mesial nematophore adnate by its whole length to the hydrotheca, with its sides parallel in profile, diverging from below upwards in front view, its distal end terminating close to the margin of the hydrotheca by a wide orifice, a short distance behind which is a transverse septum-like fold; lateral nematophores wide, overtopping the hydrotheca; hydrothecal internode with strong obliquely-directed intra-cauline ridges.

Gonosome.—Costæ of phylactocarp intimately fused together, so as to form a long nearly cylindrical, completely closed corbula, whose sides support seven or eight transverse series of slightly elevated ramified ridges, with every branch supporting a wide cup-shaped nematophore, and with a strong spur-like nematophore at the base of each series.

Aglaophenia macgillivrayi presents many features in which it differs from the typical *Aglaopheniæ*. Its doubly pinnate ramification affords in itself a character which contrasts markedly with the ramification of nearly all the other known species. This character shows itself in the thick, strongly-fascicled stem being closely set with opposite pinnæ, which are themselves destitute of hydrothecæ, but give support to the proper hydrocladia, which are disposed in alternate pinnæ from end to end of the opposite or primary pinnæ. Here and there the primary pinnæ become developed into long branches, which then repeat in all respects the ramification of the stem. The absence of true serration in the margin of the hydrotheca, and the bithalamic condition conferred on the mesial nematophore by the presence of an imperfect septum, are other important points in which *Aglaophenia macgillivrayi* differs from the typical *Aglaopheniæ*; while in the corbula, with its parietal ramifying ridges, we find a still further distinctive feature.

A comparison of the Plumularidan here described with authentic specimens of *Plumularia macgillivrayi*, Busk, brought home by the "Rattlesnake,"[1] establishes the identity of the "Rattlesnake" species with that of the Challenger. Kirchenpauer places it in his special section or sub-genus of *Aglaophenia*, to which he gives the name of *Pachyrhynchia*, and which he bases on the supposed excessive width of the mesial nematophore, believing the nematophore to surpass in this respect the hydrotheca to which it belongs.[2] I am unable, however, to accept this character as a ground for the establishment of a distinct group, more especially as its reality is not borne out by an examination of well-preserved specimens, and Kirchenpauer's figures seem to have been made from specimens whose bad state of preservation rendered them deceptive. The mesial

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[1] Voyage of H.M.S. "Rattlesnake," vol. i. p. 400.

[2] Kirchenpauer, *loc. cit.*, p. 20.

nematophore of *Aglaophenia macgillivrayi*, though large, is very far from attaining the width of the hydrotheca to which it is attached, and does not, either in size or form, depart so much from the normal condition as to justify us in assuming it as the ground on which to base a distinct section of the phylactocarpal *Plumularidæ* (*Aglaophenia* of Kirchenpauer in its widest sense); and the remaining small number of species which Kirchenpauer places in his *Pachyrhynchia* do not seem to afford any stronger grounds than *Aglaophenia macgillivrayi* for the creation of a separate systematic group. In the long corbula, with its closely adnate costæ and parietal ridges, and in the even margin of the hydrotheca, more important differences may perhaps be recognised, but still nothing to demand a separation from the other members of the genus.

A closely allied if not identical form—the *Aglaophenia cupressina* of Lamouroux, has been identified by Kirchenpauer with a Plumularian brought by Semper from the Pelew Islands, where, according to Semper, it is known by a vernacular name suggested by its stinging properties. Another of the Challenger species (*Lytocarpus secundus*, see below, p. 42), likewise brought by Semper from the Pelew Islands, would seem, according to the report of it given by this zoologist to Kirchenpauer, to be also one of those Hydroids whose formidable stinging powers cause it to be dreaded by the natives.

Aglaophenia macgillivrayi attains a size greater than that of any other *Aglaophenia* with which I am acquainted. Though the specimen from which the drawing has been made had lost a portion of its proximal end, what remains of the colony measures in height fifteen inches.

Dredged at Zamboanga, Philippines, 30th January 1875, from a depth of 10 fathoms.

Aglaophenia filicula, n. sp. (Pl. XI. figs. 1–6).

Trophosome.—Colony attaining a height of about three inches; stem monosiphonic, simple, rooted by a creeping tubular fibre; hydrocladia about one-fourth of an inch in length, alternate. Hydrothecæ deep, thimble-shaped, margin serrated, with the median tooth slightly longer than the lateral teeth; intrathecal ridge near the base of the hydrotheca, extending obliquely forwards and upwards; mesial nematophore adnate to the walls of the hydrotheca for about three-fourths of their height, and then becoming free as a beak-like process which scarcely overtops the margin; lateral nematophores tubular, overtopping the margin of the hydrotheca.

Gonosome.—Corbulæ somewhat crescentic, with about seven pairs of costæ, which are adnate to one another by their edges, with a row of tubular denticles at the lines of junction, and with a spur-like denticle at the proximal end of each row; a single free costa with dentated edges at the proximal end of the corbula.

Other corbulæ having the costæ all free occur in the same colony.

The simple stems of *Aglaophenia filicula* spring from the creeping hydrorhiza, in groups of closely approximated plumes. The mesial nematophore is provided with an imperfect septum near its distal extremity. The most remarkable fact, however, connected with the species is the occurrence of two different forms of corbula—a closed and an open—in the same colony. The closed corbula is rather short, and with its rachis so curved as to give it a somewhat crescentic form, with the concavity looking downwards. The curvature of the open corbula is less marked. In the open form the costæ are entirely distinct from one another; they are oval in outline, each margin set with tubular denticles, and every costa having a tubular spur-like denticle at its base. On the proximal margin of every costa in the open corbula, and close to its origin, is a slit-like aperture which leads into its cavity.

I am unable to assign a meaning to the presence of two different kinds of corbula in one and the same colony, and I do not know of a similar occurrence in any other species. That the two kinds of corbula are not different stages in the development of a single form would appear from their similarity in size, and the apparently mature condition of both, with their thick chitinous periderm; nor is it likely that at the time of maturity the closed corbula had become converted into the very differently formed open one by a process of dehiscence. Though in none of the open corbulæ could I find gonangia, it is yet possible that the difference may indicate a difference of sex. It is also possible that the open form may be an abnormal and imperfect condition of the corbula, not essential to the species, or universally occurring in it. With this uncertainty I have deemed it better not to include the presence of two forms of corbula as an essential character in the diagnosis of the species.

Aglaophenia filicula is an inhabitant of the deeper sea zones, having been dredged along with *Aglaophenia acacia*, at Station 75, July 2, 1873, lat. 38° 37′ N., long. 28° 30′ W.; depth, 450 fathoms; bottom, sandy.

Aglaophenia attenuata, n. sp. (Pl. XI. figs. 7–9).

Trophosome.—Colony attaining a height of about two inches; stem slender, monosiphonic, slightly and irregularly branched; hydrocladia very short, scarcely exceeding one-twentieth of an inch in length, alternate. Hydrothecæ closely approximate, deep, margin deeply dentate, with the mesial tooth bifid, anterior wall depressed just below the margin; intrathecal ridge well marked, extending transversely across the hydrotheca, at the junction of the lower and middle third of its walls; mesial nematophore stout, adnate to the walls of the hydrotheca for somewhat more than half their height, and then extending as a short, thick, free beak, which does not reach the margin of the hydrotheca; lateral nematophores stout, reaching the level of the hydrotheca margin.

Gonosome.—Corbula open, with about seven pairs of costæ, which are quite distinct from one another, and carry a row of tubular denticles on each margin; rachis with a spur-like denticle at the base of each costa.

Aglaophenia attenuata is a small and delicate species. The anterior bifid tooth of the hydrotheca and the open corbula afford good diagnostic characters. The spur-like nematophores at the base of the costæ are well developed.

A comparison of the open corbula of *Aglaophenia attenuata* with the proper Lytocarpal phylactocarp, as, for example, that of *Lytocarpus myriophyllum*, or of *Lytocarpus racemiferus*, and *Acanthocladium huxleyi* of the present Report will show that the mere fact of the costæ not being adnate by their edges affords no sufficient ground for generic separation from *Aglaophenia*, more especially as in one species at least (*Aglaophenia filicula*, see p. 36) closed and open corbulæ are borne by the same colony; in *Aglaophenia*, however, the costæ of the corbula, whether open or closed, are always more or less in the form of flat serrated leaflets, without hydrothecæ or other appendages; while in such open forms of phylactocarp as occur in the genera *Lytocarpus* and *Acanthocladium* the costæ are either long, curved, rod-like or sabre-shaped appendages, each carrying a hydrotheca, or are in the form of a series of strong spines without hydrothecæ, or are simply replaced by a series of large nematophores.

Dredged in Simon's Bay, Cape of Good Hope; depth, 10–20 fathoms.

Aglaophenia acacia, n. sp. (Pl. XII. figs. 1–4).

Trophosome.—Colony attaining a height of about six inches; stem monosiphonic, pinnately branched, branches opposite or sub-opposite, rather distant, carrying the hydrocladia, which are about two-tenths of an inch in length, and are also borne by the main stem in the intervals of the branches. Hydrothecæ deep, with deeply serrated margin, intrathecal ridge very short, situated just above the fundus of the hydrotheca; mesial nematophore adnate to the wall of the hydrotheca for about one-half their height, and then terminating as a free short spine which does not reach the level of the hydrotheca margin; lateral nematophores stout, slightly overtopping the margin.

Gonosome.—Corbulæ rather short and deep, with about six pairs of closely adnate costæ.

The habit of *Aglaophenia acacia* is somewhat loose and spreading. The main stems continue unbranched for four or five inches from the root, and then give off opposite or nearly opposite branches, which confer on the species a very distinctive aspect. The disposition of the primary branches is truly pinnate, while these again carry the pinnately disposed hydrocladia. The ramification is thus properly bipinnate, though the distances between the primary branches and between the hydrothecal ramuli give to it an aspect very different from that of *Aglaophenia macgillivrayi*, and of other bipinnate *Plumularidæ* with their closely approximated branches and hydrocladia.

Aglaophenia acacia is a deep-water species, having been dredged along with *Aglaophenia filicula*, at Station 75, July 2, 1873, lat. 38° 37′ N., long. 28° 30′ W.; depth, 450 fathoms; bottom, sandy.

Aglaophenia calamus, n. sp. (Pl. XII. figs. 5–8).

Trophosome.—Colony attaining a height of about five inches; stem monosiphonic, simple, or with a few branches springing from its anterior aspect; hydrocladia rather close, about two-tenths of an inch in length. Hydrothecæ with the margin deeply serrated; intrathecal ridge short, near the floor of the hydrotheca; mesial nematophore adnate to the walls of the hydrotheca for about half their height, and then continued as a short spur-like process, which does not reach the level of the hydrotheca margin; lateral nematophores somewhat flask-shaped, slightly overtopping the margin.

Gonosome.—Corbula rather long; cylindrical, with about seven pairs of adnate costæ, each costa carrying four or five tubular denticles, and with a spur-like denticle at its base.

Aglaophenia calamus shows no divergence from the typical *Aglaopheniæ*. It is a species with rather close-set hydrocladia, and with a tendency to send off short branches from the anterior side of the plume.

Dredged off Bahia, from a depth of 10 to 20 fathoms.

Aglaophenia coarctata, n. sp. (Pl. XIX. figs. 7–9).

Trophosome.—Hydrophyton attaining a height of upwards of six inches; stem fascicled, sending off alternate rather distant branches, along which the hydrocladia are disposed in alternate pinnæ, which scarcely attain a length of two-tenths of an inch. Hydrothecæ closely approximated, deep, with the margin crenate, and with a prominent tooth in front; mesial nematophore strong, adnate to the hydrotheca walls for about two-thirds of the height of the walls, and thence continued as a short free process, which does not reach the level of the hydrotheca margin, and with a wide emarginate orifice; lateral nematophores thick, tubular, not overtopping the hydrotheca.

Gonosome not known.

The hydrothecæ of the present species are so closely approximated that the lower end of each is included in the orifice of that which lies at its proximal end. They are unusually deep, and the margin, instead of presenting the ordinary dentate condition, is merely crenate, with an anterior mesial point in the form of a sharp tooth. The branches which support the hydrocladia are divided by oblique joints into a series of wedge-shaped internodes, each internode sending off a single hydrocladium. The main stem is strongly fascicled, and the nature of the communication between its component tubes may be easily seen. These communicate with one another by very short lateral offsets, each tube emitting numerous such offsets, whose ends meet those of corresponding offsets from the neighbouring tubes (fig. 1, p. 5).

No part of the gonosome was present in the specimen, and there is perhaps no better reason for assigning it to *Aglaophenia* than to other genera of Statoplean *Plumularidæ*.

Aglaophenia, however, being the longest-established and the largest of the Statoplean genera, may, in the absence of any strong reason to the contrary, be made to receive it until the discovery of the gonosome shall decide its true generic allocation.

The specimen is fragmentary, the hydrorhizal extremity being absent.

Dredged off Zamboanga, Philippines, January 30, 1875, from a depth of 10 fathoms.

Lytocarpus, Kirchenpauer.

Aglaophenia (section *Lytocarpia*), Kirchenpauer, Abhandl. aus dem Gebiete der Naturwiss. von dem naturwiss. Verein in Hamburg, Band v. 1872.

Generic Character. *Trophosome.*—Stem doubly or singly pinnate. Hydrothecæ with serrated or undulated margin, and with the mesial nematophore opening externally by one or two orifices.

Gonosome.—Phylactocarps always open, consisting of modified hydrocladia which never form corbulæ.

Kirchenpauer has given the name of *Lytocarpia* to a group of phylactocarpal Plumularidæ, which he regards as a subordinate section or sub-genus of *Aglaophenia*, while he takes as a type of the section the *Aglaophenia myriophyllum*, Linn.[1] The forms thus separated possess very definite characters, and I believe it will be better to regard them as constituting a true genus of equal value with *Aglaophenia*. As such I have here united a number of Challenger species, which I believe may be properly associated with those brought together by Kirchenpauer in his section *Lytocarpia*. I have found it, however, necessary to modify, to a certain extent, Kirchenpauer's definition, and have changed the termination of the name so as to bring it more into accordance with the usual form of generic designations.

The *Plumularidæ* belonging to the genus *Lytocarpus*, while their trophosomes rarely differ from those of the *Aglaophenias*, have very differently formed gonosomes. In both *Aglaophenia* and *Lytocarpus* the phylactocarp is a modified hydrocladium. In *Aglaophenia* the modification results in the formation of two series of flat leaflets, which almost always become intimately united by their edges, so as to form a closed corbula in which the gonangia are included, or, if not actually united, still lie so close to one another that the corbula thus produced forms a sort of cage in which the gonangia are contained exactly as in the closed form. In *Lytocarpus*, on the other hand, true corbulæ do not occur, and the leaflets of the latter are replaced by more or less cylindrical or sabre-shaped or spine-like appendages, which are never united to one another so as to form a closed chamber.

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[1] Kirchenpauer, *loc. cit.*, p. 20.

Lytocarpus racemiferus, n. sp. (Pl. XIII.).

Trophosome.—Colony attaining the height of about twelve inches; stem fascicled, much and irregularly branched, main branches all directed towards one side of the stem; hydrocladia alternate, scarcely exceeding one-tenth of an inch in length. Hydrothecæ rather deep, margin serrated, teeth blunt; intrathecal ridge well marked, situated near the fundus of the hydrotheca; mesial nematophore adnate to the walls of the hydrotheca for nearly their entire height, and then continued as a short, blunt beak, which scarcely overtops the hydrotheca and has both a terminal and a lateral orifice: lateral nematophores slightly overtopping the hydrotheca.

Gonosome.—Phylactocarps in the form of long racemes, laden with gonangia, springing from certain branches of the trophosome at points near the origin of the branches from the stem, and there taking the places of the proximal four or six hydrocladia, consisting of a series of internodes having every internode provided with one median and two lateral spines, each of the proximal five to eight internodes carrying also an ovate pedunculated gonangium.

Lytocarpus racemiferus is an exceedingly beautiful species. The direction of the principal branches from one side only of the main stem give it a habit not usual among the *Plumularidæ*. The phylactocarps, with their pedunculated gonangia, form elegant racemes, grouped near the proximal ends of the branches, where they replace the hydrocladia of this part of the branch. Towards its distal end the branch carries the ordinary unmodified hydrocladia, which are continued to its extremity.

The phylactocarps are, in the present species, of much morphological significance, and must be viewed as hydrocladia modified by the suppression of the hydrothecæ, whose places are taken towards the proximal end of the phylactocarp by the gonangia, and whose mesial and lateral nematophores have undergone but little change, and are represented by the three spines carried by each internode. These spines retain their essential character as nematophores, and are each provided with a terminal oblique orifice. Several of the more distal internodes are destitute of gonangia and carry only the spines.

The gonangia are supported on rather long peduncles, which spring from between the bases of the two lateral spines, and are subtended by the mesial spine. The gonophore occupies the centre of the gonangium, from whose walls it is separated by a clear space, across which may be seen a wreath of highly refringent spherules, by which the summit of the gonophore is encircled. The sex could not be determined with certainty.

Dredged off Bahia. Depth 10-20 fathoms.

Lytocarpus secundus, Kirchen. (Pl. XIV.).

Aglaophenia (section *Lytocarpia*) *secunda*, Kirchenpauer, Abhandl. aus dem Gebiete der Naturwiss. von dem naturwiss. Verein in Hamburg, Band v. 1872.

Trophosome.—Colony attaining a height of more than two and a half feet; main stem fascicled, rooted by an entangled mass of fibres, and emitting, along nearly its entire length, short branches which carry the hydrocladia, and which, though regularly disposed in alternate pinnæ, are all directed towards the same side of the stem; hydrocladia about two-tenths of an inch in length. Hydrothecæ rather deep, with crenate margin; hydrothecal ridge short and broad, situated near the base of the hydrotheca; mesial nematophore adnate to the hydrotheca walls for about two-thirds of the height of the walls, and terminating as a short, free, blunt spine, which does not reach the level of the hydrotheca margin; lateral nematophores thick, spout-shaped processes not overtopping the hydrotheca.

Gonosome.—Phylactocarps replacing the hydrocladia at short intervals along the hydrocladia-bearing branches, each consisting of a jointed rachis, supporting on every alternate internode a long curved spine, which carries from its base to its apex a double series of wide cup-shaped nematophores, similar nematophores being also borne by the rachis.

No gonangia were present in the specimens.

Lytocarpus secundus is a remarkable and beautiful Hydroid, rendered very striking by its large size, and by its regularly disposed primary branches. These are each about two inches in length, and though at their origin given off as pinnæ from opposite sides of the stem, become all directed towards one side, thus giving a secund character to the ramification. In some of the larger specimens a few branches are given off irregularly towards the base of the stem.

Another very striking feature is found in the curious comb-like phylactocarps. These are shorter than the hydrocladia, generally about half their length, and their rachis, like that of the hydrocladia, consists of a consecutive series of nearly equal internodes, which in the phylactocarp are about eighteen or twenty in number. From the same side of every alternate internode there is sent off a short thick process which supports the long slightly curved spine, the spines thus carried in a single series along the rachis giving to the phylactocarp its resemblance to a comb. Large regularly disposed cup-shaped nematophores are arranged from the base to the apex of the spine in two alternate or sub-opposite series. The spine is itself hollow, with a terminal orifice. Nematophores entirely similar to those of the spine are scattered over the rachis.

Though no gonangia were developed in the specimens, I take it for granted that the comb-like organs are true phylactocarps. The spine-like appendages (the teeth of the comb) are probably the representatives of the mesial nematophores of suppressed hydrothecæ.

In all the specimens examined the phylactocarps were enveloped in a glairy mass, insoluble in boiling water, but completely soluble in a solution of caustic potash. I have no doubt of this being the remains of the protoplasmic contents of the nematophores, and that in the living state it had been emitted as pseudopodial outflows from the cup-shaped nematophores here so largely developed.

I believe that the present species must be identified with the *Aglaophenia* (*Lytocarpia*) *secunda* of Kirchenpauer,[1] though in some points, especially in the form of the hydrotheca and of the comb-like phylactocarps, it can scarcely be brought into complete accordance with Kirchenpauer's figures. Kirchenpauer's specimens were obtained in the South Sea, the China Sea, and the Pelew Islands. From the last-named locality they were brought by Semper, who, according to Kirchenpauer, regarded the species as one of those so much dreaded by the natives on account of its stinging properties.

The limits of the plate would not allow a figure to be given of more than a portion of the entire Hydroid. The Challenger collection contains a specimen which is more than two and a half feet in length.

Dredged off Zamboanga, Philippines, 30th January 1875, from a depth of 10 fathoms.

Lytocarpus spectabilis, n. sp. (Pl. XV.).

Trophosome.—Colony attaining a height of five inches; main stem strongly fascicled sub-dichotomously branched, the branches closely set with opposite primary pinnæ, which are fascicled at their origin, and destitute of hydrothecæ, but which carry the alternately disposed hydrocladial pinnæ; hydrocladia about one-tenth of an inch in length, borne also by the main stem in the intervals of the primary pinnæ. Hydrothecæ wide, with undulated margin, an anterior parietal fold, and a very short intrathecal ridge; mesial nematophore thick, adnate to the hydrotheca walls for somewhat more than half their height, and then continued as a strong, free, spine-like process, which slightly overtops the hydrotheca margin, and has a lateral as well as a terminal aperture; lateral nematophores spine-like, conical, overtopping the hydrotheca.

Gonosome.—Phylactocarps given off at intervals among the hydrocladia, each replacing a hydrocladium, and consisting of a jointed rachis composed of some eight or nine internodes, the proximal internode carrying an ordinary hydrotheca, and each of the following internodes sending off two opposite, strong, conical spine-like processes, each with a terminal and a lateral orifice. Gonangium nearly sessile, borne by the modified second internode of the rachis.

Lytocarpus spectabilis is a beautiful bipinnate form, and presents in its details several features of interest. The margin of the hydrotheca, instead of presenting the serrated condition usual among the phylactocarpal *Plumularidæ*, is merely sinuous, while the

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[1] Kirchenpauer, *loc. cit.*, p. 35, pls. i.-iii. fig. 15.

anterior fold in its walls confers on the hydrotheca an aspect which, though not confined to the present species, is by no means common. Besides its terminal orifice, the mesial nematophore is provided with a very distinct lateral orifice, close to the point at which it ceases to be adnate to the hydrotheca.

In the specimen from which the drawings in the plate had been made, no gonangia were developed on the phylactocarps. The collection, however, contains another specimen in which they are present, and here they were always found singly on the internode which immediately succeeded the proximal or hydrotheca-bearing internode of the rachis. The phylactocarps which thus carried gonangia had also undergone a peculiar modification, which consisted partly in an enlargement both in length and width of the gonangium-bearing internode, the solitary gonangium being borne by a rounded prominence which lay between the two lateral spines of the internode, while in this internode there also existed a small mesial spine, by which the gonangium was subtended, and which did not exist in the others. Further, the whole of the more

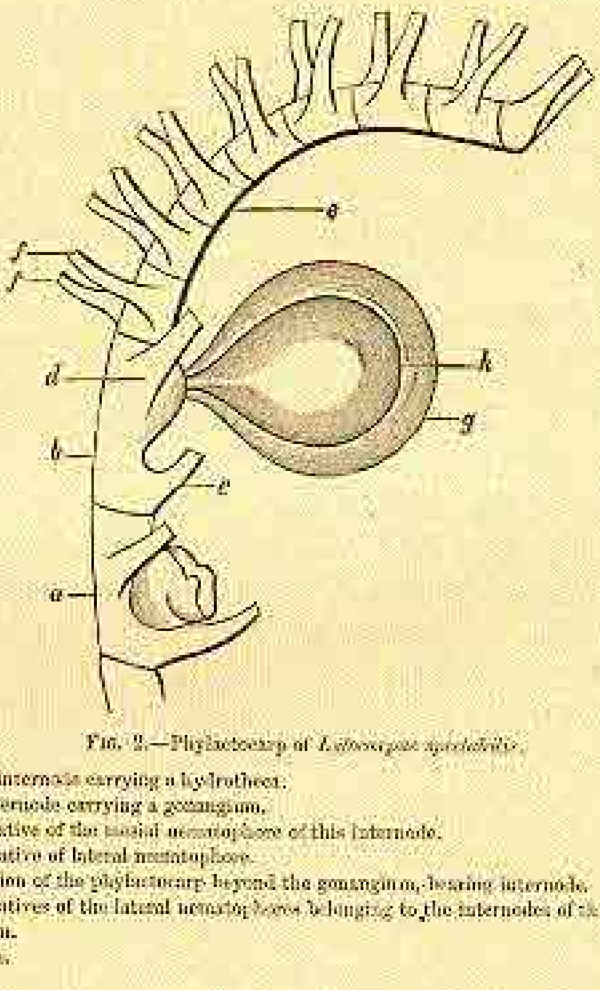

FIG. 2.—Phylactocarp of *Lytocarpus spectabilis*.

a. Proximal internode carrying a hydrotheca.
b. Second internode carrying a gonangium.
c. Representative of the mesial nematophore of this internode.
d. Representative of lateral nematophore.
e. Continuation of the phylactocarp beyond the gonangium-bearing internode.
f, f. Representatives of the lateral nematophores belonging to the internodes of this continuation.
g. Gonangium.
h. Gonophore.

distal portion of the phylactocarp was curved over the gonangium and its supporting internode, while its lateral spines were all directed backwards away from the concavity of the curve.

The morphological significance of the phylactocarp is here sufficiently obvious. There can be no hesitation in recognising in it a modified hydrocladium, in which all the hydrothecæ, except that borne by the proximal internode, have been suppressed. It is also evident that the pair of lateral spines carried by every other internode represents the lateral nematophores of the suppressed hydrotheca. Except on the proximal or hydrotheca-bearing internode, and on that on which a gonangium is developed, no representative of the mesial nematophore is to be found. On the gonangium-bearing internode, however, a mesial spine is carried by the front of the internode, at a short distance behind the gonangium, and this plainly represents the mesial nematophore of the suppressed hydrotheca. The gonangium here takes precisely the place which would have been occupied by a hydrotheca had this been developed.

It may be a question whether the phylactocarps described above, which when examined were found destitute of gonangia, are provided with gonangia at other times, or whether they are really sterile ramuli, with some other physiological significance; at all events, the difference between them and those on which gonangia were present is very remarkable, and it is difficult to see how, after they have attained the form described, they could undergo such modification as would convert them into the fertile phylactocarp. The two forms, however, may be of different sexes, and be both equally destined to carry gonangia.

Lytocarpus spectabilis comes near to *Aglaophenia rostrata* of Kirchenpauer, a species which Kirchenpauer, who has not seen its gonosome, places in his section *Macrorhynchia*. The present species, however, is a much stronger form, and with longer hydrocladia. The hydrocladia, moreover, are alternate in *Lytocarpus spectabilis*, while in *Aglaophenia rostrata* they are described as opposite.

Dredged at Zamboanga, Philippines, 30th January 1875, from a depth of 10 fathoms; also at Station 186, Torres Strait, September 8, 1874; lat. 10° 30′ S., long. 142° 18′ E.; depth, 8 fathoms; bottom, coral sand.

Lytocarpus longicornis, Busk, sp. (Pl. XIX. figs. 4–6).

Plumularia longicornis, Busk, Voyage of the "Rattlesnake," vol. i. p. 399, 1852.

Trophosome.—Colony attaining a height of about three inches; stem fascicled, irregularly branched, supporting closely set pinnately arranged alternate monosiphonic ramuli, which are themselves destitute of hydrothecæ, but give off all along their length the very short hydrotheca-bearing ramuli, which are close set, alternate, about one-twentieth of an inch in length, and though pinnate at their origin, are all directed unilaterally towards the distal ends of the main stems. Hydrothecæ deep, flask-shaped, with a deep antero-posterior constriction just below the margin; margin entire, directed forwards; mesial nematophore adnate to the hydrotheca wall for nearly half the height of the wall, and then continued for about the same distance as a free beak-like process, which is provided with a lateral as well as a terminal orifice; lateral nematophores in the form of long tubular cylindrical processes, which project far beyond the margin of the hydrotheca.

Gonosome not known.

The type of form presented by the hydrotheca of the present species is very remarkable. The deep antero-posterior constriction, the nearly vertical direction of the hydrotheca mouth, with its even margin, so exceptional among the Statoplean Plumularidæ, and the long cylindrical lateral nematophores which project like a pair of ears over the margin, confer on it an aspect singular and striking. The constriction below the hydrotheca mouth is entirely confined to the antero-posterior direction, so that though very striking in profile, it is not apparent in a front view of the hydrotheca.

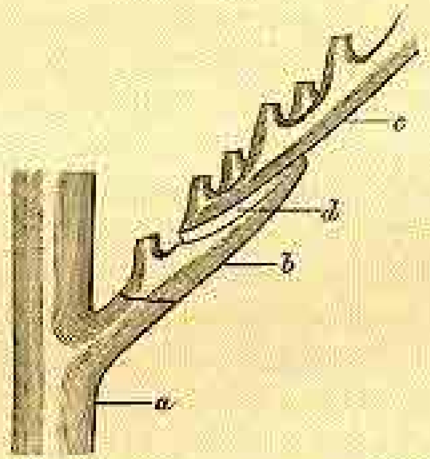

FIG. 3. Origin of a primary pinna in *Lytocarpus longicornis*, showing the splice-like joint near the proximal end of the pinna.

a. Main stem.
b. Proximal portion of pinna.
c. Distal portion. The bases of the secondary pinnæ or hydrocladia are seen with a secund disposition, along the length of the primary pinnæ.
d. Splice-like joint separating the proximal from the distal portion of the primary pinna, and filled with a colourless chitin.

The doubly pinnate ramification of the colony, with the unilateral direction of the very short hydrocladia, afford other striking characters. The hydrocladia are carried each on the summit of a strong process of the primary pinnæ, and being all directed towards one side of these, their really pinnate disposition may be easily overlooked. The basal process on which each stands has on its inner side a tubular nematophore.

The primary pinnæ, or those which being themselves destitute of hydrothecæ support the hydrocladia, are alternate, a very unusual condition in the bipinnate *Plumularidæ*, in which the primary pinnæ are almost always opposite.

Each primary pinna is supported on a short process of the stem, and its proximal end is separated from the remainder of the pinna by a very oblique joint, and forms an acute wedge-shaped segment, on which the distal portion is, as it were, *spliced* (see woodcut). The joint is occupied by a colourless chitin, and when viewed in profile appears as a broad transparent line, which strongly contrasts with the opaque brown periderm of the rest of the pinna. The curious splice-like joint thus formed is very striking and characteristic.

Among the *Plumularidæ* described and figured by Kirchenpauer,[1] are three—*Aglaophenia philippina*, *Aglaophenia urens*, and one which he believes he can identify with the *Plumularia longicornis* of Busk. The hydrothecæ of all these resemble in many points those of the present species, though the habit of the colonies is entirely different. In two of them, *Aglaophenia philippina* and *Aglaophenia urens*, he has observed the gonosome.

Kirchenpauer refers them all to *Aglaophenia* in the wide sense in which he would understand this genus, and places them in a subordinate section or sub-genus of *Aglaophenia*, to which he gives the name of *Macrorhynchia*. The group *Macrorhynchia*, however, as defined by Kirchenpauer, can scarcely be accepted, for there may be found Statoplean Plumularidæ which agree in having the long two-apertured mesial nematophore on which the group has been founded, and whose gonosomes are yet so different as to render it impossible to associate them in the same genus. Indeed, the form of gonosome which Kirchenpauer assigns to his *Macrorhynchia* may well be referred to the type which characterises his *Lytocarpia*.

The absence of gonosome in the specimens obtained by the Challenger renders it impossible to assign the present species with certainty to a definite genus, but the close resemblance of its hydrothecæ to those of the three species just mentioned, in two of which the gonosome has been observed, will perhaps justify us in giving it a place in the genus *Lytocarpus*,—a position, however, which, until its gonosome has been examined, must have a purely provisional value.

Mr. Busk's specimens of his *Plumularia longicornis* were obtained during the expedition of the "Rattlesnake,"[2] and the species defined in the account given of the Hydroids brought home by that expedition. From a comparison of authentic specimens in Mr. Busk's possession, with the *Lytocarpus longicornis* of the present Report, I have satisfied myself of the specific identity of the two forms.

Dredged at Zamboanga, Philippines, January 30, 1875, from a depth of 10 fathoms.

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[1] Kirchenpauer, *loc. cit.*, pp. 45–47.

[2] Busk, Voyage of the "Rattlesnake," vol. i. p. 399.

Streptocaulus, nov. gen.

Name from στρεπτὸς, twisted, and καυλὸς, a stem, in allusion to the torsion of the stem round its axis.

Generic Character. *Trophosome.*—Hydrocladia disposed in a continuous spiral round the stem. Hydrothecæ with entire margin. Mesial nematophore not adnate to the walls of the hydrothecæ.

Gonosome not known.

The species on which the genus *Streptocaulus* has been founded is rendered very striking by the spiral instead of pinnate disposition of its hydrocladia. Even here, however, we may regard the hydrocladia as having primarily a semi-pinnate arrangement, or as being confined to one side of the stem, while a torsion of the stem round its axis—the proximal end remaining fixed—causes the hydrocladia to fall into a continuous spiral. So remarkable a form of ramification may well be assumed as affording a character of generic value. The absence of serration in the margin of the hydrotheca, and still more the detachment of the mesial nematophore from the hydrotheca, are also characters very unusual among the Statoplean *Plumularidæ*.

Streptocaulus pulcherrimus, n. sp. (Pl. XVI. figs. 1–3).

Trophosome.—Colony attaining a height of about nine inches; stem simple, fascicled, wavy; hydrocladia nearly an inch in length, occupying about the distal half of the stem. Hydrothecæ deep, thimble-shaped, margin with a single tooth-like extension in front; mesial nematophore in the form of a free conical spine, with a terminal and a lateral aperture, springing from a point of the hydrothecal internode immediately below the hydrotheca; lateral nematophores pyriform, overtopping the hydrotheca.

The habit of this beautiful Hydroid is very different from that of every other known species. Among Statoplean forms it is the only species as yet discovered in which the disposition of the hydrocladia is not strictly pinnate.

Dredged in Porto Praya, St Jago, from a depth of 100 fathoms.

Diplocheilus, nov. gen.

Name from διπλόος, double, and χεῖλος, a lip, in allusion to the duplicature of the hydrotheca margin.

Generic Character. *Trophosome.*—Hydrotheca with a duplicature of its walls forming an external calycine envelope, which surrounds the hydrotheca for some distance behind the orifice. Mesial nematophore in the form of a shield-like process not adnate to the hydrotheca; lateral nematophores absent.

Gonosome not known.

In the external calyx-like duplicature of the hydrotheca walls of the remarkable Plumularian on which the genus *Diplocheilus* has been founded, we have a character which is absolutely unique among known Plumularians. A scarcely less exceptional character is found in the absence of lateral nematophores, and in the reduction of the mesial nematophore to a sessile, shield-like process unconnected with the hydrotheca.

Diplocheilus mirabilis, n. sp. (Pl. VIII. figs. 4–7).

Trophosome.—Colony attaining a height of two or three inches, sparingly branched; stem monosiphonic, divided into internodes by oblique joints; hydrocladia about two-tenths of an inch in length, having their internodes separated by very oblique joints. Hydrothecæ widening from below upwards, and with the margin everted; mesial nematophore very short and wide, forming a concave shield-like process, with a central perforation at a short distance below the hydrotheca.

Gonosome not known.

Diplocheilus mirabilis presents unmistakable points of affinity with both Eleutheroplean and Statoplean Plumularidæ. To the Statoplean forms it is connected by its fixed nematophores, and this character is presented not only by the mesial nematophore of the hydrothecal internode, but by certain cauline nematophores which are developed on the internodes of the stem. To the Eleutheroplea it shows an affinity by the non-serrated margin of its hydrotheca, and by the very oblique joints which separate the internodes of the hydrocladia, a character which specially recalls a similar condition in the Catharina group of the Eleutheroplea.

Its position among the Statoplean rather than among the Eleutheroplean Plumularidæ must be regarded as decided by the entire absence of moveable nematophores.

Diplocheilus mirabilis—the only known species of its genus—is represented in the collection only by a fragmentary specimen.

Dredged at Station 162, April 2, 1874, off Moncœur Island, Bass Strait; depth, 38–40 fathoms; bottom, sandy.

Cladocarpus, Allm.

Cladocarpus, Allman, Trans. Zool. Soc. Lond., vol. viii., 1873.

GENERIC CHARACTER. *Trophosome.*—A simple or branched hydrosoma, with pinnately disposed hydrocladia.

Gonosome.—Gonangia not included in corbulæ, or protected by any other form of modified hydrocladium, but borne on the sides or at the base of special protective branches, which are appendages of the hydrocladia.

The genus *Cladocarpus* was founded for a Hydroid obtained in the eastern part of the North Atlantic, during one of the expeditions of H.M.S. "Porcupine."[1] The same species also occurs in the collection of the Challenger. The essential characters of the genus are found in the nature of the phylactocarp, which differs from that of every other phylactocarpal Plumularidan in the fact of its not being a transformed hydrocladium, but a special appendage which springs from the hydrocladium. The hydrocladium itself has undergone no essential modification, the greatest change which in any case takes place consists in a greater or less diminution of its length, caused by a reduction in the number of its internodes and hydrothecæ.

In all the species of *Cladocarpus* at present known, the phylactocarps are twig-like appendages, more or less ramified, destitute of hydrothecæ, but richly provided with more or less modified nematophores. In every instance known they spring from a hydrocladium immediately behind its first or proximal hydrotheca, and the gonangia they are destined to protect are borne either by the phylactocarp itself or by the common stem close to the origin of the hydrocladium from which the phylactocarp springs.

Besides *Cladocarpus formosus*, the original species of the "Porcupine," the Challenger collection contains another fine species. Three other species of the genus are among the Hydroids dredged during the exploration of the Gulf Stream by the United States Coast Survey,[2] while to the same genus I must refer a Plumularidan dredged by G. O. Sars in the North Atlantic, and described by him under the name of *Aglaophenia bicuspis*.[3] They appear to be all inhabitants of deep water.

Cladocarpus pectiniferus, n. sp. (Pl. XVII.).

Trophosome.—Colony attaining a height of about six inches; stem slender, monosiphonic, simple, springing from a tuft of tubular filaments; hydrocladia alternate, distant, attaining the length of an inch. Hydrothecæ distant, deep, narrow, nearly cylindrical, with entire margin, and destitute of intrathecal ridge; mesial nematophore small, quite detached from the hydrotheca; lateral nematophores cylindrical, overtopping the hydrotheca.

Gonosome.—Phylactocarp springing from the proximal internode of the hydrothecal ramulus, and consisting of a very short stem, which immediately divides into two jointed and pectinated branches which carry the gonangia on their sides.

The present species is closely allied to *Cladocarpus dolichotheca* and *Cladocarpus ventricosus* of the Gulf Stream exploration. From both these species it differs in the single bifurcation and pectinated branches of the phylactocarp, and in the fact that the

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[1] Report on the Hydroida collected during the Expeditions of H.M.S. "Porcupine." *Trans. Zool. Soc. Lond.*, 1873, vol. viii. part 8.

[2] Hydroids of the Gulf Stream, p. 49, pls. xxx.-xxxiii.

[3] G. O. Sars, *loc. cit.*, p. 98, tab. ii. figs. 7-10.

gonangia are borne on the branches of the phylactocarp instead of being carried at its base by the stem. From *Cladocarpus ventricosus* it further differs in the cylindrical instead of ventricose form of the hydrotheca.

The pectination of the branches of the phylactocarp is due to the presence of nematophores, which are disposed in two opposite series from the base to the summit of the branch, and which, instead of remaining in the usual condition of small sessile cups, have become developed into long cylindrical tubes. In *Cladocarpus dolichotheca* and *Cladocarpus ventricosus*, the nematophores, which are also present on the branches of the phylactocarp, are disposed in a single series, and retain their normal form.

The hydrocladial internodes of *Cladocarpus pectiniferus* are provided with numerous transverse intra-cauline ridges, situated at equal distances from one another. Owing to the transparency of the chitinous periderm, these are very distinct, and give to the internode the appearance of being divided into distinct chambers by regular septa—a character which is very obvious and striking.

The hydrotheca of the internode, from which the phylactocarp springs, is destitute of mesial nematophore, and the phylactocarp springs not exactly from the mesial line of the internode, but from a point a little to the side of this, just below the hydrotheca. The absence of a mesial nematophore, in its normal form, is here not without significance, and affords grounds for believing that the phylactocarp, notwithstanding its slight displacement, is its homological representative.

Cauline nematophores are borne in a single series along the front of the stem, and give to its lower end, where this is destitute of pinnæ, an appearance easily comparable to that of some of the single-sided graptolites. Like most deep-water species, *Cladocarpus pectiniferus* is distinguished by the delicacy and transparency of its chitinous periderm.

Dredged at Station 76, July 3, 1873, lat. 38° 11′ N., long. 27° 9′ W.; depth, 900 fathoms; bottom temperature, 4°·2 C.; bottom, globigerina ooze.

Cladocarpus formosus, Allm. (Pl. XVI. figs. 4, 5).

Cladocarpus formosus, Allman, Trans. Zool. Soc. Lond., vol. viii., 1873.

Trophosome.—Colony attaining a height of about four inches; stem simple or very sparingly branched, fascicled below, becoming monosiphonic distally, springing from a tuft of delicate tubular filaments; hydrocladia alternate, attaining a length of about one inch. Hydrothecæ cylindrical, with crenate margin; mesial nematophore divided by an imperfect transverse septum into a proximal and a distal half, adnate for somewhat more than half its length to the hydrotheca, then becoming free, attaining the level of about half the height of the hydrotheca, and opening by a wide terminal emarginate orifice; lateral nematophores short, cup-shaped, very slightly overtopping the hydrotheca.

Gonosome.—Phylactocarp in the form of a slender branch, which springs from the proximal internode of a hydrocladium, bifurcating three or four times, and carrying an ovate, nearly sessile gonangium at the angle of every bifurcation; branches of the phylactocarp set with two series of alternately disposed cup-shaped nematophores.

Cladocarpus formosus was also obtained during one of the expeditions of H.M.S. "Porcupine," and has been described in the Report on the Hydroids then collected.[1] The specimen in the Challenger collection is a very fine one, and with its long flexile pinnæ and its phylactocarps clustered in a continuous series along their bases, forms a striking and beautiful object.

The condition of the mesial nematophore of the hydrothecal internode is exceptional. This nematophore consists of two portions—a proximal or basal portion, which, like the mesial nematophore, as usually seen, is simply continuous with the internode, and a distal portion, which is separated from the proximal by a transverse joint.

No mesial nematophore is present on the internode which carries the phylactocarp. This springs from the internode somewhat out of the mesial line, and just below the hydrotheca. *Cladocarpus formosus* thus agrees with *Cladocarpus pectiniferus* in the evidence it affords as to the homological significance of the phylactocarp.

Dredged at Station 236, June 5, 1875; lat. 34° 58′ N., long. 139° 30′ E.; depth, 775–420 fathoms; bottom temperature, 2°·8 C.; bottom, mud.

Sub-family—STATOPLEA.

Section—GYMNOCARPA.

Halicornaria, Busk, M.S. (in part).

GENERIC CHARACTER. *Trophosome.*—Hydrocladia pinnately disposed. Hydrothecæ with mesial and lateral nematophores.

Gonosome.—Gonangia destitute of special protective apparatus.

The genus *Halicornaria* was instituted by Busk, who included under it all the then known Plumularian forms whose gonangia were not protected by corbulæ. It is here used in a more restricted sense, and is confined to such Plumularidæ as have their trophosome constructed on the general plan of *Aglaophenia*, but whose gonosomes never develop any form of phylactocarpal apparatus.

Halicornaria plumosa, n. sp. (Pl. XVIII.).

Trophosome.—Colony attaining a height of six inches; stem simple, monosiphonic, springing at intervals from a creeping ramified fibre; hydrocladia about half an inch in length, alternate. Hydrothecæ wide, with a deep lateral notch and a strong anterior

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[1] *Loc. cit.*, p. 478, pl. lxviii.

parietal fold; intrathecal ridge obsolete; mesial nematophore adnate to the hydrothecal walls for the entire height of the walls, and then projected as a strong curved spine for about the same height; lateral nematophores wide, conical.

Gonosome not known.

Halicornaria plumosa is a singularly beautiful species. Though it is highly probable that I have correctly referred it to the genus *Halicornaria*, this determination cannot, in the absence of the gonosome, be regarded as otherwise than provisional.

One of its most striking features is seen in the very long mesial nematophore, which is adnate to the anterior wall of the hydrotheca for its entire height, and is then continued as a long, curved, horn-like spine for nearly the same distance. The margin of the hydrotheca, instead of presenting the serrated condition usual in the Statoplean Plumularidæ, is seen, when viewed in profile, to have a deep obliquely-directed notch on each side, but is otherwise destitute of serration. The deep fold in the anterior walls of the hydrotheca, though occurring in other species, is also characteristic.

In its long mesial nematophore it presents a character in which it would agree with Kirchenpauer's *Macrorhynchia* section or sub-genus of *Aglaophenia*. For reasons, however, already mentioned,[1] the *Macrorhynchia* of Kirchenpauer can scarcely be accepted as a definite group.

The present species appears to come near to the *Halicornaria speciosa* of the Gulf Stream exploration.[2] In general habit there is a close agreement between the two, while in both the wide hydrotheca has an anterior parietal fold, and its margin—though in the Gulf Stream species this does not present the deep lateral notch of *Halicornaria plumosa*—is in both destitute of true serration, being in *Halicornaria speciosa* merely crenate. The mesial nematophore, however, in *Halicornaria speciosa* is not continued beyond the margin of the hydrotheca in the form of the long, curved, beak-like process seen in *Halicornaria plumosa*.

That the Gulf Stream species is a true *Halicornaria* there is no doubt, for the gonosome was present in the specimens examined, and removed all difficulty as to generic identification.

Dredged at Station 122, September 10, 1873, off Barra Grande, Brazil, from a depth of 32 fathoms.

Azygoplon, nov. gen.

Name from ἄζυγος, unpaired, and ὅπλον, a weapon, in allusion to the absence of the lateral nematophores.

GENERIC CHARACTER. *Trophosome.*—Hydrocladia pinnately disposed. Mesial nematophore adnate to the walls of the hydrotheca; no lateral nematophores.

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[1] See above, p. 47.

[2] Hydroids of Gulf Stream, p. 54, pl. xxxiv.

Gonosome.—Gonangia springing from the stem, and destitute of special protective apparatus.

The genus *Azygoplon* is essentially characterised by the very exceptional condition of having no lateral nematophores—a condition which, except in *Diplocheilus*, does not occur elsewhere among the known genera of Plumularidæ. So far as is yet known, *Azygoplon* is represented by one species only.

Azygoplon rostratum, n. sp. (Pl. XIX. figs. 1–3).

Trophosome.—Colony attaining a height of upwards of three inches; stem much and irregularly branched, monosiphonic; hydrocladia about two-tenths of an inch in length. Hydrothecæ rather shallow, with one strong marginal tooth on each side, and a long beak-like process in front; mesial nematophore adnate for its entire length to the anterior wall of the hydrotheca, and then bearing on its summit a free membranous scoop-shaped appendage.

Gonosome.—Gonangium nearly spherical, narrowed into a short stalk at its point of attachment to the stem close to the base of a hydrocladium.

This is a very remarkable Hydroid. The form of the hydrotheca is exceptionally striking, for instead of the serrated margin usual in the Statoplean Plumularidæ, this condition is here replaced by a single strong tooth on each side and a long beak-like projection of the margin in front. The mesial nematophore—the only one present in the genus—is divided into two portions by a transverse joint; the proximal portion is the proper nematophore, and is, as in the mesial nematophore of other Statoplean forms, a simple continuous projection of the hydrothecal internode, and is adnate for its entire length to the anterior walls of the hydrotheca; the distal portion consists of a free membrane bent into a scoop-shaped form, the concavity of which is turned towards the hydrotheca and embraces its anterior wall.

The stem is divided into internodes by transverse joints, and every internode gives off from alternate sides a hydrocladium. The joints by which the internodes of the hydrocladia are separated from one another are unusually well marked—a feature in which *Azygoplon rostratum* approaches the Eleutheroplean rather than the Statoplean forms.

The specimen had been broken away from its hydrorhizal end, and on this account no exact assertion can be made of the height which the species may attain.

Azygoplon rostratum comes very near to a species described and figured by Kirchenpauer under the name of *Aglaophenia avicularis*, from specimens brought from Bass Strait. If it were not for the very different form of the mesial nematophore, I should have regarded the Challenger species as identical with that of Kirchenpauer.

Dredged at Station 161, April 1, 1874, off the entrance to Port Philip; depth, 38 fathoms; bottom, sandy.

GEOGRAPHICAL AND BATHYMETRICAL DISTRIBUTION.

We do not yet possess the data necessary for a complete exposition of the geographical distribution of the Plumularidæ. It may be generally asserted of this group that it attains its greatest development in the warmer seas of both hemispheres, and that in tropical and sub-tropical regions it has its maximum in multiplicity of form, in the size of the colonies, and in individual profusion.

The dredgings of the Challenger and of the United States Exploration of the Gulf Stream would further seem to point to two centres of maximum development within the area thus indicated,—an eastern centre, which is situated in the warm seas around the Philippines and other islands of the East Indian Archipelago, and a western centre, which will be found in those which lie around the West Indian Islands, and bathe the eastern shores of Central and Equinoctial America. From these two centres the largest known Plumularian colonies have been obtained, and we learn, on the authority of Semper, that the natives of the Philippine Islands regard with dread, in consequence of their formidable stinging powers, some of the great Plumularians which occur around their shores.

These eastern and western centres of Plumularian distribution remind us of the two great centres in which the Cheiroptera have their maximum development, as seen in the gigantic bats of both hemispheres,—centres of Cheiropteran distribution which are nearly coincident with these regions of maximum development in the Plumularidæ.

In bathymetrical distribution the Plumularidæ present considerable variation. Among the species described in the present Report some are quite littoral, having been dredged from depths ranging between 8 and 20 fathoms. The greater number however of the Challenger species have been obtained from depths between 20 and 150 fathoms, while the dredge has brought up three species, *Aglaophenia filicula*, *Aglaophenia acacia*, and *Polyplumaria pumila*, from a depth of 450 fathoms. The striking and beautiful genus *Cladocarpus* consists of eminently deep water forms, and of the two species here described one, *Cladocarpus formosus*, was obtained in the Japan Seas from a depth varying between 420 and 775 fathoms—the same species having been dredged by the "Porcupine" in the seas lying to the north of Scotland from 167, 560, and 632 fathoms —while *Cladocarpus pectiniferus* was dredged by the Challenger off the Azores from 900 fathoms. This last is the greatest depth from which any Plumularidan is known to have been obtained.

PLATE I.

Figs. 1–4.—*Plumularia flabellum.*

Fig. 1.—Natural size.

Fig. 2.—Portion of a hydrocladium magnified; lateral view.

Fig. 3.—Same; front view.

Fig. 4.—Portion of branch, with origin of hydrocladia.

Figs. 5, 6.—*Plumularia laxa.*

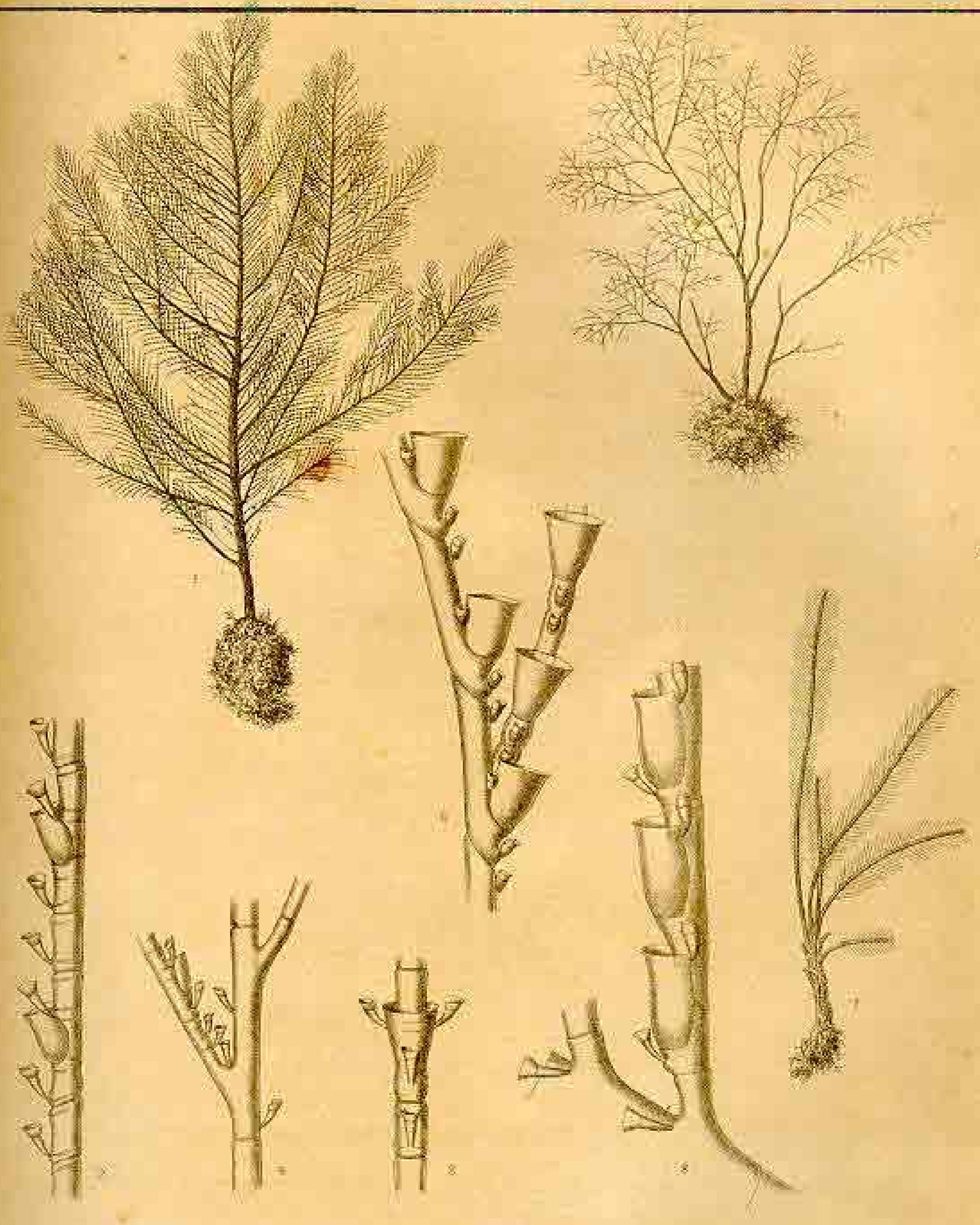
Fig. 5.—Natural size.

Fig. 6.—Portion of hydrocladium giving origin to a secondary hydrotheca-bearing ramulus; magnified.

Figs. 7, 8.—*Plumularia dolichotheca.*

Fig. 7.—Natural size.

Fig. 8.—Portion of hydrocladium; magnified.



1_4 PLUMULARIA FLABELLUM. 5_6 PLUMULARIA LAXA.
7_8 PLUMULARIA DOLICHOTHECA.

PLATE I.

PLATE II.

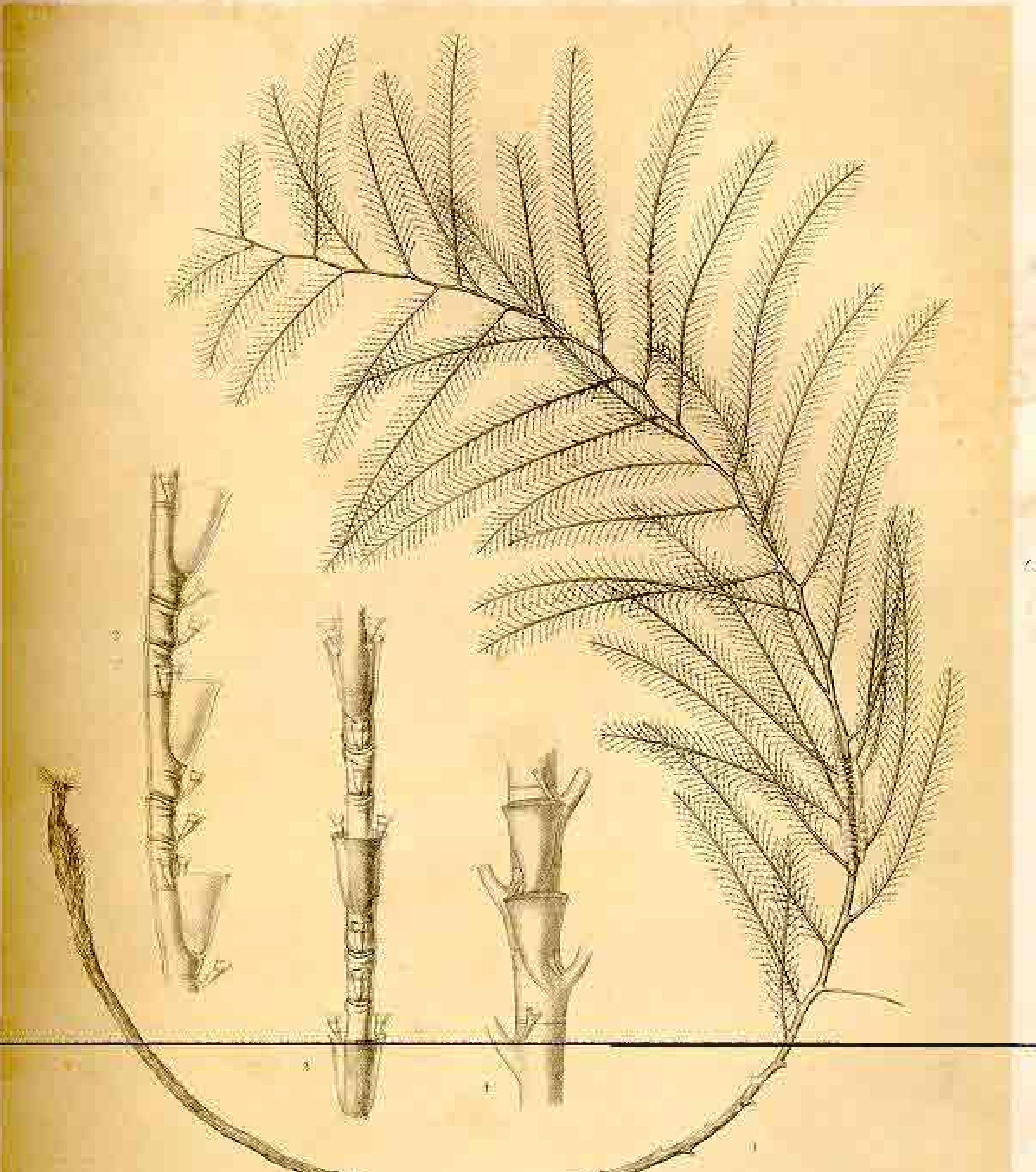
Figs. 1–4.—*Plumularia insignis.*

Fig. 1.—Natural size.

Fig. 2.—Portion of hydrocladium, magnified; lateral view.

Fig. 3.—Same; front view.

Fig. 4.—Portion of branch with immature gonangia.



A. Francis del. [illegible]

PLUMULARIA INSIGNIS

PLATE II.

PLATE III.

PLATE III.

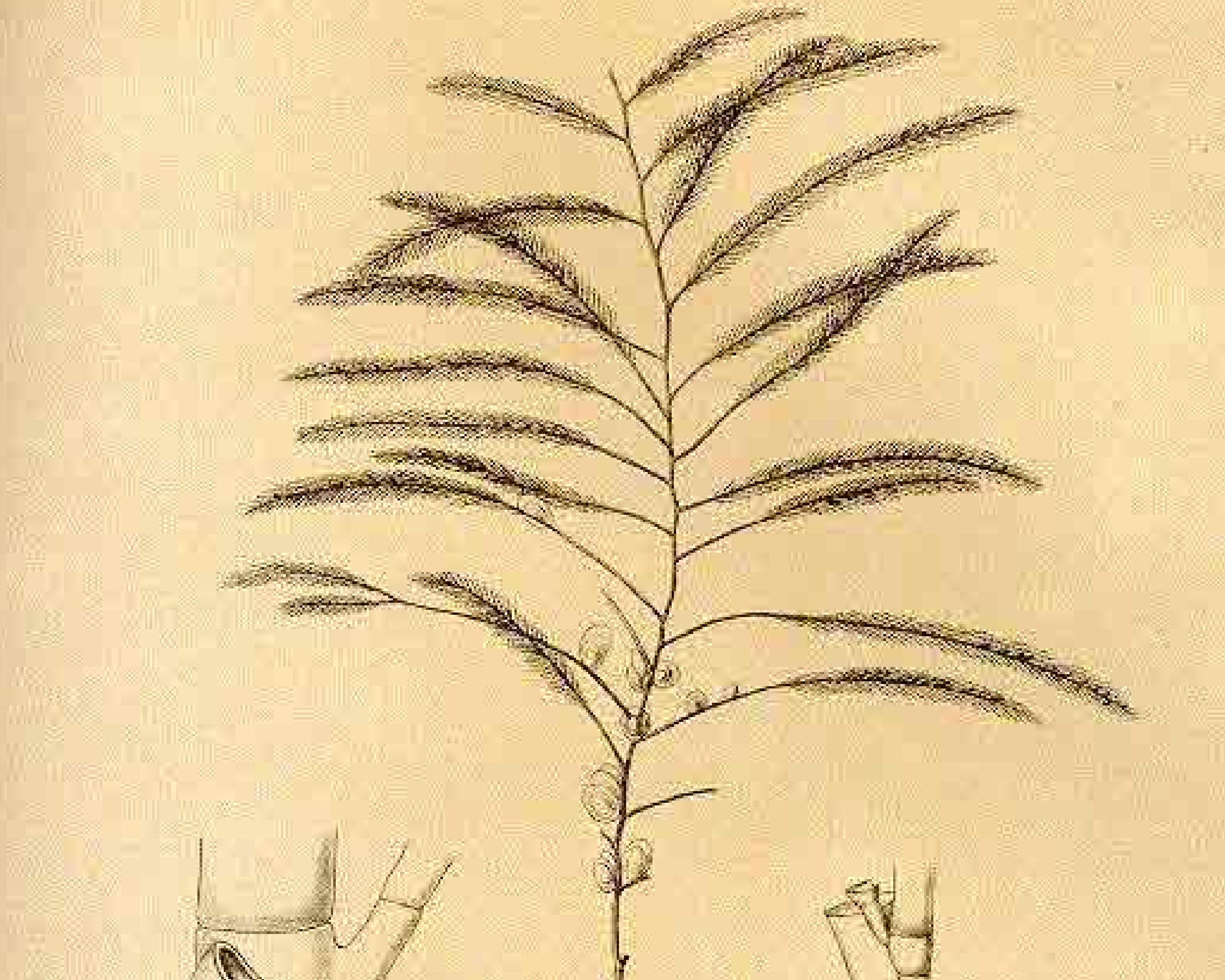
Figs. 1–4.—*Plumularia abietina.*

Fig. 1.—Natural size, with young Avicula-like Mollusca attached to the stem and branches.

Fig 2.—Portion of hydrocladium magnified ; lateral view.

Fig. 3.—Same ; front view.

Fig. 4.—Portion of a branch with gonangium.



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PLUMULARIA ABIETINA.

PLATE IV.

PLATE IV.

Figs. 1, 2.—*Plumularia stylifera.*

Fig. 1.—Natural size.

Fig. 2.—Portion of a hydrocladium with gonangium; magnified.

Figs. 3, 4.—*Plumularia armata.*

Fig. 3.—Natural size.

Fig. 4.—Portion of stem with hydrocladia and male and female gonangia; magnified.

Figs. 5, 6.—*Antennularia fascicularis.*

Fig. 5.—Natural size.

Fig. 6.—Portion of stem with hydrocladia and gonangium; magnified.

Figs. 7, 8.—*Polyplumaria pumila.*

Fig. 7.—Natural size.

Fig. 8.—Portion of main stem, with two primary pinnæ and hydrocladia; magnified. One of the primary pinnæ carries a gonangium, and every hydrocladium bears an accessory ramulus.

1, 2. PLUMULARIA STYLIFERA. 3, 4. PLUMULARIA ARMATA.
5, 6. ANTENNULARIA FASCICULARIS. 7, 8. POLYPLUMARIA PUMILA.

PLATE V.

PLATE V.

Figs. 1–4.—*Sciurella indivisa.*

Fig. 1.—Natural size.

Fig. 2.—Portion of hydrocladium, magnified; lateral view.

Fig. 3.—Same; front view with gonangia.

Fig. 4.—Internode of stem with origins of hydrocladia.

SCIURELLA INDIVISA

PLATE VI.

PLATE VI.

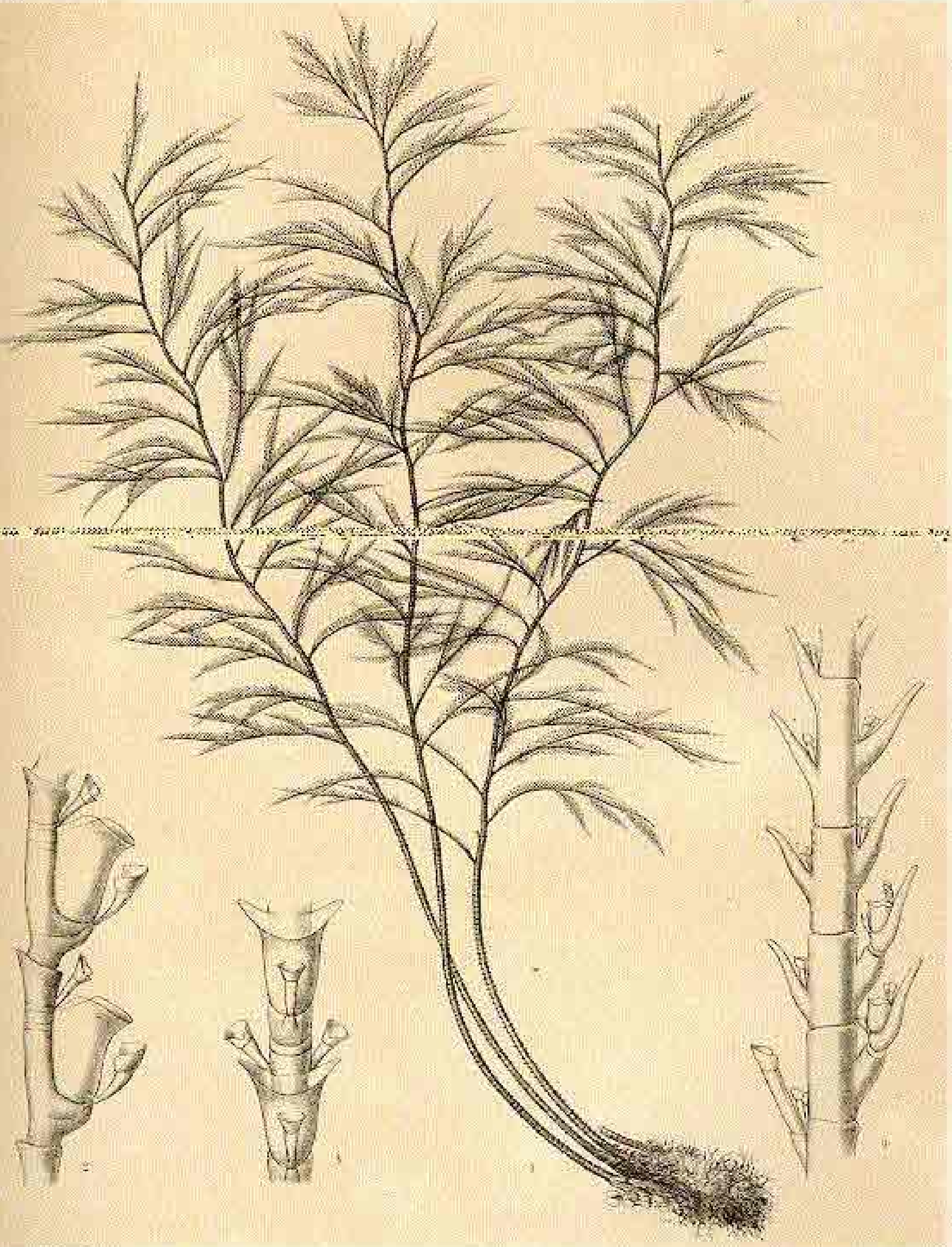
Figs. 1–4.—*Acanthella effusa.*

Fig. 1.—Natural size.

Fig. 2.—Portion of hydrocladium, magnified; lateral view.

Fig. 3.—Same; front view.

Fig. 4.—Portion of branch, near its distal end, showing the spine-like appendages carried by every internode, and here replacing the hydrocladia.



ACANTHELLA EFFUSA

PLATE VII.

PLATE VII.

Figs. 1–3.—*Schizotricha unifurcata.*

Fig. 1.—Natural size.

Fig. 2.—Portion of a hydrocladium, magnified; showing its single bifurcation and the gonangia carried by the ramuli.

Fig. 3.—Variety of same species with short hydrocladia; natural size.

Figs. 4, 5.—*Schizotricha multifurcata.*

Fig. 4.—Natural size.

Fig. 5.—Portion of a hydrocladium, magnified; showing three bifurcations and the gonangia borne by the ramuli.

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1-3 SCHIZOTRICHA UNIFURCATA. 4,5 SCHIZOTRICHA MULTIFURCATA.

PLATE VIII.

PLATE VIII.

Figs. 1–3.—*Heteroplon pluma.*

Fig. 1.—Natural size.

Fig. 2.—Portion of hydrocladium, magnified ; front view.

Fig. 3.—Portion of stem with hydrocladia ; lateral view.

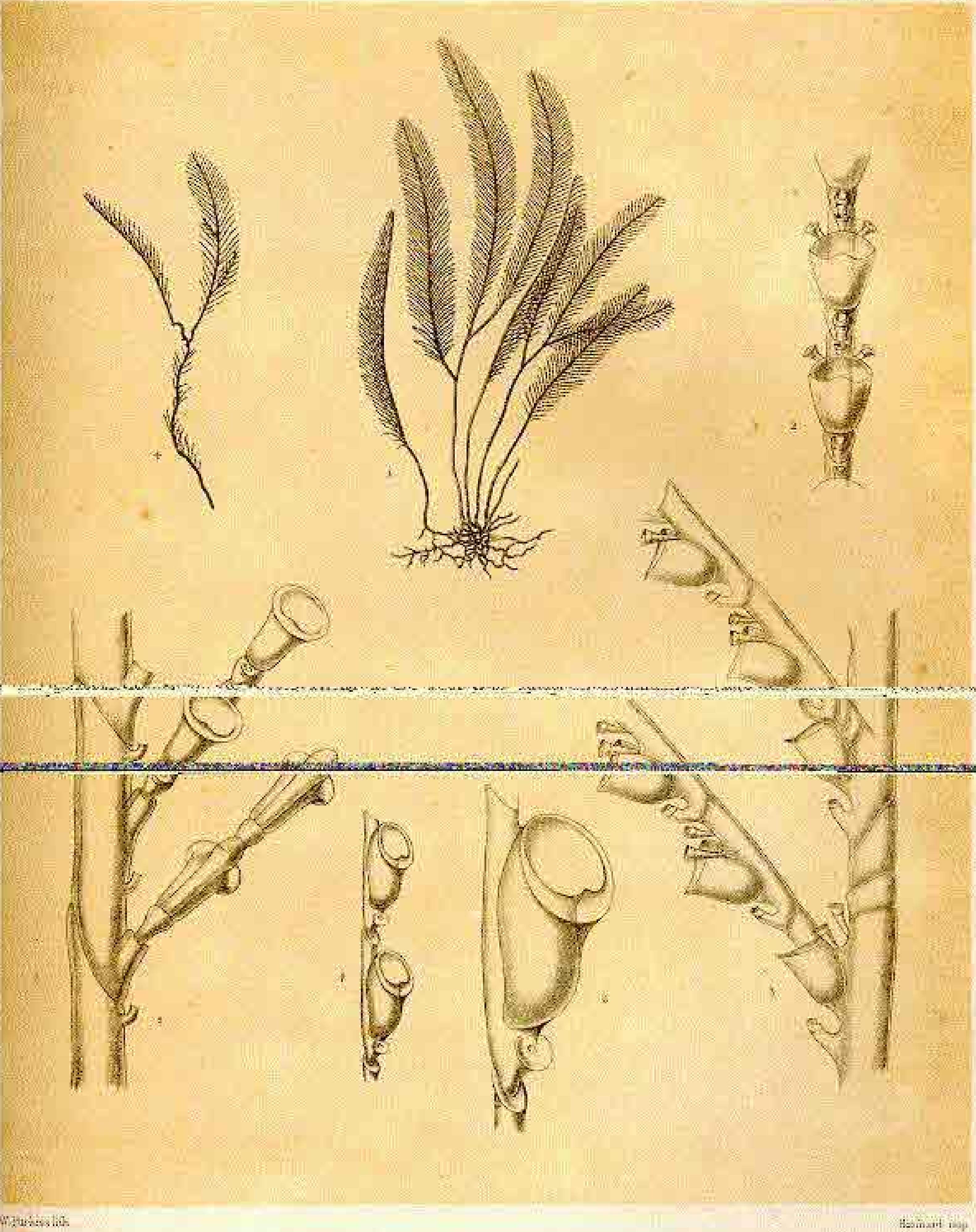
Figs. 4–7.—*Diplocheilus mirabilis.*

Fig. 4.—Natural size.

Fig. 5.—Portion of stem with two hydrocladia, magnified ; showing front and back views of hydrothecæ.

Fig. 6.—Internode of a hydrocladium with its hydrotheca ; half profile.

Fig. 7.—Portion of hydrocladium consisting of two internodes, each with its hydrotheca ; half profile.



W. Purkiss lith.

Hanhart imp.

1-3 HETEROPLON PLUMA. 4-7 DIPLOCHEILUS MIRABILIS.

PLATE IX.

PLATE IX.

Acanthocladium huxleyi; natural size.

For magnified details see Plate XX. figs. 1–3.

W. Purkiss lith.

Hanhart imp.

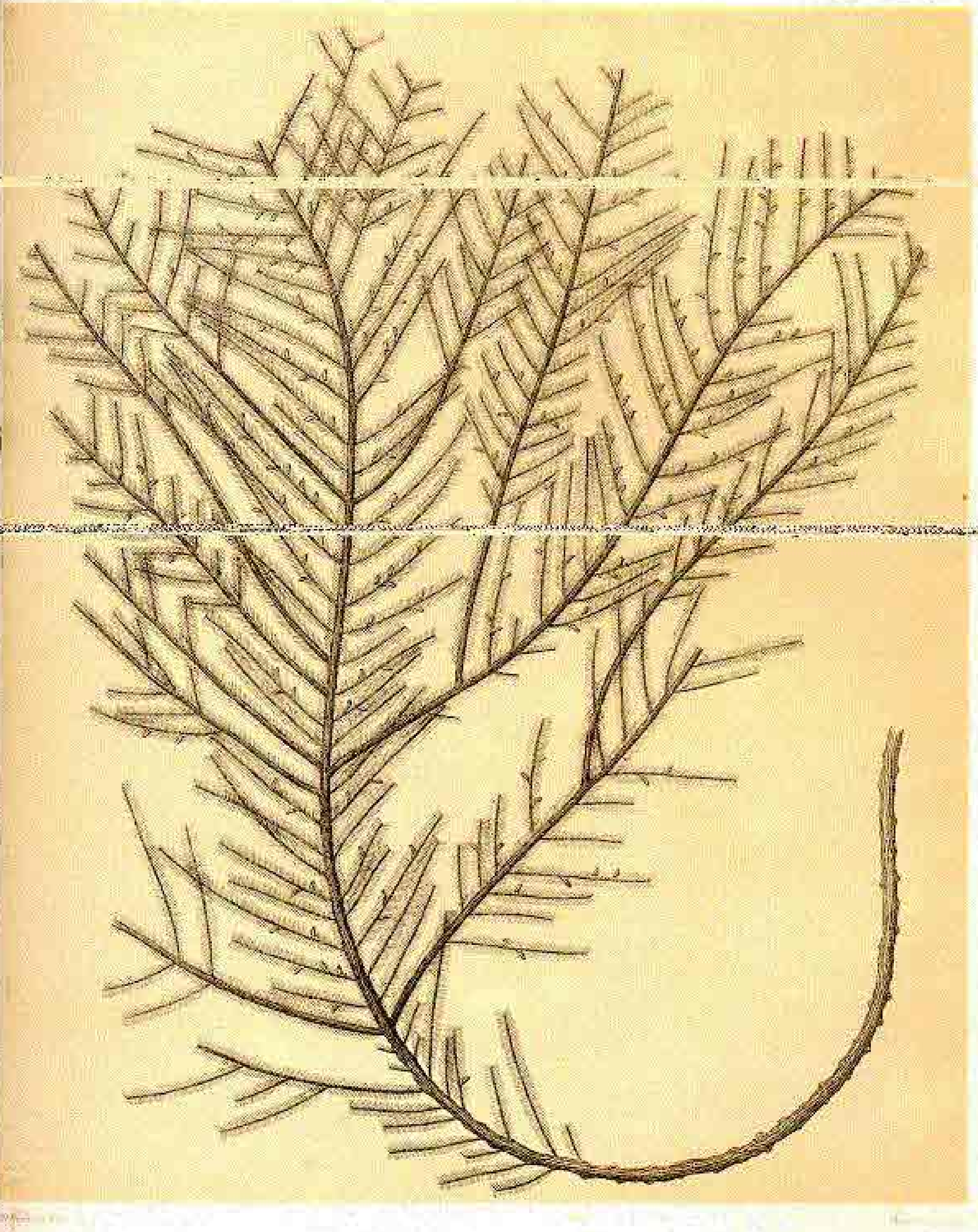
ACANTHOCLADIUM HUXLEYI

PLATE X.

PLATE X.

Aglaophenia macgillivrayi; natural size.

For magnified details see Plate XX. figs. 4–6.



AGLAOPHENIA MACGILLIVRAYI

PLATE XI.

PLATE XI.

Figs. 1–6.—*Aglaophenia filicula.*

Fig. 1.—Natural size.

Fig. 2.—Portion of hydrocladium, magnified; lateral view.

Fig. 3.—Same; front view.

Fig. 4.—Corbula, closed form.

Fig. 5.—Corbula, open form.

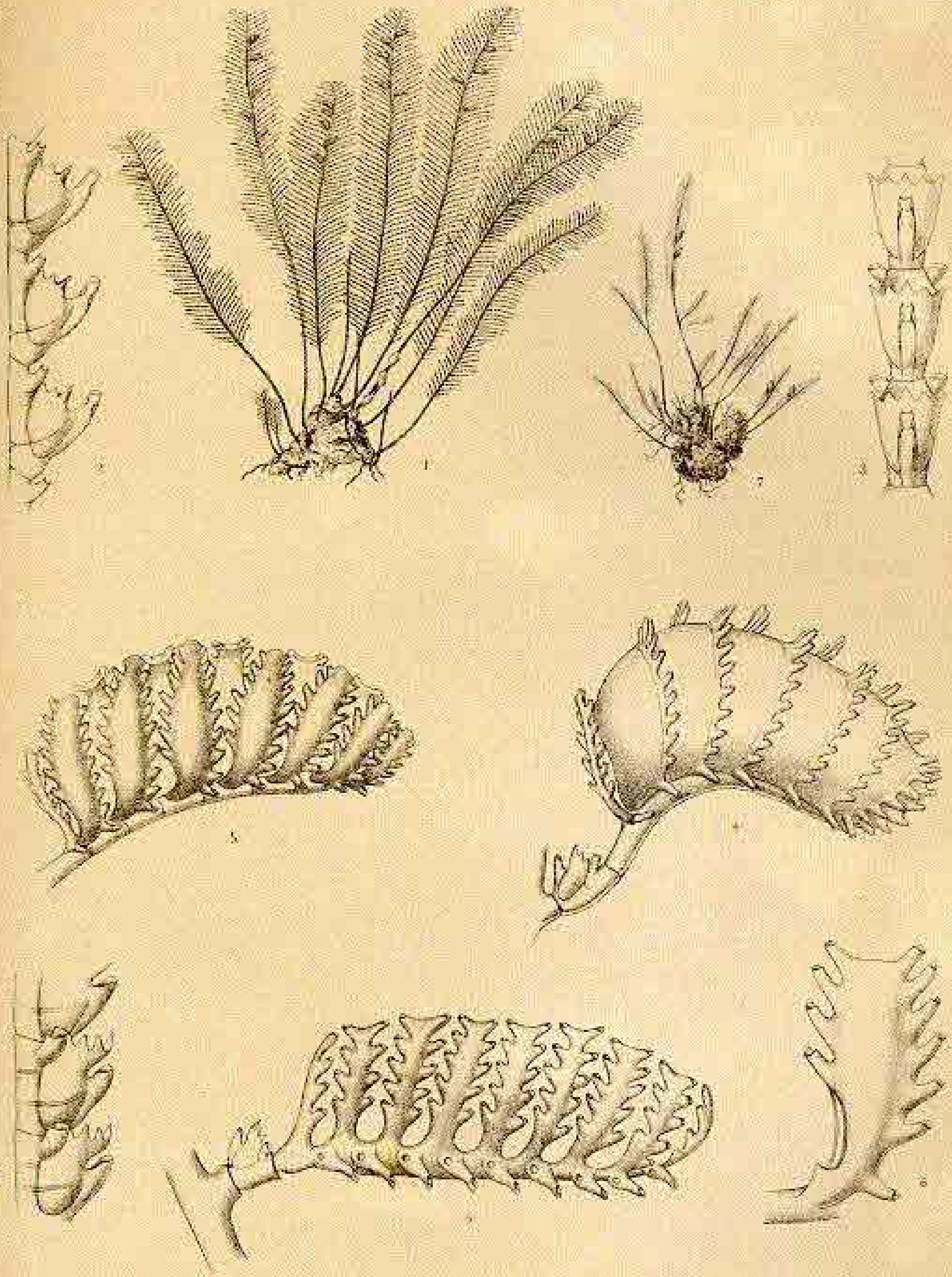
Fig. 6.—One of the costæ of the open form of corbula, showing the slit-like orifice near its base.

Figs. 7–9.—*Aglaophenia attenuata.*

Fig. 7.—Natural size.

Fig. 8.—Portion of a hydrocladium; magnified.

Fig. 9.—Corbula.



1-6 AGLAOPHENIA FILICULA. 7-9 AGLAOPHENIA ATTENUATA.

PLATE XII.

PLATE XII.

Figs. 1–4.—*Aglaophenia acacia.*

Fig. 1.—Natural size.

Fig. 2.—Portion of hydrocladium, magnified ; lateral view.

Fig. 3.—Same ; front view.

Fig. 4.—Corbula.

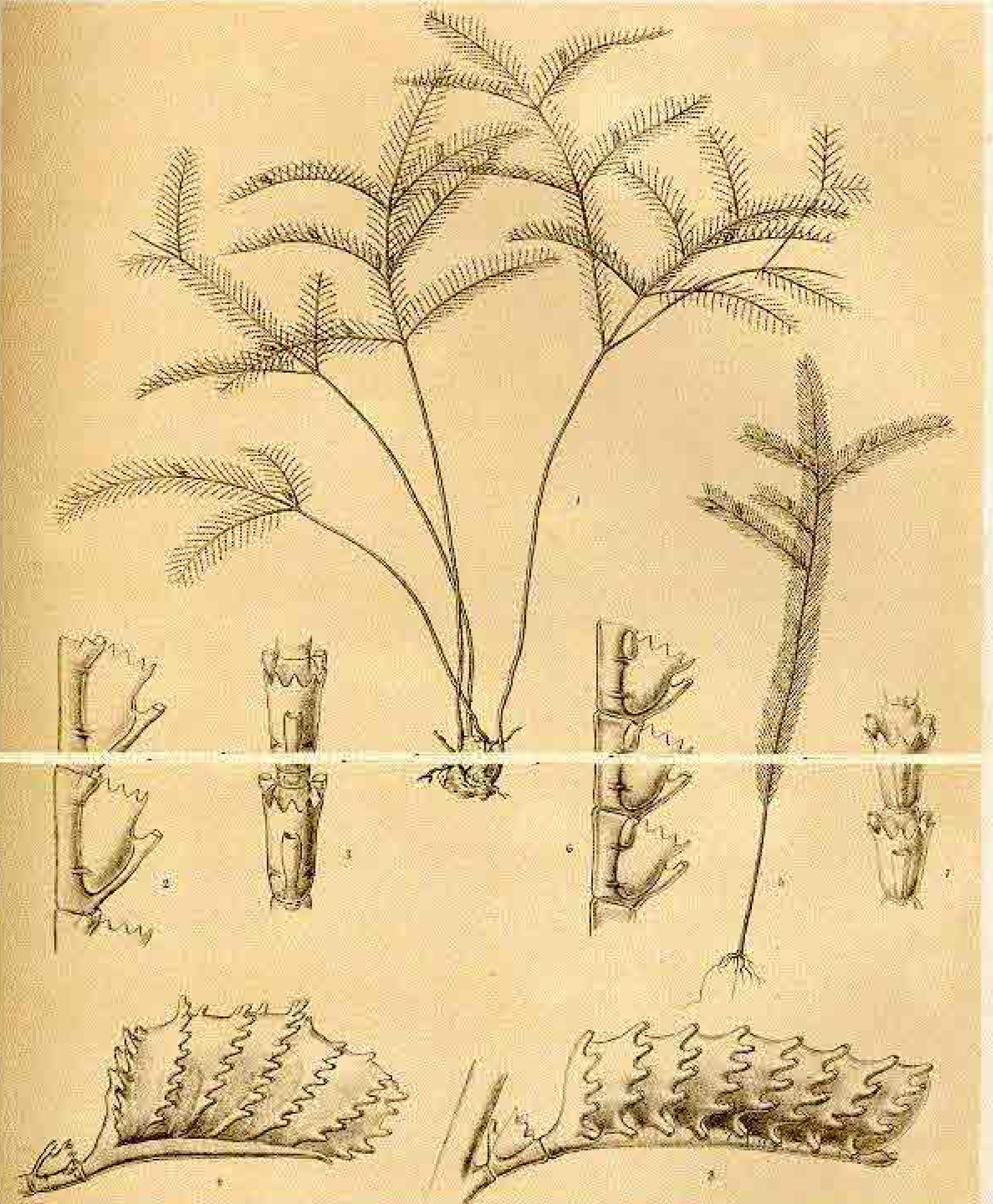
Figs. 5–8.—*Aglaophenia calamus.*

Fig. 5.—Natural size.

Fig. 6.—Portion of hydrocladium, magnified ; lateral view.

Fig. 7.—Same ; front view.

Fig. 8—Corbula.



[illegible] del. Hanhart imp.

1.4 AGLAOPHENIA ACACIA. 5.8 AGLAOPHENIA CALAMUS.

PLATE XIII.

PLATE XIII.

Figs. 1–6.—*Lytocarpus racemiferus.*

Fig. 1.—Natural size.

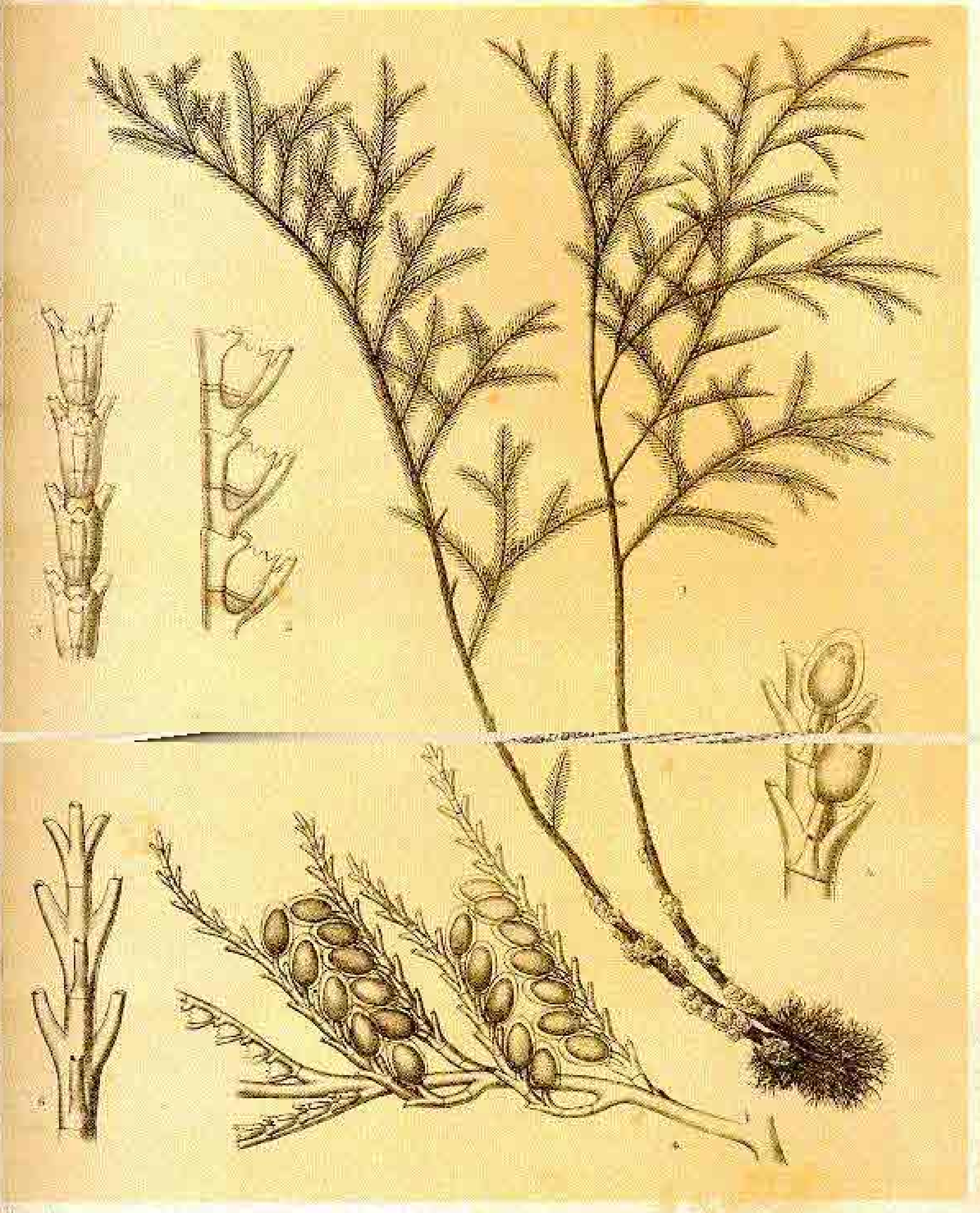
Fig. 2.—Portion of hydrocladium, magnified; lateral view.

Fig. 3.—Same; front view.

Fig. 4.—A branch with phylactocarps loaded with gonangia.

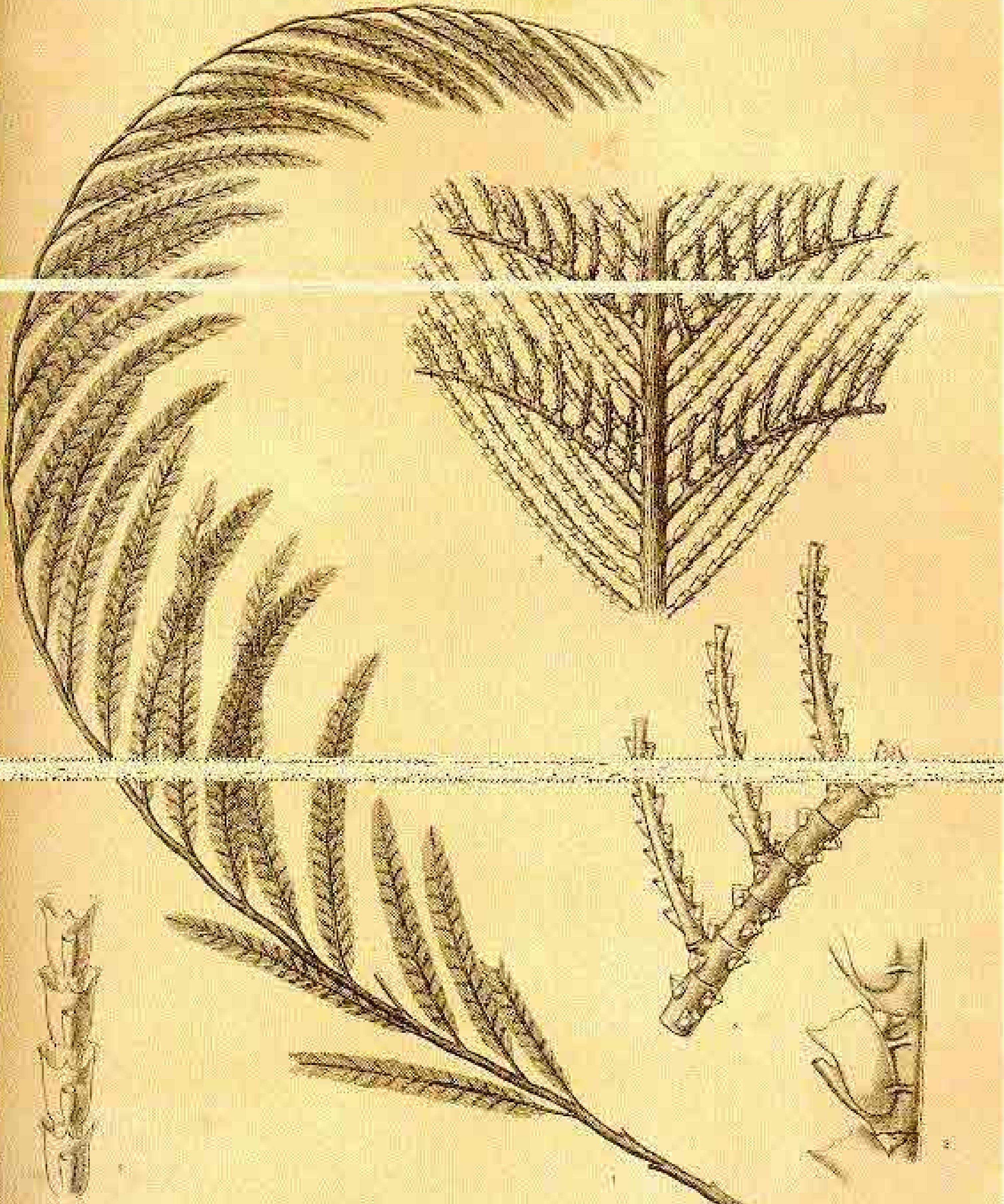
Fig. 5.—Portion of a phylactocarp still further magnified.

Fig. 6.—Distal end of phylactocarp.



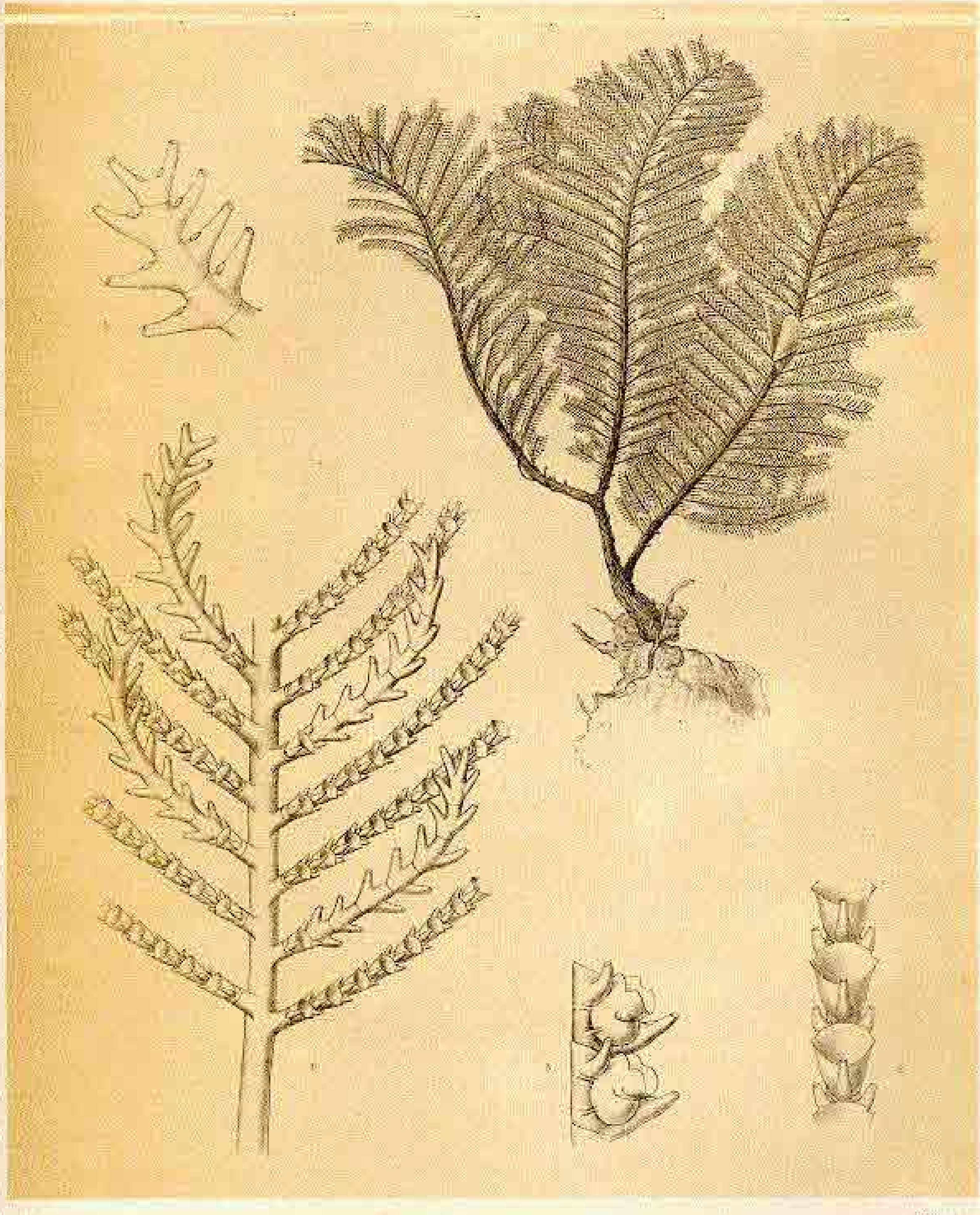
LYTOCARPUS RACEMIFERUS.

PLATE XIV.



LYTOCARPUS SECUNDUS

PLATE XV.



LYTOCARPUS SPECTABILIS.

PLATE XVI.

PLATE XVI.

Figs. 1–3.—*Streptocaulus pulcherrimus.*

Fig. 1.—Natural size.

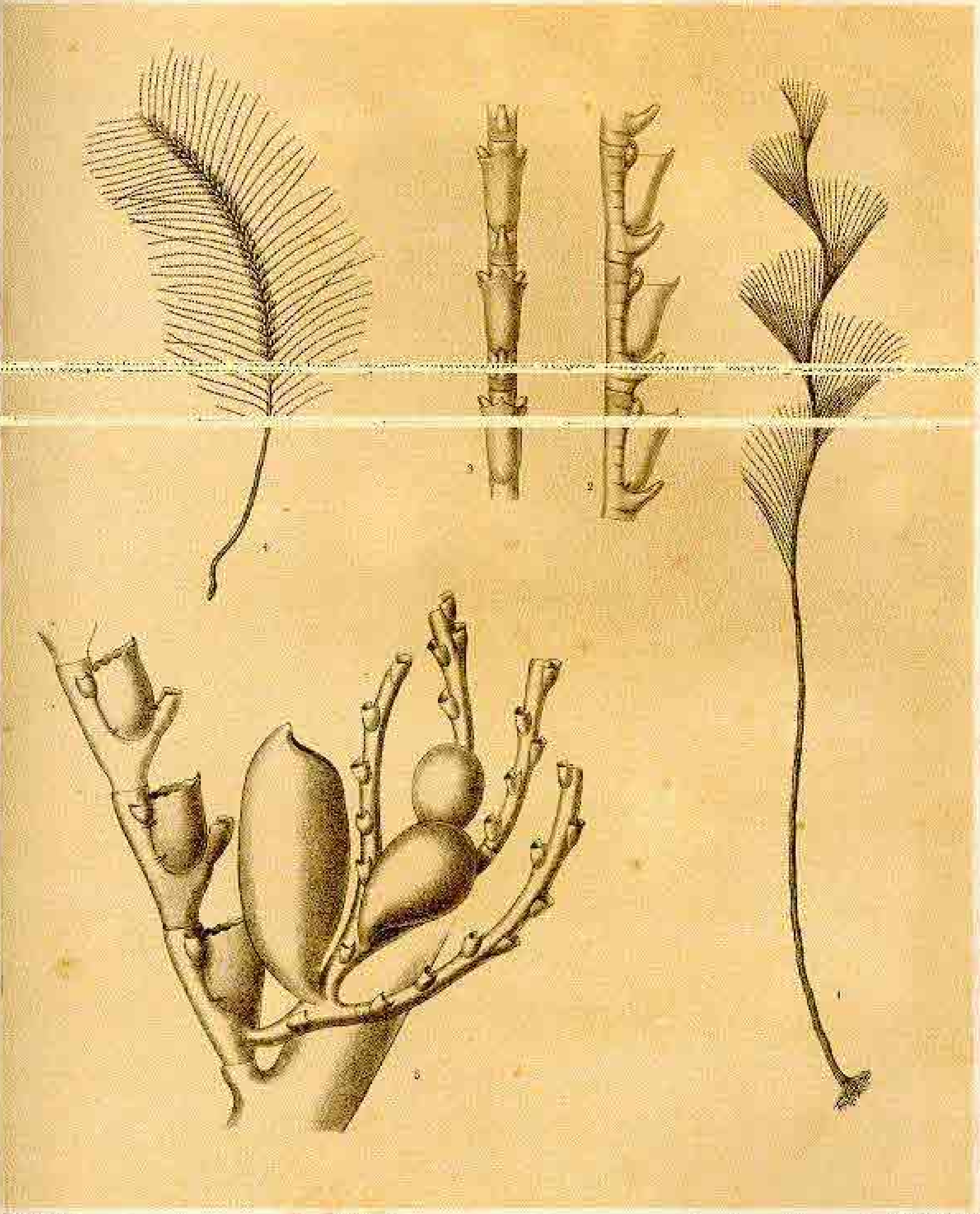
Fig. 2.—Portion of hydrocladium, magnified; lateral view.

Fig. 3.—Same; front view.

Figs. 4, 5.—*Cladocarpus formosus.*

Fig. 4.—Natural size.

Fig. 5.—Portion of stem carrying a hydrocladium with phylactocarp and gonangia; magnified.



1-3 STREPTOCAULUS PULCHERRIMUS.
4, 5 CLADOCARPUS FORMOSUS.

PLATE XVII.

PLATE XVII.

Figs. 1–5.—*Cladocarpus pectiniferus.*

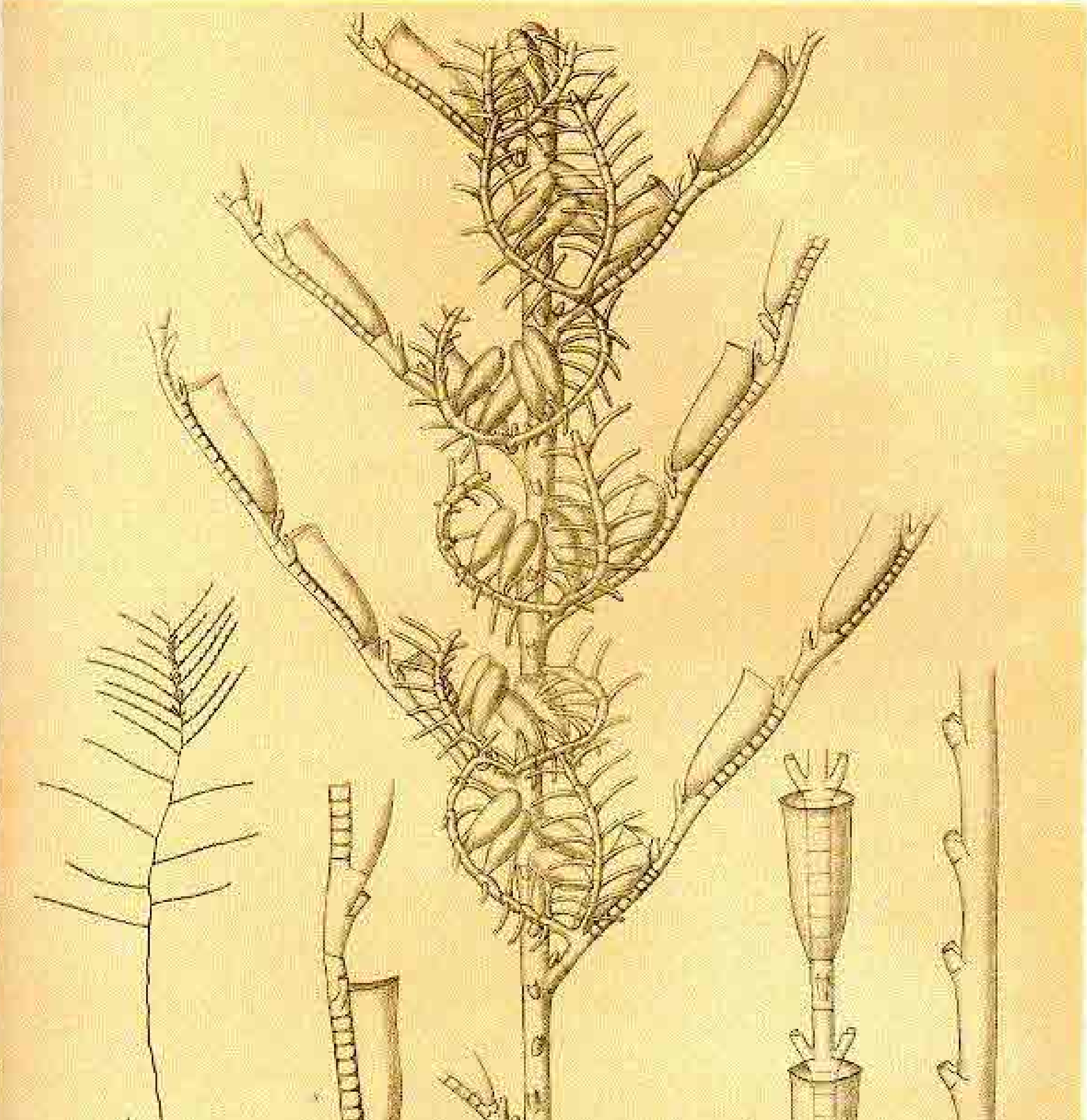
Fig. 1.—Natural size.

Fig. 2.—Portion of a colony, taken from near the distal end, with phylactocarps and gonangia; magnified.

Fig. 3.—Portion of a hydrocladium, still further magnified; lateral view. The origin of a phylactocarp is seen close to its proximal end.

Fig. 4.—Same; front view.

Fig. 5.—Part of the stem near its proximal end; showing cauline nematophores arranged in a single linear series.



CLADOCARPUS PECTINIFERUS

PLATE XVIII.

PLATE XVIII.

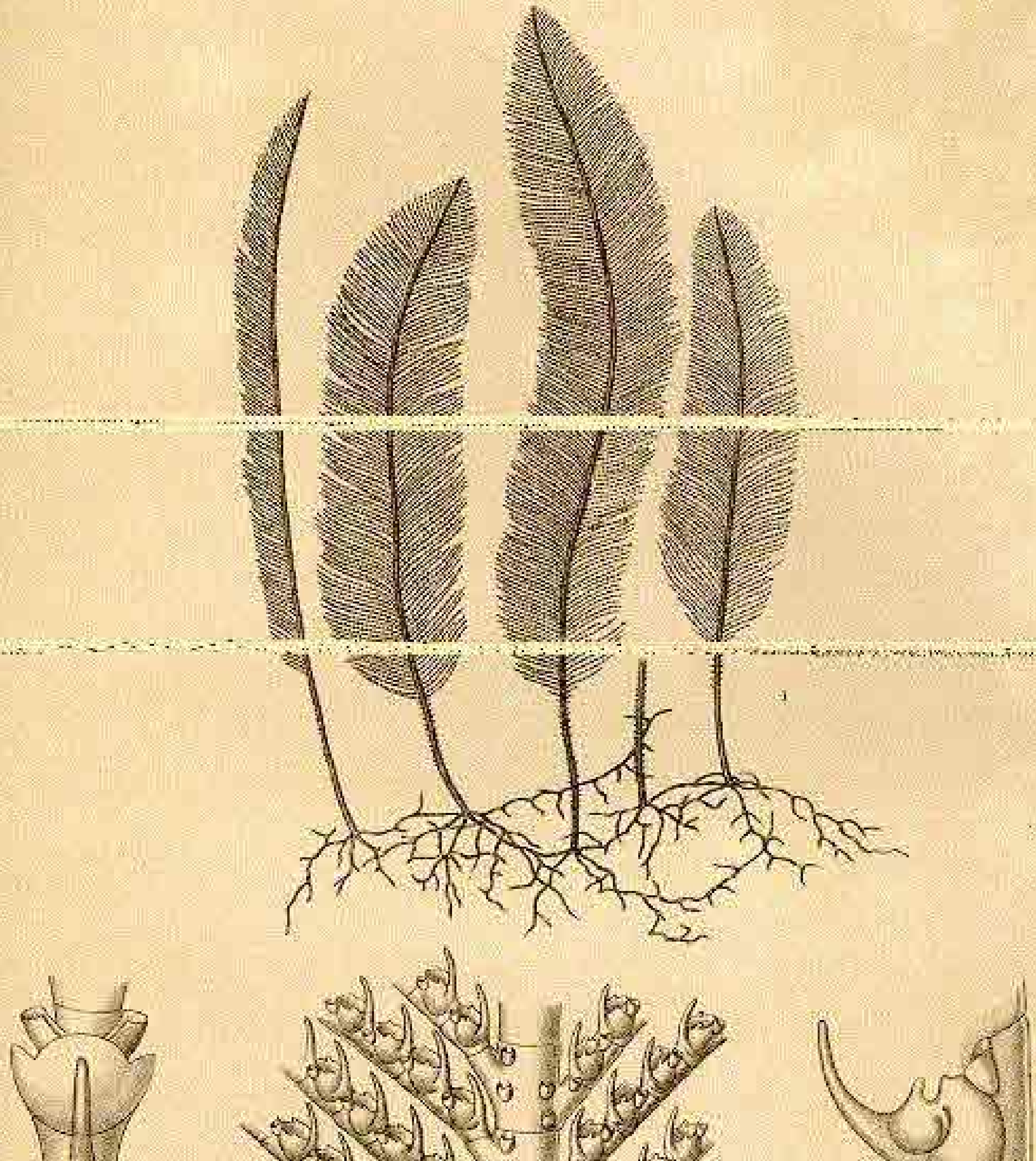
Figs. 1-4.—*Halicornaria plumosa.*

Fig. 1.—Natural size.

Fig. 2.—Portion of stem with hydrocladia; magnified.

Fig. 3.—Portion of hydrocladium, still further magnified; lateral view.

Fig. 4.—Same; front view.



W. Purkiss lith.

Hanhart imp.

HALICORNARIA PLUMOSA.

PLATE XIX.

PLATE XIX.

Figs. 1–3.—*Azygoplon rostratum.*

Fig. 1.—Natural size.

Fig. 2.—Portion of a hydrocladium, magnified; lateral view.

Fig. 3.—Portion of stem with hydrocladia and gonangia; front view.

Figs. 4–6.—*Lytocarpus longicornis.*

Fig. 4.—Natural size.

Fig. 5.—Portion of hydrocladium; magnified.

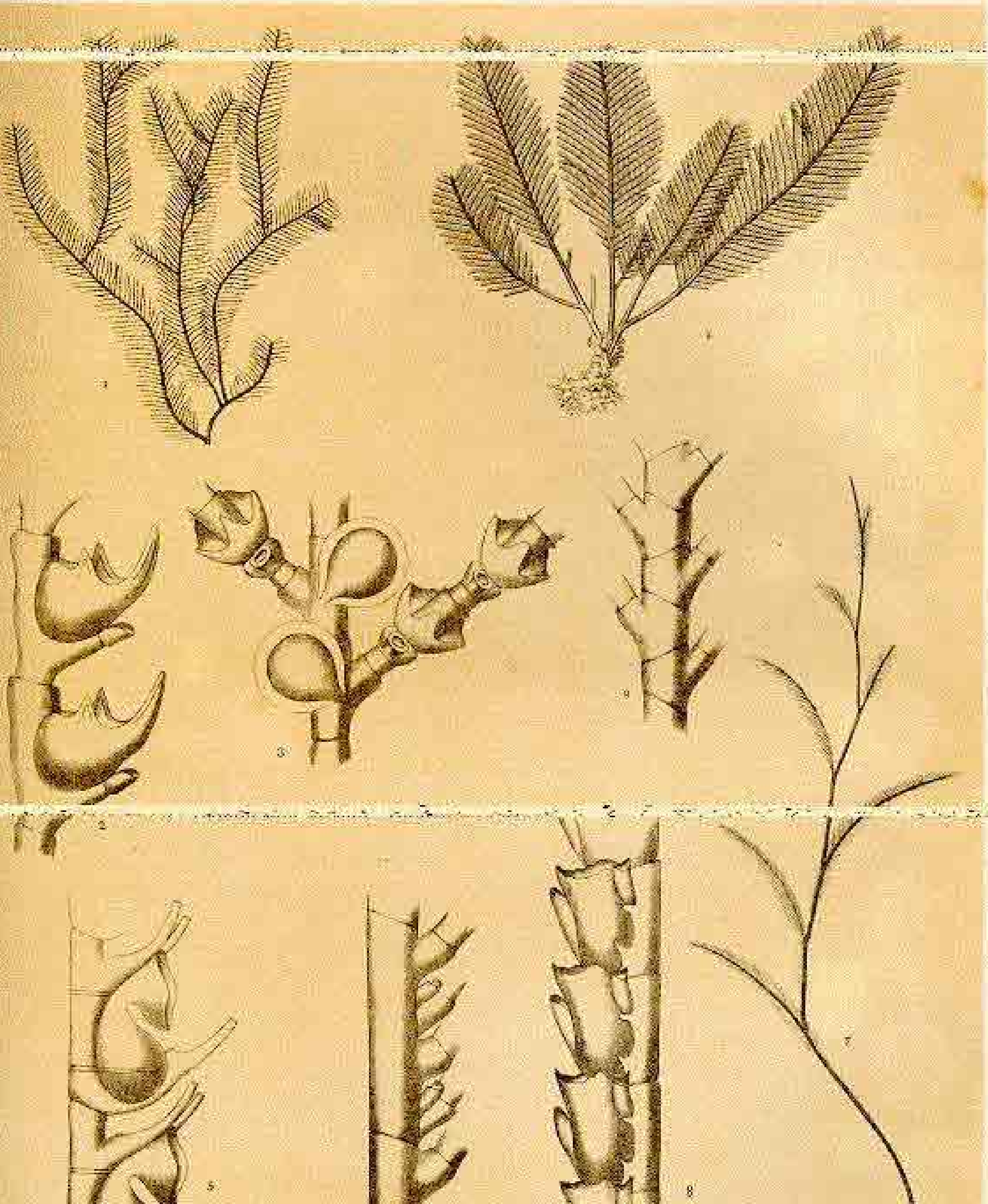
Fig. 6.—Portion of a primary pinna, with origins of hydrocladia.

Figs. 7–9.—*Aglaophenia coarctata.*

Fig. 7.—Natural size.

Fig. 8.—Portion of hydrocladium; magnified.

Fig. 9.—Portion of a branch with origins of hydrocladia, showing wedge-shaped internodes.



W. H[illegible] del. [illegible]

1-3 AZYGOPLON ROSTRATUM. 4-6 LYTOCARPUS LONGICORNIS.
7-9 AGLAOPHENIA COARCTATA.

PLATE XX.

PLATE XX.

Figs. 1–3.—*Acanthocladium huxleyi.* Magnified details.

Fig. 1.—Portion of a phylactocarp with a gonangium. The points from which the other gonangia had been detached are seen close to the bases of the costæ.

Fig. 2.—Portion of a hydrocladium with two hydrothecæ; lateral view.

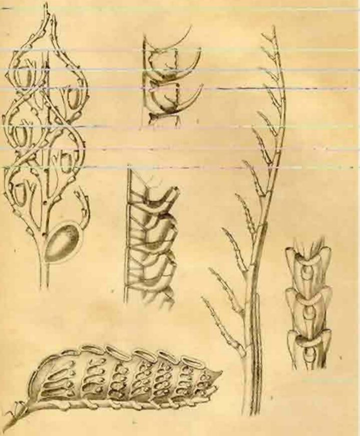
Fig. 3.—Distal extremity of a branch, showing the spine-like appendages by which the hydrocladia are here replaced.

Figs. 4–6.—*Aglaophenia macgillivrayi.* Magnified details.

Fig. 4.—Portion of a hydrocladium; lateral view.

Fig. 5.—Same; front view.

Fig. 6.—Corbula.



1-3 ACANTHOCLADIUM HUXLEYI. 4-6 AGLAOPHENIA MACGILLIVRAYI.

THE
VOYAGE OF H.M.S. CHALLENGER.

ZOOLOGY.

REPORT on the specimens of the Genus ORBITOLITES collected by H.M.S. Challenger during the years 1873-1876. By WILLIAM B. CARPENTER, C.B., M.D., LL.D., F.R.S., F.L.S., F.G.S.; Corresponding Member of the Institute of France, of the Königl. Baier. Akademie der Wissenschaften zu München, of the American Philosophical Society, &c., &c.

INTRODUCTION.

THIRTY-SIX years ago, when engaged in the study of the Microscopic structure of the calcareous skeletons of the lower Invertebrata, I received from my friend Prof. Edward Forbes some small discoidal bodies, which had been dredged-up in considerable abundance on the coast of Australia by Mr. J. Beete Jukes, whilst holding the post of Naturalist in H. M. surveying ship "Fly," between 1842 and 1846, with the information that these disks were probably identical with those which had been collected by MM. Quoy and Gaimard in the same locality during the voyage of the "Astrolabe," and described by them in the "Zoology" of that voyage, under the generic designation *Marginopora*. I could not, however, find any mention of this genus, either in the text or in the plates of their great work; but on consulting the Manuel de l'Actinologie of M. de Blainville, I found it there described (p. 412), on information received from MM. Quoy and Gaimard, in immediate sequence to the genus *Orbitolites*,—both genera being placed by De Blainville, though with hesitation, among his "Polypiers." Having examined, in the Paris Museum, the original specimens on which the genus was founded, I at once saw that Mr. Jukes's disks belonged to the same type, though with some modifications of detail; and I saw also their very close alliance to the fossil genus *Orbitolites*, originally established by Lamarck in his Système des Animaux sans Vertèbres (1801), on the basis of a well-known fossil of the Calcaire Grossier, which he placed among his "Polypiers Foraminés," between *Lunulites* and *Millepora*, giving the following as its diagnostic characters :— "Polypiarium lapideum, liberum, orbiculare, planum seu concavum, utrinque vel margine porosum, nummulitem referens. Pori minimi, adamussim dispositi, conferti, interdum vix conspicui." These bodies, he says, are distinguished from Nummulites by the opening of their marginal pores, and by the absence of any spiral arrangement in their minute chambers or cells. In his Histoire Naturelle des Animaux sans Vertèbres (1816–1822), which ranks as a second edition of the preceding, Lamarck altered the name of this type from *Orbitolites* to *Orbulites* ; but as the latter designation had been previously applied to a Molluscan genus, the original one was restored by M. Milne-Edwards, in the posthumous edition of Lamarck's great work which he edited in conjunction with M. Deshayes. Under one or the other of these names, the genus was accepted by almost every systematist of repute as a Zoologist or a Palæontologist ; but no one gave any account either of the internal structure of the calcareous disk, or of the animal that forms it ; or made any essential modification in Lamarck's definition of the genus, which all left in the place he had assigned to it :—even Dujardin, who first recognised the true zoological position of the Foraminifera (which had been ranked, up to his time, as a peculiar group of Cephalopod Mollusks), speaking unhesitatingly of the Orbitolite-disk as a polypary, and of the animals which formed it as polypes. It seems to have been by Defrance (Dict. des Sci. Nat., tom. xxxvi., 1825, pp. 294, 295) that the existence, on the coast of New Holland, of a recent type closely resembling the fossil *Orbitolites* of the Paris basin, was first publicly stated, probably on information obtained from MM. Quoy and Gaimard.

The existence of a recent form of *Orbitolites* of far smaller size and much simpler structure than the fossil *Orbitolites complanata* had, however, been previously indicated by Lamarck in his second edition, where he defines it under the specific name *marginalis*, as *Orbitolites utrinque plana, margine porosa*, speaking of it as found attached to fuci, corallines, &c., in the Mediterranean. This type was carefully studied by M. de Blainville, who expressed himself (*op. cit.*, p. 412) as almost convinced that these small calcareous disks are not true polyparies, but internal pieces, increasing at their circumference. It is evident, he says, that there are no true polype-cells ; but he speaks of "deux plans de locules qui occupent le bord," and says that "tout le reste est couvert d'une légère croûte crétacée, qui ferme les anciens pores." Being well acquainted with the Mediterranean specimens to which these remarks apply, I can well understand how M. de Blainville came to overlook the single row of true *marginal* pores, and to regard as genuine "les deux plans de locules" which they very frequently present, but which are the result of the abrasion of their edges. That Lamarck's little *Orbitolites marginalis* is a humble representative of the type of structure which attains its full development in the *Marginopora* of Quoy and Gaimard, does not seem to have occurred to him; and it is evident, from his description of the latter, that in that type also he failed to recognise the true marginal pores,—what he supposed to be such being incomplete chamberlets left open in the frilled edges of the abnormal specimens (resembling those figured in Pl. VII.) which represent this genus in the Paris Museum.

Notwithstanding the special attention which M. d'Orbigny was giving to the minute shells now ranked as Foraminifera, he does not seem, when he presented in 1825 to the Académie des Sciences his Tableau Méthodique of that group (which he then ranked as a sub-class of Cephalopoda), to have had the least idea that *Orbitolites* and *Marginopora* should have a place in it; and no mention is made of either in the systematic arrangements published by him in 1844 (Dict. Univ. d'Hist. Nat., tom. v.) and in 1846 (Foram. Foss. de Vienne), in both of which he fully accepted the view of the Rhizopodal character of the animals that form Foraminiferal-shells, which had been promulgated by M. Dujardin in 1835.

Dujardin's doctrine, however, was strongly opposed by Prof. Ehrenberg; who, in 1838, announced to the Berlin Academy[1] his conclusion—avowedly based on observation of certain forms of these animals in the living state—that the true place of the Foraminifera in the animal kingdom is in the class Bryozoa, first constituted by him on the basis of what were then known as "Ciliobrachiate Polypes," viz., *Flustræ*, *Halcyonellæ*, &c. In this group he correctly assigned a place to the genus *Lunulites*; and it seems to have been from the superficial resemblance which (as both Lamarck and De Blainville had noticed) is borne to the calcareous disk of *Lunulites* by *Orbitolites*, that he associated the latter with the former in his Order *Polythalamia*, Family *Asterodiscina*. Having some years previously visited the Red Sea, for the purpose of zoological exploration, Prof. Ehrenberg had brought thence two kinds of small calcareous disks, which he saw to possess similar general characters; upon one of these he conferred the generic name *Sorites*, and upon the other *Amphisorus*; and he erected these into the Family *Soritidæ*, which he placed next to the *Asterodiscina*. It is perfectly clear, from his descriptions and figures of these disks, that Ehrenberg's *Sorites* is identical with Lamarck's *Orbitolites marginalis*, the small recent type inhabiting the Mediterranean; and that his *Amphisorus* is so closely allied to this, that its difference is not more than specific. But he was so completely carried away by his preconceived ideas, as not only to describe the entirely closed cells of the surface of these disks (which are only open in dead and abraded specimens) as covered with a moveable operculum, which shuts their orifices when their animals are retracted, but actually to figure an eight-armed Bryozoon as issuing from one of them.

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[1] Ueber noch jetzt lebende Thierarten der Kreidebildung, und den Organismus der Polythalamien. *Abhandlungen der königl. Akad. der Wissenschaften zu Berlin*, 1839, p. 81.

Such was the general state of knowledge, or rather of ignorance, in regard to the zoological characters of *Orbitolites* and *Marginopora*, at the date (1848) when I undertook a careful microscopic examination of Mr. Jukes's specimens of the latter, the results of which led me to compare their structure with that of the fossil *Orbitolites complanatus.* These results I communicated to the Geological Society in May 1849, and they were published in its Quarterly Journal for Feb. 1850. The place universally assigned to these genera by zoologists and palæontologists being in immediate proximity to *Lunulites* (whose Bryozoic nature could not be reasonably doubted),—and the living *Soritida* of Prof. Ehrenberg having been described and figured as Bryozoic, on the basis of personal observation, by the microscopic autocrat of the time, whose dicta it was heresy to question,—I entered upon the investigation without the least suspicion that this organism was to be regarded in any other light; and that I was not at once undeceived, was mainly due to the fact that among the small number of specimens first placed in my hands by Prof. E. Forbes, there was not one by any means perfect,—all being more or less abraded, and not one possessing that central "nucleus" which is the portion most indicative of their Foraminiferal affinities. Nevertheless, the marked dissimilarity in structure which I found to exist between the calcareous disk of *Orbitolites*, and the skeleton of *Lunulites* or any other undoubted BRYOZOA, made me even then express myself doubtfully as to its title to be closely associated with them. I found that between the recent *Marginopora vertebralis* of Quoy and Gaimard, and the fossil *Orbitolites complanata* of Lamarck, the differences are so trivial as to amount at most to a specific distinction; so that the later genus must be abolished, and the Australian disk be ranked as the recent type of the fossil so abundant in the Calcaire Grossier. And I showed that, in the one as in the other, the "cells" (which I now designate as "chamberlets") are normally closed-in over the whole surface; that the two surfaces are separated from each other by an intervening stratum, traversed by a set of round columnar cavities of its own, with inter-communicating passages; that each superficial cell communicates with this intermediate cavitary system by two small apertures; and that the only real external orifices are the minute pores at the margin of the disk, which do not communicate directly with the cells of the superficial layers, but are the openings of passages leading to the outermost series of columnar cavities in the intermediate stratum. To this complicated arrangement I could find no parallel in the Class BRYOZOA, but I was equally unable to indicate any parallel to it elsewhere.

At what date the Foraminiferal nature of *Orbitolites* first came to be suspected by M. d'Orbigny there is no means of knowing; but in the year 1852 (Cours Elémentaire de Paléontologie) he assigned it a place in that group; creating for it, and for some other genera having a like discoidal form, the Order *Cyclostègues*, which he defined as follows:—"Animal composé de segments nombreux, placés en lignes circulaires. Coquille discoïdale, composée de loges concentriques, simple ou multiples; point de spirale."

He united Quoy and Gaimard's recent *Marginopora* (as I had myself previously done) with Lamarck's fossil *Orbitolites;* but so little did he know of the internal structure of this type, that he altogether failed to perceive its very close similarity to that of *Orbiculina*, which he ranked with *Peneroplis*, *Dendritina*, and other genera allied to these, among his "Hélicostègues."

This similarity had been already recognised (1850) by Prof. W. C. Williamson, whose previous studies of Foraminiferal structure had so far prepared him for the right appreciation of it, that, on coming into possession of specimens of *Orbitolites marginalis*[1] from the calcareous sands of Havannah, and of a small worn specimen of the recent *Orbitolites complanata* from Tonga, he made it perfectly clear, by a comparison of their internal structure with that of the proteiform *Orbiculina adunca*, that these three types closely accord in their general structure, differing only in their plan of growth (Transactions of Microscopical Society, vol. iii., 1852). And it is greatly to his credit, that at a time when the authority of M. d'Orbigny was generally accepted as the highest in regard to Foraminifera, Prof. Williamson should have ventured not merely to call in question the value of "plan of growth" as an *ordinal* character, but even to rank it as good only for *specific* differentiation. He clearly showed (1) that the well-known *Orbiculina adunca* of the Antilles, though always *beginning* life as a *Hélicostègue*, often ends it as a *Cyclostègue;* its first-formed arcuate rows of chamberlets, which represent the successive chambers of the flattened spire of *Peneroplis*, often sending backwards two alar extensions, which meet at the back of the first-formed spire, so as to form a complete annulus, after which every successive addition takes place on the *cyclical* plan; (2) that whilst in *Orbitolites marginalis* the first growth is spiral, yet this very early gives place to the *cyclical* plan; and (3) that in *Orbitolites complanata* the growth is *cyclical* from the beginning, the very first row of chamberlets forming a complete annulus, and all further additions being made on the same plan. He also showed that *Orbitolites marginalis* and *Orbitolites complanata* alike originate in a globular or pyriform primordial chamber, which opens by a flask-shaped neck into a second chamber; and that it is from the latter that the first row of chamberlets originates in each case. He fully recognised also the "simplicity" of the structure of *Orbitolites marginalis*, with its single tier of chamberlets, and the "complexity" of that of *Orbitolites complanata*, with its "multiplication of strictly analogous parts"; and he showed that the latter is further differentiated by its possession of concentric rows of superficial fossæ, distinct from the cavities of the intermediate stratum of the disk. And the only considerable error in his whole description, which arose from the abrasion of the surface of his single specimen of the "complex" type, was his treating the chamberlets of the superficial plane, which are closed-in by lamellæ of shell, as open fossæ. The great importance, then, of Prof. Williamson's memoir, lay in

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[1] It is unfortunate that Prof. Williamson misnamed the specimens he so well described. His *Orbiculina complanata* is clearly the *Orbitolites marginalis* of Lamarck; while his *Orbiculina tonga* is no less clearly the *Marginopora vertebralis* of Quoy and Gaimard, the recent type of Lamarck's fossil *Orbitolites complanata*.

its clear demonstration of the close affinity between *Orbitolites* and *Orbiculina*, whereby, as the place of the latter in the group FORAMINIFERA was beyond all question, that of the former also was assured,—the Bryozoic doctrine of Ehrenberg being thus altogether disposed of. And it followed, as a corollary, that any classification of Foraminifera must be based on wrong principles, which ranked two organisms so essentially similar as *Orbitolites* and *Orbiculina* in different Orders.

Having afterwards come into possession, by the kindness of Mr. Jukes, Mr. Hugh Cuming, Prof. E. Forbes, Prof. J. Quekett, and other friends, of a large series of different types of Orbitoline structure, obtained from different localities, including several very perfect specimens which had been taken alive and preserved in spirit, I applied myself afresh to the study of the genus; and soon found it to have a most important bearing on the great question of the "Range of Variation within the Limits of Species," which was occupying the attention of some of the most thoughtful Naturalists of that date (1850-56), before the appearance of the new light thrown upon it by the publication of the Origin of Species. And in 1855 I presented to the Royal Society a Monograph of the genus *Orbitolites* (Phil. Trans., 1856, p. 181), in which I treated all its forms —fossil as well as recent—that I had been able to examine as varieties of one fundamental type, incapable of being ranged under specific definitions, because of the gradational transition clearly traceable throughout the entire series, from the smallest and simplest *Orbitolites marginalis* to the largest and most complex *Orbitolites complanata*,—this transition showing itself alike in the progressive complication of the general structure, and in the exchange of the *spiral* plan of growth for the *cyclical*.

My subsequent studies of other types of FORAMINIFERA gave me a clearer insight into the place of *Orbitolites* in the series: and in the concluding summary appended to my fourth Memoir (Phil. Trans., 1860, p. 571), I showed how completely the results of my researches were opposed to the principles on which the classification of M. d'Orbigny had been framed; and sketched-out the line of "descent with modification," by which a division of the primary segments that form the simply-chambered shell of a *Peneroplis* into sub-segments, would give origin to the spiral *Orbiculina*, while the transition from the latter to the perfectly cyclical *Orbitolites* is quite gradational.

When I subsequently undertook, in conjunction with my friends W. K. Parker and T. Rupert Jones, to frame an entirely new classification of FORAMINIFERA on the basis of the principles I had laid down, I felt no difficulty in assenting to their view that the pedigree of this series might be traced yet further back, viz., to those simplest forms of the Milioline type whose shell is a flattened nautiloid spire, altogether destitute of partitions, belonging to that "monothalamous" section which all previous systematists had ranked as fundamentally distinct from the "polythalamous." "From the undivided spiral of *Cornuspira*" (I pointed out in my Introduction to the Study of the Foraminifera, p. 67) "to the regular scarcely-divided spiral of certain Spiroloculine forms of *Miliola*, the transition is almost insensible; and from the Spiroloculine we pass by easy steps to all the other forms of the Milioline types." Again, a subdivision of the widely-expanded spire of *Cornuspira* into segmental chambers, gives us *Peneroplis*, with its septal planes perforated by a row of separate pores; while from this, it was again pointed out, the spiral *Orbiculina* might be derived by a further division of the sarcodic body into subsegments, with a corresponding division of the primary chambers of the shell into chamberlets.

It was therefore with no small satisfaction that I recognised, among the products of the deep-sea dredgings carried on in the "Porcupine" expedition of 1869, a "missing link" that reproduces the whole of this genetic series in its own single organism, namely, a chambered calcareous disk, of which, though nearly the whole is constructed on the typically Orbitoline plan, the central (or youngest) part shows, in the first place, the simple undivided tubular coil of a young *Cornuspira*; then the partial interruption of that coil by incomplete septa, as in *Spiroloculina*; then the flattening-out of the spire, and its partitioning into chambers by perforated septa, as in *Peneroplis*; then the subdivision of the spirally-growing chambers into chamberlets, as in *Orbiculina*; and finally, the substitution of the cyclical for the spiral plan of growth, constituting it a true *Orbitolites*, —as will be presently set forth in detail in the description of *Orbitolites tenuissima*.

I had pointed out (Phil. Trans., 1860, p. 574) that the shells of the whole of this series—together with that of the fusiform *Alveolina*, which I regarded as another derivative from the same fundamental type—have that *porcellanous* character, whose distinctive importance was first indicated by Prof. W. C. Williamson, though he did not venture to adopt it as a basis of the primary subdivision of the group; and that a precisely parallel relation exists among those generic types of the series forming *vitreous* shells, which present the most highly specialised forms of Foraminiferal organisation. For whilst *Operculina* is (so to speak) a "vitreous" *Peneroplis*, and *Heterostegina* a "vitreous" *Orbiculina*, we have in *Cycloclypeus*, which shows a perfectly cyclical mode of growth in a finely tubulated shell, the "vitreous" parallel of *Orbitolites*; the parallelism being completed by the existence, in the probably "vitreous" *Fusulina*,[1] of the same plan of growth around an elongated axis as is shown in the "porcellanous" *Alveolina*.

In the same concluding summary (1860) I presented, as results of my researches, certain "general propositions" (p. 584), which I think it desirable here to reproduce; because, as my original investigation of the forms of the genus *Orbitolites* then known to

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[1] I was obliged at that time to speak with hesitation of the place thus assigned to *Fusulina* (whose fossil shells make up the bulk of certain beds of Carboniferous limestone in Russia and elsewhere), "the metamorphic condition of its shell interfering with the minute study of its structure"; but a subsequent examination of specimens well preserved in the clays of the Carboniferous limestone of Iowa has satisfied me that my original interpretation of its microscopic appearances was correct (*Monthly Micr. Journ.*, vol. iii, 1870, p. 180). By previous systematists, *Fusulina* had been generally associated with *Alveolina*, to which its external resemblance is most remarkable.

me had been the starting-point of my rearrangement of the entire group,—of which it is one of the most conspicuous members,—so the examination I have now made, after a lapse of thirty years, of the vastly greater collection of more diversified forms recently obtained, has given me the opportunity of testing those conclusions by their applicability to a far larger range of facts.

I. "The range of variation is so great among FORAMINIFERA, as to include not merely the differential characters which systematists, proceeding upon the ordinary methods, have accounted *specific*, but also those upon which the greatest part of the *genera* of this group have been founded, and even in some instances those of its *orders*."

No verification of this proposition could be more complete than that afforded by the discovery of the *Orbitolites tenuissima* just referred to. If its development were arrested in its first stage, it would be taken for a young *Cornuspira*; if in its second, it would be ranked as a *Spiroloculina*; if its third stage had been first a little prolonged, and then checked, it would be recognised as a true *Peneroplis*; a specimen which had attained its fourth would be accepted as a true *Orbiculina*; and only when it has entered its fifth and last does it attain that characteristic Orbitoline structure and cyclical plan of growth, which are manifested in the typical *Orbitolites* from the very commencement. Now in the Classification of M. d'Orbigny, which was in 1860 the one generally followed, *Cornuspira* should, in virtue of its undivided cavity, count as a "Monostègue," *Spiroloculina* is an "Enallostègue," *Peneroplis* and *Orbiculina* are "Hélicostègues," and *Orbitolites* is a "Cyclostègue." That the fundamental characters of four out of the seven Orders which constitute, in M. d'Orbigny's view, the primary subdivisions of the group, should be thus presented by one and the same individual in the successive stages of its growth, is a sufficient proof that those assemblages cannot possibly be *natural*; and the proof obviously applies, *a fortiori*, to their generic subdivision; a very marked example being presented by the relation between *Orbiculina* and *Orbitolites*,—some advanced forms of *Orbiculina* abandoning the spiral for the cyclical plan of growth characteristic of the Orbitoline type, whilst all, save the highest and most advanced forms of *Orbitolites*, exhibit in the earlier stages of their development more or less of the spiral arrangement of their chamberlets, which is the distinctive characteristic of the Orbiculine type.

II. "The ordinary notion of *species* as assemblages of individuals marked out from each other by definite characters that have been genetically transmitted from original prototypes similarly distinguished, is quite inapplicable to the group of FORAMINIFERA; since even if the limits of such assemblages were extended so as to include what would elsewhere be accounted genera, they would still be found so intimately connected by gradational links, that definite lines of demarcation could not be drawn between them."

Not only have my own subsequent studies of this group fully confirmed me in this conclusion, but I have found it accepted by every one of my fellow-workers in this country whose range of study has been similarly wide;[1] the doctrine that in each of the two great series of Porcellanea and Vitrea "everything passes into everything else" being one in which my friends W. K. Parker, T. Rupert Jones, and H. B. Brady entirely accord with me. Not the less, however, do we all recognise the fact that particular types of form *are* transmitted with marked genetic continuity, and the necessity, for the purposes of systematic arrangement and description, of marking these types by distinctive generic and specific names.

The genus *Orbitolites*, as shall presently appear, furnishes a peculiarly illustrative example of our mode of dealing with the subject. Four very well-marked types of form present themselves, round which the entire assemblage of specimens collected over a very wide geographical area, and from a great bathymetrical range, can be arranged without difficulty. Three of them belong to the littoral zone of warmer seas, where (as on the Fiji reef) they are generally found living together; and they differ in little else than *grade of development*, the smallest and simplest (*Orbitolites marginalis*) retaining the greatest resemblance to what may with almost certainty be regarded as the common ancestral type of *Orbitolites* and *Orbiculina;* the next (*Orbitolites duplex*) being a transitional form, in which the generalised ancestral characters very early give place to the distinctive peculiarity of the Orbitoline type, while an indication is given of advance towards the complexity of the highest and most specialised form; and the third (*Orbitolites complanata*) being the one which shows all the peculiarities of the type

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[1] It is quite true that our conclusions on this point are not accepted by several Continental zoologists and palæontologists of repute. Prof. Möbius, for example, who a few years since brought home a gathering of *Foraminifera* from a reef off Mauritius, has expressed his dissent from it, on the ground that he sees no reason to believe that species are less sharply defined among *Foraminifera* than they are in other groups of the Animal Kingdom, and that it is a logical error to pass at once from the *individual* to the *genus*. Now I find in Prof. Möbius's own valuable monograph (Foraminifera von Mauritius) a very characteristic illustration of our position. The form he has described as *Orbitolites complanata* is so far from being a characteristic example of that species, that not only the central (or earlier) portion of the animal figured by him (pl. IV., wrongly lettered III., fig. 5), but the whole disk of which he gives a vertical section (pl. V. fig. 2), save its three outer annuli, is formed upon the plan characteristic of my *Orbitolites duplex*, his specimen being a young example of one of the *transitional* forms above adverted to. Now if Prof. Möbius should reply that the existence of such forms only shows that our conception of Foraminiferal species should be enlarged, and that the type I have here distinguished as *Orbitolites duplex* should be merged in *Orbitolites complanata*, I have simply to reply that as the two types are well and clearly differentiated in the hundreds of specimens of each which have passed under my review, and as *Orbitolites duplex* is much more nearly allied in the "simplicity" of its structure to *Orbitolites marginalis* than it is to the "complex" *Orbitolites complanata*, the utmost confusion would be the result of such an enlargement of our conception of the latter, as would be necessary to enable it to include the former. If Prof. Möbius will attentively study Part III. of my Researches on the Foraminifera (*Phil. Trans.*, 1859), he will find that, on the logical principle he advocates, our conception of his *Peneroplis pertusus* must be enlarged to include not only all the species of the genus *Peneroplis*, but also those of the genera *Dendritina* and *Spirolina;* for my series of forms of these types, collected from a very wide geographical area, and under very diversified conditions of climate and sea-depth, shows such a *gradational* passage from one type to another, that it is impossible to break up the assemblage into even *primary* groups—much less into *secondary*—that could be limited by precise definitions. I may add that before committing myself to the publication of an opinion which was at that time opposed to the doctrine taught by all the highest authorities in Systematic Zoology, I had the advantage of submitting it to the criticism of M. Deshayes, one of the ablest Conchologists then living; who, after an attentive examination of the series which I placed before him, avowed his inability to draw a definite line of demarcation through any part of it. And yet to abolish *Peneroplis*, *Dendritina*, and *Spirolina* as "generic types" would be out of the question.

in their very highest grade of development. And yet, whilst these three types of form are so well marked, and so constantly reproduced genetically, that the whole Challenger collection (with an exception to be presently referred to) can be ranged under one or another of them, yet even in the assemblage that is characterised by the most complex type of structure, certain individuals are found, which, in the earlier stages of their development, are no less characteristically representative of the lowest and intermediate. But the fourth of these specific types, *Orbitolites tenuissima*, in which the pedigree just now traced-out presents itself most completely and unmistakably, is not only (so far as is yet known) remarkably constant in its characters, but, whilst constructed on the very simplest plan, is separated from *Orbitolites marginalis* (which is precisely on the same grade of development with itself) by very sharply-defined peculiarities of its own. And it is not a little remarkable that its *habitat* should be almost entirely different from that of the other three; its home being apparently in the cold depths of the North Atlantic, whence it has strayed into the littoral zone of the Iberian peninsula, and thence along the Mediterranean into the Ægean, where it encounters a similar "outlier" of *Orbitolites marginalis*, which has probably found its way thither through the Red Sea.

III. "The only natural classification of the vast aggregate of diversified forms which this group contains will be one which ranges them according to their direction and degree of divergence from a small number of principal family types; and any subordinate groupings of genera and species which may be adopted for the convenience of description and nomenclature, must be regarded merely as assemblages of forms characterised by the nature and degree of the modifications of the original type, which they may have respectively acquired in the course of genetic descent from a common ancestry."

Of this principle, the evidence I have now to present of the genetic derivation of the most complex and highly-specialised Orbitoline type from the simplest and most generalised Milioline, will be found—to say the least—peculiarly illustrative; its special value as a "Study in the Theory of Descent" consisting in this, that whilst the ancestral relations of the higher types of organisation are for the most part evinced in transitory phases of development, of which few or even no traces may remain in the adult, we here find the whole genetic history distinctly recognisable in the completed type.

Having thus set forth what I regard as the principles on which alone a Natural System of the FORAMINIFERA generally can be framed, I shall proceed to apply these in the description I have now to give of the genus *Orbitolites*, and of the specific types which my enlarged study of it now enables me to recognise.

DESCRIPTION OF GENUS AND SPECIES.

Orbitolites, Lamarck.

Orbitolites, Lamarck, Système des Animaux sans Vertèbres (1801).
Orbulites, Lamarck, Histoire Naturelle des Animaux sans Vertèbres [1816–22].
Orbitolites, Milne-Edwards, in posthumous edition of Lamarck's Animaux sans Vertèbres.
Marginopora, Quoy and Gaimard, in De Blainville's Manuel de l'Actinologie, p. 412 [1834].
Orbitolites, d'Orbigny, Cours Élémentaire de Paléontologie [1849].
Orbiculina, Williamson, Trans. Micr. Soc., vol. iii. [1852].

The fundamental distinction of this Generic type, which separates it from all other "porcellanous"-shelled Foraminifera (the existing genus *Cycloclypeus*, Carpenter, and the fossil genus *Orbitoides*, d'Orbigny, representing it in the "vitreous" series), consists in its *cyclical* plan of growth, that is, in the arrangement of the sub-segments of the sarcodic body of the animal, connected together by *annular* "stolons," in concentric zones; a new annulus being formed by the extension of *radial* sarcodic "stolon-processes" from the last or outermost of the preceding annuli, giving origin to a new circlet of sarcodic masses, which put forth lateral extensions that unite them with their fellows, and thus complete the ring (fig. 1). The innermost of these sarcodic rings

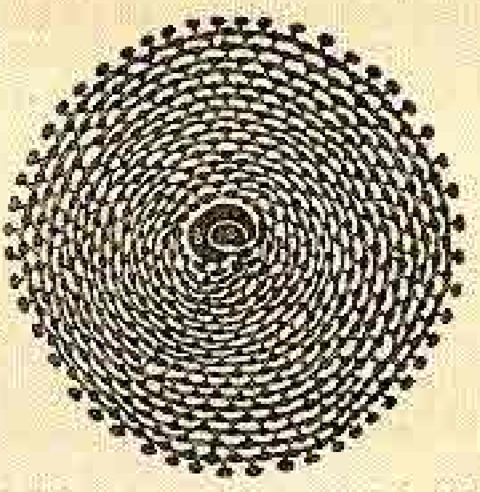

Fig. 1.—Cyclical arrangement of parts of sarcodic Body of *Orbitolites*

a, Primordial segment.
b, Circumambient segment; each subsequent formation divided into sub-segments connected by annular stolons, and each annulus connected with the next by radial stolon-processes.

is produced by pullulation from the circumference of the first-formed *nucleus*,[1] which occupies the centre of the disk; and this "nucleus" consists of a "primordial segment" *a*, from one end of which is given off a larger "circumambient segment" *b*, which passes completely round it, and is itself surrounded by the first annulus. The shelly disk (fig. 2) which encloses this sarcodic body, and is (so to speak) modelled upon it, is marked on each surface by a series of distinct concentric circles, the spaces between which are channeled-out in the interior into concentric series of chamberlets, connected together by annular galleries; and the cavitary space of each zone is connected with that of the next by short radial passages, of which one usually passes-off from one of the short galleries that connect the chamberlets of each zone, into a chamberlet of the zone that surrounds it. These passages, in the outermost zone, open as "pores" on the margin of the disk; these orifices constituting the only means of communication between the cavitary system of the disk and the outer world. Each concentric zone, when itself the outermost, thus communicated *directly* with the exterior; but each, when surrounded by another zone, can only do so through its intermediation, what were in the first place its *marginal* pores, being closed-in by a new annulus of shell, and opening into its chamberlets. The "nucleus" of the shell, round which its first annulus is formed, contains a "primordial chamber" (fig. 2, *a*), surrounded by a "circumambient chamber" *b*; and, in the highest or most specialised representatives of the Orbitoline type, radial passages (*e*, *e*, *e*, fig. 3) are given-off from the whole circumference of this "circumambient" chamber, which carry stolon-processes (Pl. V. fig. 18) that swell into the sarcodic sub-segments which occupy the successive annular series of chamberlets *c*, *c*, *c*.

FIG. 2.—Typical plan of structure of shelly Disk of *Orbitolites*.

a, Primordial chamber.

b, Circumambient chamber; together forming a "nucleus," which is surrounded by concentric rings of chamberlets connected with each other by annular galleries and radial passages, the latter appearing as pores along the margin.

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[1] This use of a term which has an altogether different and well-understood signification in Biology, is doubtless open to objection; and I can only plead in excuse that having employed it in my original Memoir, published when that signification was far more limited, I have not been now able to think of any other which should be equally applicable. The term *centrum* might have been substituted, if it were not that (as I shall hereafter show) the "nucleus" is often eccentric.

The "simple" ground-plan is amplified in the "complex" edifice built-up on it by a sort of vertical piling of one storey on another, marked externally by the multiplication of the rows of marginal pores. In so far as this is effected by the vertical extension of the sarcodic sub-segments into columns, and by an addition to the number of their annular and radial stolon-processes, the increase may be regarded—like the successive addition of new zones to the periphery—as consisting in *growth* only. But when, instead of a multiplication of similar parts, we meet with a *differentiation* in the arrangement of these, if not in their character, shown in a separation of the two superficial layers of chamberlets from the intermediate structure (Pl. VI. fig. 4), by which the "complexity" of the calcareous fabric is considerably increased, this differentiation must be regarded as an act of *development*, marking the highest stage of the evolution of the type.

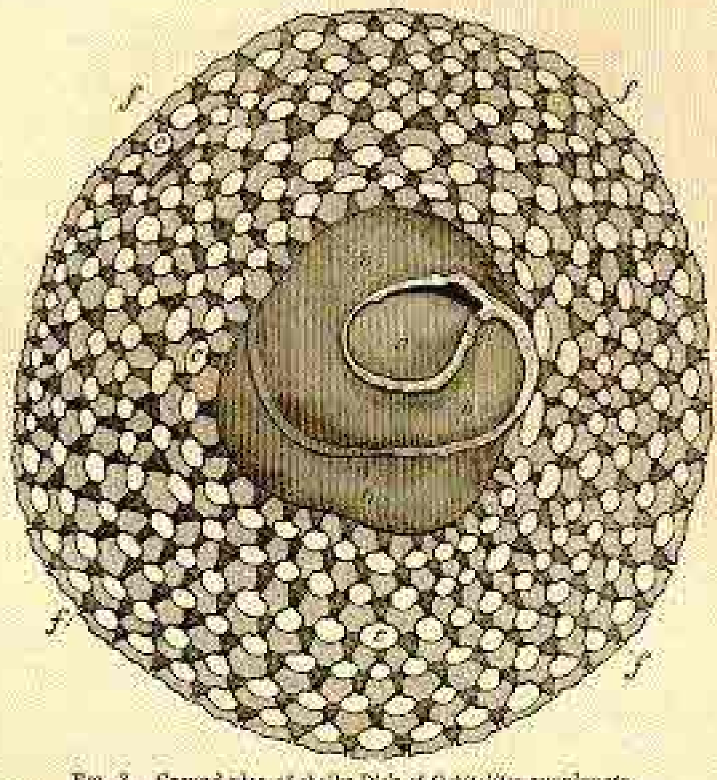

Fig. 3.—Ground-plan of shelly Disk of *Orbitolites complanata*.

a, Primordial chamber.
b, b, Circumambient chamber; a part (b′) of which is often partially cut off from the rest by an imperfect partition.
c, c, c, Chamberlets of different successive annuli.
d, Passage from primordial into circumambient chamber.
e, e, Radial passages from circumambient chamber into chamberlets of first annulus.
f, f, Radial passages opening at the margin of the disk as marginal pores.

I have not been able, however, to detect any evidence of local differentiation in the substance of the sarcodic body; every part of which, even in the most complex forms, seems to have the same character as every other part. A curious evidence of this absence of differentiation is afforded by the fact, that in all the specimens in which the sarcodic body has been preserved in alcohol, the cavities of several outer zones are quite empty, whilst those of the "nucleus" and inner zones are quite filled. For the shrinkage of the sarcodic substance, produced by the corrugating action of the spirit, has drawn the substance of the peripheral annuli towards the central portion of the disk; and this could not happen, but for the entire absence,—*first*, of any attachment of the body to the walls of the cavities that enclose it, and, *second*, of any resistance to the complete change of form it must undergo, to allow the passage of the substance that occupies the chamberlets of the outer zones, through the narrow connecting passages which lead to the inner cavities of the disk, in which it so completely fuses with their own body-substance, as not to present the least appearance of heterogeneousness.

This absence of differentiation is further made apparent by the extraordinary reparative power possessed by every form of *Orbitolites*; not only losses of substance to any amount and in any part of the disk being made good, but even a small detached peripheral fragment having the power to develop a new disk, as shown in Pl. I. figs. 6, 7, and in Pl. VIII. figs. 2–10. It is clear that connection with the central "nucleus" is not in the least degree requisite for the continued growth of the peripheral part; and it is also clear that after the cyclical stage of growth has been once attained, the reparative process is entirely directed to the reproduction of the complete discoidal form. This is obviously to be explained by an extension of the homogeneous sarcodic body-substance around the whole margin of the fragment, so as to form an annulus which buds-off a new and complete circlet of chamberlets.

Thus, we have every reason to believe, each sub-segment of the sarcodic body precisely repeats the rest, and would be equally capable of maintaining its own existence if detached from the disk of which it forms part. It is clear that the inner portion of the disk can only be nourished through the intermediation of the outer, as it has no communication with the medium around, except through the marginal pores; and from the analogy of other Rhizopods there is strong reason to believe that during life there is a continual flow of semi-fluid protoplasm from one part to another, so that any nutrient material obtained by the peripheral annulus from without is speedily diffused through the entire mass.

Owing to the smallness of the number of spirit-specimens of the deep-sea type, *Orbitolites tenuissima*, that have come into my possession, I have not thought it well to decalcify any one of them for the examination of its very attenuated body. But the superficial lamellæ which close-in the chamberlets are so transparent, that the general condition of the protoplasmic substance which occupies them can be pretty clearly made out. This seems to have the dark olive-green hue, which is commonly met with in the sarcodic body of the "arenaceous" deep-sea Foraminifera; and it does not present the corpuscular aspect which I shall presently describe in the sarcodic bodies of *Orbitolites duplex* and *Orbitolites complanata*. But in one of these specimens several nuclear-looking bodies can be plainly discerned, which correspond in size and appearance with the nuclei described by Hertwig in the fresh-water monothalamous *Microgromia*,[1] and subsequently in *Spiroloculina*, *Globigerina*, *Rotalia*, and other marine polythalamous forms.[2] The very irregular distribution of these nucleus-like bodies shows that they cannot have any particular *local* function. In the specimen here figured (Pl. II. fig. 1) two of the outer half-whorls of the Spiroloculine centre (shown on a larger scale at *b*, *b*, *b′*, *b′*, fig. 4) are crowded with them, while in a single chamberlet (*c*) of one of the interior zones there are as many as five. Elsewhere they present themselves with less frequency, only one or two occurring in any single chamberlet (*d*, *d*, *d*), and a large proportion of the chamberlets being entirely devoid of them. Their diameter is about $\frac{1}{1750}$th of an inch.

The substance of the sarcodic bodies of *Orbitolites duplex* and *Orbitolites complanata*, on the other hand, consists in great part of an aggregation of spherical corpuscles about $\frac{1}{2000}$th inch in diameter, as shown under a power of 120 diameters in Pl. V. fig. 3, and magnified 180 times in fig. 16. These corpuscles might be easily taken for cells; but not only does a careful examination of them fail to bring into view either nucleus or limitary membrane, but they are found, when subjected to pressure, to break-up into a multitude of separate rounded granules, of extremely pellucid aspect, from $\frac{1}{8000}$th to $\frac{1}{12000}$th inch in diameter. Sometimes the spherical corpuscles are very closely packed together, especially in the primordial segment; in other instances there are considerable spaces between them, as shown in Pl. V. fig. 16.

The whole sarcodic body of *Orbitolites duplex* has a reddish tinge, which is most decided in the primordial and circumambient segments, and in the inner annuli of subsegments. And in these I can generally observe, more or less distinctly, a limiting membrane (Pl. V. fig. 5), sometimes rather deeply tinged with red, which is probably of a chitinous nature. On the other hand, scattered irregularly in different parts of the disk, certain bodies present themselves (Pl. V. figs. 4, *a*, *b*, *c*, 15, 17), which have a much more distinct cellular nature, having a very thick (apparently cellulose) cell-wall, and a deep red endochrome. These I am strongly inclined to regard as vegetable. Their diameter (usually about $\frac{1}{400}$th inch) is much too great to allow them to have passed through the marginal pores in their present condition; but as there are now several well-established cases of parasitic vegetation, I cannot think it impossible that the germs of these cells found their way in from without, and have undergone their subsequent development in the places they now occupy. The living specimens of the "duplex" type were for the most part obtained in the 18 fathoms' dredging on the bank of the Fiji reef; and it does not seem improbable that their sarcodic bodies derive their red hue from zoospores or other particles of the Rhodosperm *Algæ* inhabiting that zone, which they may take-in as food. For the sarcodic bodies of *Orbitolites complanata*, whose living specimens

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[1] *Archiv. für Mikroskop. Anat.*, Bd. x. Supplement-heft.

[2] *Jenaische Zeitschrift*, Bd. ix.–xi.

were for the most part found on the surface of the reef, have a greenish tinge, as if they lived on the corresponding particles of the Chlorosperm *Algæ*. When growing attached to marine plants, the animal bodies of *Orbitolites* may be nourished by the gelatinous investment with which those plants are covered. In my former Memoir I mentioned that some of the spirit-specimens I had then examined by decalcification proved to be invested by a sort of cuticle formed of *Diatoms*, *Desmids*, and other minute *Algæ*; but I have not met with any such investment among the large number of spirit-specimens of both types which I have examined in the Challenger collection.

As to the Reproduction of *Orbitolites*, I regret to be unable to afford the least information, having searched in vain for any further evidence of the mode in which it is effected, than that which I had formerly obtained. In my Introduction to the Study of the Foraminifera (p. 38) I described and figured some extremely young specimens of *Orbitolites*, consisting only of the "nucleus" and a single annulus of sub-segments,—which had been taken out from the grooved margin of a large plicated disk, resembling those figured in Pl. VII. And I have found similar specimens in the same situation in some of the large Fijian disks.[1] As I shall hereafter state more in detail, the marginal annuli of the largest disks often have no radial partitions, their cavities being continuously annular; and as the thin external walls of these annuli, being unsupported by internal partitions, are very fragile, it may not be thought unlikely that gemmules may be formed within these peripheral zones, which may be set free by the rupture of this wall, and may retain for a time the protection of the overhanging superficial lamellæ, which form a deep channel for their lodgment. Of a very curious variation in the *mode of growth* of *Orbitolites complanata*, which seems constantly related to the *size* of the "nucleus" in which it commences, particulars will be given hereafter (pp. 38, 41).

1. *Orbitolites tenuissima*, Carpenter (Pls. I. and II.).

Orbitolites tenuissimus, Carpenter and Jeffreys, Proc. Roy. Soc., vol. xviii., 1869, p. 421, and vol. xix., 1870, p. 155.

This very beautiful and most interesting form of the Orbitoline type (Pls. I. and II.) was first obtained in the deep-sea dredgings of the "Porcupine" expedition of 1869, between the north-west of Ireland and the Rockall Bank; and has been subsequently brought up from abyssal depths in other parts of the North Atlantic, as also from shore bottoms off the coast of Portugal, and within the Mediterranean. It is at once distinguished from all other specific forms by the extreme disproportion between the area and the thickness of its disks; for whilst its largest examples approach in diameter the smaller specimens of *Orbitolites complanata*, and their surface presents the same regular

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[1] Such young disks will be found represented in Pl. XVI. figs. 1-4, of Mr. Brady's Report on the Foraminifera of the Challenger Expedition, Zool. Chall. Exp., part xxii.

arrangement of concentric annuli crossed by straight radiating lines (compare Pl. I. fig. 1 with Pl. VI. fig. 4), their thickness does not exceed that of the smallest specimens of *Orbitolites marginalis*, with which this type corresponds in the simplicity of its structure (indicated by the singleness of the row of pores along its margin), but from which it is obviously differentiated by the shape of its chamberlets, indicated by its surface-markings.

The disks of this species, which are usually remarkable for their flatness and regularity, seem to attain a diameter of at least 0·6 inch; but specimens of that size are seldom or never brought up entire, their extreme tenuity, and the slight adhesion of their successive annuli to each other, rendering them extremely fragile. Their thickness does not exceed $\frac{1}{500}$th of an inch. The inner margin of each shelly annulus is slightly grooved, as shown in Pl. I. fig. 4; and the two edges of this groove embrace the thin edge of the preceding annulus, as shown in sectional view at *a*, *a*, fig. 3. In all but the central portion of these disks (Pl. I. fig. 1), the annuli are complete and of nearly uniform breadth; but the inner portion of the disk shows a marked excentricity, the "nucleus" being considerably out of centre, and the first-formed zones being developed from one side of it only; so that it is not until after repeated additions, that the *cyclical* plan of growth characteristic of the Orbitoline type comes to be established. When the cavity of the disk is laid open, either by grinding or by the action of dilute acid on its thin superficial lamellæ, or even when an unaltered specimen mounted in Canada balsam is viewed by transmitted light, the radiating lines with which the surface is marked are seen to correspond with internal partitions (Pl. I. fig. 2, and Pl. II. fig. 5), which divide each flattened annular chamber into a multitude of narrow chamberlets. This division, however, is not complete; for the radial partitions do not extend to the outer margin of the annulus, so that a sort of gallery is left, into which every one of the chamberlets opens at its outer end. The septum which forms the peripheral wall of this gallery is perforated by pores at regular intervals; and each of these opens into a chamberlet of the next annulus,—those of the outermost annulus opening along the margin of the disk (Pl. I. fig. 5). It is characteristic of this species that the pores are more or less elongated in the plane of the disk, instead of being either circular or vertically-oval, as they are in other *Orbitolites*. Similar pores are seen on the internal (fig. 4) as well as the external margin of any zone that has been detached by fracture; and it is obvious that they constitute the channels of communication between the central and peripheral portions of the cavitary system; whilst the annular galleries, seen in transverse section at *b*, *b*, *b*, fig. 3, maintain the like continuity between the different portions of each zone. Thus, whatever may be the number of these concentric annuli, a perfectly free communication exists throughout; the departure shown in this species from the general plan of structure already described, having reference only to the shape of the chamberlets, and their relation to the undivided gallery. And it is at once seen that this departure marks out *Orbitolites tenuissima* as an earlier and less specialised form; since if the chambers of a *Peneroplis* were subdivided by partitions answering to its surface-markings (fig. 7, p. 46), springing from their inner septa between the pores, but not extending to their outer, the result would be exactly what we here find.

Now the peculiar point of interest attaching to this *Orbitolites tenuissima*, is that the structure of the inner part of every disk shows it to have thus originated: for the "nucleus" is here a continuous spire of five or six turns (Pl. II. fig. 3), closely resembling that of a young *Cornuspira*, with an indication of imperfect septal interruptions resembling those of a *Spiroloculina*; the spire, when beginning to open-out (fig. 5, *a*), is interrupted by a complete septum traversed by pores, exactly corresponding to that of *Peneroplis*: whilst the next chamber, *b*, is divided into four chamberlets by three partitions springing from this septum between its pores, this subdivision converting the incipient *Peneroplis* into a young *Orbiculina*. In the specimen here figured, this chamber is not separated by a completely-formed septum from the next chamber *c*, and the latter is undivided save by a single radial partition; and although this is a mere individual variation, it is of interest as showing a reversion to the "peneropline" type, even after the assumption of the "orbiculine." The orbiculine type prevails through several succeeding chamber-additions; but the *spiral* plan of growth characteristic of it soon begins to give place to the *cyclical*; for the next-formed chamber *d*, *d*, which is divided into chamberlets by radiating partitions that spring from the inner septum between the pores, sends backwards alar extensions *d′*, *d′*, which begin to enclose the spiral "nucleus." This extension is still more marked in the next chamber *e*, *e*, whose two alæ, *e′*, *e′*, reach the ends of the transverse diameter of the original spire; and the alæ of the subsequently-formed chambers extend themselves further and further back around the spire (as shown in Pl. I. fig. 1), until—in the specimen here figured—those of the ninth chamber meet at the opposite side of the spire, so as to enclose it all round, while the tenth forms the first complete annulus, to be itself surrounded by a succession of similar annuli, the number of which in full-sized specimens may exceed thirty.

Thus we have, in this one organism, a complete transition from the simple slightly interrupted spiral tube of the least differentiated *Miliolines*, through the expanded and chambered spire of *Peneroplis*, and the chamberletted spire of *Orbiculina*, to the concentric annulation and subdivided chambers of the typical *Orbitolites*. And we shall presently see how this last plan undergoes, in other species, a progressive modification, until, in its most specialised types, we lose all trace of derivation from a spiral,—the annuli being formed concentrically, from their very commencement, around a discoidal "nucleus," and their chamberlets being so modified in shape and disposition, as not to suggest their origin in the subdivision of a *Peneroplis*-chamber by radial partitions.

Reparations.—As might be expected from the extreme tenuity and fragility of the disks of this species, they are obviously very liable to fracture; scarcely any specimen having presented itself which did not bear some evidence of injury of this kind. Where only small portions of the margin are broken away, the next-formed annuli extend themselves along the fractured edge; and thus the cyclical mode of growth is completely maintained, with only a temporary irregularity. In Pl. I. fig. 6, is shown a disk of which more than one-half, together with the "nucleus," had been lost before the production of the last two zones. These have not only been formed, as ordinarily, round the unbroken margin, but have extended themselves along the fractured edge, and have even filled up the space originally occupied by the "nucleus"; and the annuli being thus completed, the disk will continue to grow on the cyclical plan, and even (as is shown in the like examples of *Orbitolites complanata*, Pl. VIII.) may recover in great degree its circular shape. But even a mere fragment broken away from the margin of a disk may suffice to originate a new one, as shown in Pl. I. fig. 7; the form characteristic of the type being completely restored. Owing to the transparence of this specimen, I have been able to assure myself that *every part* of the margin of this fragment—whether broken or unbroken, peripheral, central or lateral—has contributed to the formation of the first new complete annulus, by which the foundation was laid of the subsequent regular series of concentric zones; thus clearly indicating that a sarcodic extension took place from every chamberlet laid open by the fracture, as well as from the normal pores of the last septal plane, and that these extensions coalesced to form a continuous ring, as in the formation of the ordinary succession of concentric annuli. It is most interesting to observe that the zone of chamberlets to which this sarcodic ring gave origin is formed upon the *perfected* type, without any reversion to the earlier "peneropline" stage.

Geographical and Bathymetrical Distribution.—So far as is at present known, *Orbitolites tenuissima* inhabits only the North Atlantic Ocean and the seas in communication with it. The first complete specimens of this type were obtained in the "Porcupine" dredgings of 1869, at depths of from 630 to 1443 fathoms, between the north-west of Ireland and Rockall Bank. In the "Porcupine" expedition of 1870, however, it was brought up from a bottom of only 64 fathoms, in Setubal Bay on the coast of Portugal, and afterwards from a shallow bottom within the Mediterranean, near Carthagena. That it is an inhabitant of other parts of the Mediterranean I then inferred from having detected fragments of it in the Foraminiferal dredgings made at 250 fathoms' depth by Prof. Edward Forbes and Lieut. (now Admiral) Spratt in the Ægean, in 1842; and it is stated by the Rev. A. M. Norman, in Dr. J. Gwyn Jeffreys's Report on the "Valorous" cruise, that it has been dredged by the Marquis da Monterosato, at from 100 to 200 fathoms' depth, off the coast of Sicily. That it might extend far to the north, would be expected from its capability of bearing the low temperature of 37° Fahr., which prevails over the deep bottom from which it was first brought up; and this expectation was verified by its presenting itself in one of the

"Valorous" dredgings in Baffin's Bay (lat. 62° 6′ N., depth 1350 fathoms, bottom temperature 34°·6 Fahr.), as well as at two Stations in the North Atlantic, both in the parallel of 56°,—No. 12, depth 1450 fathoms, and No. 13, depth 690 fathoms.[1] It has been only once brought up in the Challenger expedition, viz., at Station 44, off Cape Hatteras, on a bottom of 1700 fathoms, over which creeps (there is strong reason to believe) an under-flow of cold water from the Arctic basin. It has since, I understand, been found plentifully in a dredging taken by the "Travailleur," in the Bay of Biscay (Fosse de Cape Breton), at a depth of 1200 fathoms.—It would seem, therefore, that *Orbitolites tenuissima* has its proper home on the sea-bottom of the deeper parts of the North Atlantic, where the temperature ranges from 37° Fahr. downwards; but that it is also capable of living, not only in much shallower, but also in much warmer waters. For the temperature of the Mediterranean and Ægean, even at depths below 100 fathoms, is never less than 54°; whilst on the shallow bottom of Setubal Bay, and the shore-slope near Carthagena, the summer temperature must be considerably higher.

Looking to the singular retention, in this beautiful Orbitoline, of the Milioline type, its derivation from which may now be confidently affirmed, and also to that elongated form of its chamberlets which seems to mark it out as more nearly related than either of the other "simple" types to *Peneroplis*, the probability seems strong that it was a very early form; and although no specimens of it have yet been met with in the fossil state, its absence from the Geological Record may be considered as sufficiently accounted for by its extreme fragility. I need scarcely point out how completely the idea of its antiquity is borne out by its persistence in the abyssal depths of the North Atlantic,—the home of so many other early types of animal life.

2. *Orbitolites marginalis*, Lamarck (Pl. III. figs. 1–7, Pl. IV. figs. 1–5).

Orbitolites marginalis, Lamarck, Syst. des Anim. sans Vertèbres [1801].

Sorites orbiculus, Ehrenberg, Familien und Gattungen der Polythalamien. Abhandl. der König. Akad. der Wissenschaften zu Berlin, 1839.

Orbiculina complanata, Williamson, Trans. Micr. Soc., vol. iii., 1852, p. 115.

This species was established by Lamarck on the basis of specimens discovered by M. Sionest of Lyon, attached to corallines, fuci, &c., in the Mediterranean; and was the only recent type of the genus then known. Lamarck's description of it—*utrinque plana, margine poroso*—is quite insufficient to differentiate it either from the preceding or from the species I shall have subsequently to describe; but as no other Orbitolite is known to inhabit the Mediterranean or Ægean, there is no difficulty in specifically identifying the Lamarckian type with the more highly developed examples of it which are found in the Red Sea, on the coast of Australia, in the Philippine Sea, and on the Fiji reef. The

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[1] *Proc. Roy. Soc.*, June 15, 1876.

diameter of Lamarck's specimens is stated by him at only 2 mm., or about 0·08 inch; but that of the Fijian specimens ranges to 0·2 inch, or somewhat more. The form of the complete disks (Pl. III. fig. 1), when their growth has not been interrupted by injury, is very regularly circular; and their surface, in all but their central portion, is marked by concentric circles that divide it into annuli having a pretty constant breadth of $\frac{1}{100}$th inch, each of them marked at regular intervals by dark punctations. When the surface of a peripheral portion of the disk is viewed by reflected light under a higher magnifying power (Pl. III. fig. 3), each of these punctations shows itself as a dark spot surrounded by a lighter space, which is often somewhat elevated; and if the margin of the disk is viewed obliquely, as at *a*, these circles are seen to be the summits of rows of short cylindrical columns, whose projection gives a slight "fluting" to the edge of the disk. When the edge of the disk is turned directly towards the eye (as at fig. 4, *a*), a single marginal pore is seen in each of the depressions between the columnar projections: this pore is usually elongated vertically, so as to form a fissure; and sometimes, when the margin of the disk is unusually thick, as at *b*, the fissure is crossed by a shelly bridge, dividing it into two pores. This, however, is not a real duplication of the pores, such as that which is seen at the margin of the species to be presently described (fig. 13). The central portion of the disk (fig. 2) resembles that of *Orbitolites tenuissima* in the excentricity of its "nucleus," and the incompleteness of the rows of chamberlets first developed around it; presenting in this stage of its growth exactly that conformity to the *spiral* plan, which is shown in the third or "orbiculine" stage of the preceding, and the same early approach to the *cyclical*, which is made by the extension of each new row of chamberlets beyond its predecessor, so that the two ends of the eighth or ninth row meet on the opposite side of the nucleus, forming the first complete annulus.

Although the "nucleus" itself shows more conformity to the Orbitoline than to the Milioline type,—consisting of a rather large primordial chamber nearly surrounded by a circumambient chamber,—yet its character will be presently seen to be most singularly intermediate between the two. Not unfrequently the "orbiculine" centre of the disk is somewhat thicker than the annular portion by which it is immediately surrounded, so as to form a marked projection from its surface. As new annuli are added-on, however, to the exterior of those first formed, and as the vertical thickness of each is usually rather greater than that of its predecessor, the disk as a whole becomes somewhat biconcave.

The marginal thickness of the largest disks I have seen of this species is about 0·006 inch, or about one thirty-fifth of their diameter. The calcareous lamellæ which cover-in the ends of the columnar chamberlets, are so thin as to be translucent, and are very easily abraded; so that specimens of this type picked out from shore-sands often have the cavities of their chamberlets laid open, as shown in Pl. III. fig. 7. The amount of solid substance in these disks is far greater in proportion to the cavitary system, than in *Orbitolites tenuissima;* at least half the breadth of each annulus being occupied by the inter-annular septum, and the partitions that separate the adjoining chamberlets being also much thicker. These partitions are best brought into view by a concentric fracture separating one annulus from another, so that the outer series of chamberlets is laid open on its central aspect, as shown in fig. 5; but such a separation is much less easy in this type than in the preceding, in consequence of the much larger surface of adhesion between the successive annuli. When the cavitary system is laid open by a section in the radial direction, so as to traverse a succession of annuli (fig. 6), there is seen in each of the partitions that divide the chamberlets a large fissure on its peripheral side, by which the adjoining chamberlets of the same annulus are brought into connection. This fracture also shows that the columnar chamberlets of the marginal portion of the disk are not straight, but arcuate; their two extremities bending inwards, or towards its centre.

It is only, however, by reducing the thickness of the disk by grinding, so that it can be examined by transmitted light, that its internal structure can be properly traced out. If only one of its surfaces be ground away, so that the sectional plane passes near the other, it will traverse the chamberlets, but not the passage-system which connects them, as is seen in Pl. IV. figs. 1, 2, 3; but when this plane is made, by grinding from both surfaces alike, to pass through the middle of the thickness of the disk, the communications between the chamberlets are brought into view, as shown in fig. 4. Here we see the flask-shaped primordial chamber *a*, opening at its neck into the circumambient chamber *b*, which almost completely surrounds it; while from the other end of this, there issues a passage that leads into the undivided chamber *c*.

Taking this chamber as our starting-point for comparison with the "orbiculine" portion of the disk of *Orbitolites tenuissima,* we find the parallelism extremely close. The septal plane which bounds it externally is traversed by two passages that lead into two chamberlets *d*, which are connected with each other laterally by a passage left in the partition between them. The septal plane that closes-in these two chamberlets is traversed by five radial passages, leading to as many chamberlets in the next row *e;* of these passages two proceed from each of the chamberlets in row *d*, and one from the passage that connects them; and all five chamberlets are brought into lateral connection with each other by passages left in the radial partitions, as shown in Pl. III. fig. 6. The next septal plane is traversed by a radial passage from each of the passages of communication between the chamberlets of the preceding series, and also by passages from the chamberlets themselves; and as each of these leads to a chamberlet of the succeeding row, the number of these is further increased. The same mode of growth continues, until the lateral extension of the rows of chamberlets (each representing a single "peneropline" chamber) brings together their extremities so as to complete the circle;

and every new annulus that is afterwards formed, exhibits exactly the same arrangement. As a general rule, the chamberlets in each annulus *alternate* in position with those of the annuli internal and external to them; the radial passages which lead to them from the preceding annulus having their origin, not in its chamberlets, but in the annular passage that connects them. And it is only when an additional chamberlet is interpolated, in accordance with the increased diameter of the added ring, that the passage leading to it comes off directly from a chamberlet of the previous one. And thus it comes to pass that the pores seen along the margin of the disk (Pl. III. fig. 4) open *between* the columnar chamberlets, each of them communicating with the chamberlet on either side of it, as shown at *f*, *f*, Pl. IV. fig. 4.

The meaning of these arrangements is made clear by reference to Pl. IV. fig. 5, which shows the sarcodic body of *Orbitolites marginalis*, obtained by the solution of its calcareous shell by dilute acid. The primordial segment *a* communicates by a narrow pedicle or stolon-process with the circumambient segment *b*, and this, again, by a similar pedicle with the segment *c*, which answers to the segment *a*, Pl. II. fig. 1. From this are given off the two radial pedicles that enlarge into the two sub-segments *d*; and these are united laterally by a pedicle, that gives off the radial extension which enlarges into the sub-segment *e* of the next band. The same plan is maintained through each successive addition, the sub-segments of each row showing themselves as enlargements of a continuous cord of sarcode, on which they are threaded, as it were, like beads upon a string. Each row of sub-segments represents the entire segment which occupies the undivided chamber of a *Peneroplis;* and so, when the first annulus is completed by the meeting of the two extremities of that cord, it has still the same equivalent, which is, of course, equally to be recognised in all subsequent annuli. In the outer portions of the disk of *Orbitolites marginalis*, the sub-segments acquire a columnar form by vertical growth, which is in striking contrast with their extreme flattening in *Orbitolites tenuissima.*

Thus, not only in the "orbiculine" stage, but throughout the whole later growth of the disk in this type, we recognise the same essential features as in the preceding;—the subdivision of the "peneropline" chambers into chamberlets, and of the segments of the body into sub-segments, taking place on precisely the same plan in both, and exactly the same system of communications being maintained between the subdivisions;—the only difference being in the *form* of these subdivisions, which is obviously a character of comparatively trivial import. The question now suggests itself, what is the relation between the "spiroloculine" shell of *Orbitolites tenuissima*, and the "nucleus," consisting of "primordial chamber" and "circumambient chamber," of *Orbitolites marginalis*. This will be best answered by comparing the sarcodic bodies of the two types; for whilst the small primordial segment of the one gives off a long, slender, slightly interrupted cord, which coils round it several times before it begins to expand (Pl. II. fig. 1), the large primordial segment of the other gives off a far thicker cord, which only makes a single turn. It can scarcely be doubted, I think, that this circumambient segment represents the whole of the original "spiroloculine" coil drawn up into itself, and thus perpetuates, under a form which at first sight appears entirely unrelated, the "milioline" plan of origin; thereby giving the key to the import of this "nucleus" in the more specialised forms to which we shall next proceed.

From this point of view, it is a circumstance by no means insignificant, that even the varietal forms of this well-marked species present a gradational transition to the next, in the diminished excentricity of the "nucleus," the less marked restriction of outgrowth to one side of it, and the consequent earlier exchange of the spiral for the cyclical plan of growth.

Geographical and Bathymetrical Distribution.—This species appears to be pretty generally diffused along the littoral zone of the warmer temperate and tropical seas, being met with abundantly in shore-sands and in shallow-water dredgings. It seems least common, however, in West Indian seas, where it is replaced by the small varieties of *Orbiculina adunca.* The largest specimens of it hitherto obtained are those brought up in the 18 fathoms' dredging of the Challenger on the Fiji reef. So far as can be judged from the specimens contained in shore-sands, this type attains a much smaller size in the Red Sea, although numerically abundant. And it would seem to die out in the Mediterranean and Ægean, where it is a comparatively rare form, and stunted in its growth. Hence its most congenial habitat may be said to be the littoral zone of tropical or subtropical seas.—It is worthy of note that the small Red Sea disks often have their surface-layers thickened by an irregular exogenous deposit of shell-substance, which obscures the cyclical arrangement that is so conspicuous in the large Fijian specimens. The somewhat larger disks of Philippine and Australian shores often exhibit irregular radiations of such deposit; but between these radiations the cyclical arrangement is generally conspicuous.

Geological Distribution.—Among the *Orbitolites* that have been described as fossil there does not seem any that is distinctly referable to this type. I am inclined to think, however, that the *Cyclolina armorica* of d'Archiac, the *Archiacina armorica* of M. Munier-Chalmas (to whose kindness I am indebted for specimens of it), may be regarded as an ancestral form of *Orbitolites marginalis.* Though the diameter of its disk does not exceed that of the largest specimens of *Orbitolites marginalis,* its thickness is two or three times greater; this excess being partly due to the thickness of the superficial shell-deposits, and partly to that of the chambered layer they enclose. The cavitary system appears, in its earlier stage, to have been distinctly "peneropline," without division of the chambers into chamberlets; and to have early become "cyclical" by the extension of the chambers around the "peneropline" umbilicus, so that they completely enclose it annularly. But the chambers, instead of being partitioned into chamberlets, show only the indications of subdivision which are marked on the "internal casts" of the sarcodic body[1] as slight constrictions;—the type thus presenting as complete a link between the undivided "peneropline" and the labyrinthic "orbitoline" systems of chambering as it does between their respective geometrical plans of growth. It occurs in the "sables de Fontainbleau," near Rennes, which form part of the "Oligocene" Tertiaries.

3. *Orbitolites duplex*, Carpenter (Pl. III. figs. 8–14; Pl. IV. figs. 6–10; Pl. V. figs. 1–10).

Amphisorus hemprichii, Ehrenberg, Familien und Gattungen der Polythalamien. in Abhandl. der könig. Akad. der Wissenschaften zu Berlin, 1839.

Orbitolites, duplex type, Carpenter, Phil. Trans., 1856, pp. 220, 224, and Introd. to Study of *Foraminifera*, 1862, p. 118.

Orbitolites macropora (?), Lamarck, Animaux sans Vertèbres, ed. 2, tom. ii. p. 196; figured in Goldfuss's Petrefacta, pl. xii. fig. 8.

In my former Memoir (Phil. Trans., 1856, §§ 4, 59, 63) I indicated the existence of a well-marked type of Orbitoline structure, which differs from the ordinary "simple" type in having a double series of marginal pores, and from the "complex" in the limitation of the pores to two rows. My knowledge of this *duplex* type was at that time chiefly derived from the small and worn specimens of it which I had picked out of some shell-sand brought from the Red Sea; and these I could pretty certainly identify with the forms on which Prof. Ehrenberg had founded his genus *Amphisorus*, and which he had ranked with his *Sorites* (*Orbitolites marginalis*) among Bryozoa. But the large number of unworn specimens of this type—many of them alive when captured—that are contained in the collection made in the 18 fathoms' dredging of the Challenger on the Fiji reef, enables me now to furnish a more accurate and complete account of it than it was formerly in my power to give.[2] As this type is sufficiently and constantly differentiated by the character I have just specified, I designate it as *Orbitolites duplex*.

The disks of this species (Pl. III. fig. 8) have usually a very regular circular form, and a nearly plane surface; their thickness being almost uniform, with the exception that the inner or central portion of any disk is usually rather thinner than its outer or peripheral portion. The greatest diameter I have met with in the disks of this species is 0·32 inch, and the greatest thickness 0·012 inch, the proportion of the two dimensions being thus that of a

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[1] I am not fully satisfied that I am correct in my interpretation of the structure of this fossil; the *shell* of which seems to me to have undergone the same kind of softening that is common in that of deep-water *Miliolinæ*, whilst the cavitary system appears to have been occupied by a calcareous deposit of much firmer consistence.

[2] In my former description of it, I fell into the error of supposing that the doubling of the series of pores indicates the existence, not only of two tiers of chamberlets, but of two annular canals. There is, as I shall presently show, only a single annular canal, and, strictly speaking, but a single series of chamberlets, although there is frequently a want of continuity between the upper and under portions of each cylindrical cavity.

rather thin coin. Departures from the typical flatness, however, are not unfrequent; one of the most common being a sort of plaiting into radial folds, which, beginning near the centre, increases towards the margin—as is slightly indicated in the above-cited figure, but is more strongly shown in the specimen represented in Pl. XVI. fig. 7 of Mr. Brady's Report on the *Foraminifera*. Each surface of the disk is marked-out into regular concentric annuli; but the division between these is not so conspicuous as in *Orbitolites marginalis*; and specimens not unfrequently present themselves, whose surface in certain aspects looks rather "engine-turned" (like that of the section shown in Pl. IV. fig. 6) than concentrically annular. This appearance, however, does not mark any difference of internal structure, and seems to depend upon the manner in which the light is reflected from the thin films of shell-substance that cover-in the individual chamberlets, which are often slightly convex. When a portion of the surface of a specimen containing the sarcodic body of the animal is viewed under a sufficient power by reflected light (Pl. III. fig. 10) the cavity of every chamberlet is marked by a circular or oval spot, surrounded by a thick wall of shell-substance, which is divided by a definite line from the walls of contiguous chambers. It is further noticeable that the double wall which thus separates two contiguous chamberlets of the same annulus, is quite as thick as that which separates the chamberlets of consecutive annuli. The chamberlets of successive annuli generally alternate with one another in position, so as to lie in oblique rows, which, when the interior of the disk is viewed under a low magnifying power (Pl. IV. fig. 6), seem like parts of excentric circles.

The inner (first-formed) portion of the disk in *Orbitolites duplex* shows only a very slight approach to that "orbiculine" spire which is typical alike of *Orbitolites tenuissima* and of *Orbitolites marginalis*, approximating much more closely to the true cyclical plan of *Orbitolites complanata*. The nucleus consists, as in *Orbitolites marginalis*, of a small primordial chamber, which is surrounded by a circumambient chamber; and round this nucleus is seen (Pl. III. fig. 14) a row of chamberlets, which often at once forms a nearly entire annulus, the ring being soon completed in succeeding circlets, and all subsequent additions being made on the cyclical plan. When this nucleus is examined in thin section (Pl. IV. fig. 10) it is seen that this early assumption of the cyclical plan arises from the fact that the circumambient chamber *b*, *b'* gives off *several* passages on its outer margin, which lead into as many chamberlets; so that it is as completely surrounded by chamberlets, after three or four successive additions, as it is in *Orbitolites marginalis* (fig. 4) after twelve or more. In this particular, then, *Orbitolites duplex* presents us with a very interesting transition from *Orbitolites marginalis*, in which only a single chamber is put forth from the extremity of the circumambient chamber, to *Orbitolites complanata*, in which it sends forth passages round its entire margin, so that the very first series of chamberlets forms a complete annulus (Pl. VI. figs. 1, 2, 3). The arrangement of parts in the sarcodic body of the animal (Pl. V. fig. 6) entirely answers to the structure of the shell moulded upon it. The flask-shaped primordial segment *a* gives off the circumambient segments *b*, *b′*, the further portion of which often (as in the instance here figured) splits, as it were, into two parts *b′*, *c*; and the first-formed sub-segments *d* pullulate by short stolons (not seen in this figure) from its sarcodic substance.

Turning now to the margin of the disk (Pl. III. fig. 13), we see that it presents a *double* series of pores, very distinctly separated from each other by the elevated ridges of shell by which they are severally surrounded; and that those of the upper and lower series usually alternate with one another in position,—an arrangement whose meaning will presently become apparent.

The general plan of structure in *Orbitolites duplex* closely corresponds with that which has been described in *Orbitolites marginalis*; the principal difference being in the mode in which the successive annuli of the sarcodic body communicate with one another, which will be best understood by examining the structure of the decalcified body in the first instance. Its surface-aspect, when viewed under a power of 25 diameters, is shown in Pl. V. fig. 1; the circles of somewhat rounded spots being the expanded summits (shown on a larger scale in fig. 10) of the separate columnar sub-segments (fig. 2), which spring in two series (*a*, *a′*, *b*, *b′*) from the continuous annular stolon *c*, *c′*; the columns of the lower series usually alternating with those of the upper in position, as at *a*, *b*, but being occasionally opposite, as *a′*, *b′*. Between the bases of these columns, the annular cord gives off a double series of short and slender stolon-threads *d*, *d*, *d′*, *d′*; these pass obliquely, the one upwards the other downwards, through passages in the septal plane; and while, in the interior of the disk, these passages lead from the annular canal of each ring of shell, into the upper and lower chamberlets of the one exterior to it, those of the last-formed ring open on its exterior as the marginal pores. Now as the columnar sub-segments of the upper and lower series usually alternate with each other, the upper and lower series of stolon-processes that intervene between the columns of either row will have the like alternation; and this expresses itself (so to speak) in the alternate position of the marginal pores of the upper and lower series.

The upper and lower rows of columnar sub-segments do not arise from the annular stolon in the same vertical plane, or stand on it perpendicularly to the surface of the disk; but both of them slope considerably towards its centre, and therefore towards each other, the chamberlets they occupy having the same arcuate shape as those of *Orbitolites marginalis* (Pl. III. fig. 6); and thus it comes to pass that when they are seen either from above or from beneath, as in Pl. V. figs. 7, 9, instead of in side view, as in figs. 2, 8, they seem to lie *between* the annular stolons, instead of *upon* them. The part of each column which is continuous with the annular stolon is generally much smaller than the part nearer the surface of the disk (fig. 8); so that while the expanded terminals of the columns often lie very close to each other, as in fig. 10, a section taken parallel to the surface of the disk on a deeper plane (fig. 9) shows their diameters to be smaller, and the intervals between them (filled-up by the shell-substance of the disk) to be wider; and another cross-section taken just above the plane of their junction with the annular cord (fig. 7) shows the still further reduction exhibited laterally in fig. 8. Now it is this deeper and slenderer pedicle of each columnar segment (fig. 8) that receives the stolon-process from the sarcodic cord of the annulus next interior to its own; and it is the connection of this pedicle with the sarcodic cord of its own annulus that brings that cord into continuous connection with that of its interior annulus. Thus, while both series of columnar sub-segments of any one annulus are all connected together by its annular sarcodic cord, the connection between the successive annuli is established by the radial stolon-processes that pass from the upper and lower margins of each annular cord to the upper and lower columnar sub-segments of the next annulus.

When this arrangement has been rightly apprehended, there is no difficulty in understanding what is otherwise somewhat perplexing in the structure of the calcareous disk. When the surface-layer of an empty disk has been removed by grinding or by the action of acid, so as to lay open the chamberlets that lodge the columnar sub-segments, these chamberlets are looked into from above (Pl. III. fig. 12), not in the direction of their axes, but in lines more or less oblique to them; so that, instead of seeing downwards into the annular canals, we are really looking, in each chamberlet, against the oblique septum that separates it from the chamberlet of the next interior annulus,—as is shown in the accompanying diagram (fig. 4), in which A B, A′ B′ are the superficial planes of the disk, *ch*, *ch*, the chamberlets lying obliquely to it, *s*, *s*, the septa that divide them, and *o*, *o*, *o*, *o*, the lines of sight. The pores, *p*, *p′*, seen in each hollow correspond to the marginal pores, *mp*, *m′p′*, of the peripheral ring; being the outlet of the passages which lead into each chamberlet from the annular canal, *ac*, *ac*, of the interior ring, and which convey from its sarcodic annulus the radial stolon-processes that originate the new columnar sub-segments. When, again, we carry our section through the median plane of the disk, we lay open the concentric annular galleries (Pl. III. fig. 11); and along the *concave* (or *inner*) borders of the septa that divide them, we see the small pores forming the entrances of the passages just described, which lead to the chamberlets of the next annulus; while along their *convex* (or *outer*) borders of the septa (as shown also in the transparent section, Pl. IV. fig. 7) are seen the larger oblique passages, which are occupied by the pedicles of the columnar sub-segments of their own annuli. When this median stratum has been removed, the chamberlets of the lower layer are laid open (Pl. III. fig. 9, *a*); and these being viewed, like those of the upper, in an oblique direction, but being seen from their

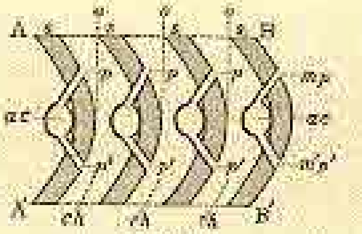

Fig. 4.

medial instead of from their superficial ends, seem to be crossed by the septal planes that divide the annular canals.[1] The meaning of this appearance is best seen in a transparent section (Pl. IV. fig. 8); which, traversing the annular galleries, shows the large orifices *c*, *c*, *c*, along their floors, that lead to the chamberlets of the plane beneath; and the small orifices *st*, *st*, along the *concave* borders of the septa, that lead into the chamberlets of the next annulus.

Thus the cavitary system of the disk of *Orbitolites duplex* is composed of a median series of annular concentric galleries, each freely opening, as in *Orbitolites marginalis*, into a double tier of chamberlets, one above and the other beneath; but each having *two* series of passages, that lead severally to the upper and the lower tiers of chamberlets of the next annulus. The cavitary system of every part is here in as free communication with that of every other part as it is in the "simple" forms previously described: but there is an advance in the development of this type, which shows itself *first*, in the suppression of the "orbiculine" stage, and the assumption of the cyclical plan almost from the beginning; and *second*, in the foreshadowing of the coming separation between the upper and the lower tiers of columnar sub-segments in *Orbitolites complanata*, which is given in the replacement of the *single* row of radial stolon-passages on the mesial plane, communicating between the cavitary system of each annulus and the next, by the *double* series that lead into the chamberlets of its upper and its lower tiers respectively.

Geographical and Bathymetrical Distribution.—This species appears to have the same general range, alike in area and in depth, with *Orbitolites marginalis;* but though small forms of it are abundant in the Red Sea, I have not been able to trace it as accompanying that species into the Mediterranean. Like *Orbitolites marginalis*, it acquires its maximum size in waters of no great depth off tropical shores.

Geological Distribution.—Though it is impossible to identify, with any certainty, our *Orbitolites duplex* with any of the fossil species described by Lamarck, yet as worn specimens of it often present a close resemblance to the representation given by Goldfuss (Petrefacta, Pl. XII. fig. 8) of his *Orbitolites macropora*, which he distinguishes by its *poris utroque latere majusculis*, I think it probable that the two are identical. The fossil habitat of Lamarck's specimens is given as "la montagne Sainte Pierre."

4. *Orbitolites complanata*, Lamarck (Pl. V. figs. 11–18; Pl. VI., VII., VIII.).

Orbitolites complanata, Lamarck, Syst. des Anim. sans Vertèbres [1801].
Marginopora vertebralis, Quoy and Gaimard, in De Blainville's Manuel de l'Actinologie [1834], p. 412.
Orbiculina tonga, Williamson, Trans. Micr. Soc., vol. iii. 1852, p. 115.

We come, lastly, to the large and highly differentiated form which must be regarded

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[1] The relation of fig. 9 (Pl. III.) to fig. 11 will be better understood by conceiving the former to be turned a quarter round, so that the side *a* of fig. 9 should correspond with the lower border of fig. 11.

as the type of the genus,—the *Orbitolites complanata* of Lamarck, which, at first known only as a fossil in the Calcaire Grossier of the Paris basin and other parts of France, has been since found to present itself as a living form in such abundance on Australian and Polynesian reefs, that its accumulated disks sometimes constitute no inconsiderable proportion of their material.[1] The disks of this species were the earliest examples of the Orbitoline type that attracted attention; and, as I have already pointed out (pp. 1, 2), many strange ideas were entertained in regard to their character. When Lamarck constituted the genus *Orbitolites* (p. 2), he defined this species as follows:—*Orbitolites tenuis fragilis, utrinque plana et porosa;* his idea having apparently been that the porosity of each of its surfaces differentiated it from *Orbitolites marginalis*, which is also *utrinque plana*, but porous at the margin also. This differentiation is altogether incorrect, being founded on fossil specimens whose outer lamellæ have been worn away, so as to lay open the subjacent chamberlets, which are closed in perfect recent specimens of *Orbitolites complanata*, as in *Orbitolites marginalis*. The first intimation of the present existence of this species seems to have been given by Defrance (Dict. des Sci. Nat., tom. xxxvi., 1825, pp. 294, 295), who, in describing the well-known fossil type, states that living specimens closely allied to it had been found on the coast of Australia. These were probably the disks collected by MM. Quoy and Gaimard in that locality during the "Voyage de l'Astrolabe," which they designated by the generic term *Marginopora;* and this designation was adopted by M de Blainville (Man. d'Actinologie, 1834, p. 412), who was the first to publish a description of the recent type, under the name *Marginopora vertebralis*, in immediate sequence to that of the recent *Orbitolites marginalis* already cited (p. 21). As in the previous case, Blainville's account of it was not only incomplete, but in some respects inapplicable to the ordinary form of the type; so that I should not have felt sure of its identity, if I had not myself examined (in the Paris Museum) the very specimens for which the genus *Marginopora* was created, and which are exactly conformable to one of the varieties of the recent *Orbitolites complanata* which I am about to describe. The closeness of the relationship borne by his *Marginopora vertebralis* to *Orbitolites complanata* was held by Blainville to be further indicated by the conformity of the internal structure of the two disks; each being found, when one of its surfaces is rubbed away, to present a series of concentric canals, separated by annular partitions, and themselves divided into cells. He doubted, however, whether either *Orbitolites* or *Marginopora* should be considered as a true polypary, allied to *Eschara* or *Retepora;* and thought it more likely that the Orbitoline disk is "quelque pièce intérieure." I have already alluded to the extraordinary error committed by Prof. Ehrenberg, in not only ranking *Orbitolites* among his BRYOZOA, in close proximity to *Lunulites*, but in actually

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[1] I was informed by the late Prof. J. Beete Jukes, whose specimens were the first which I had the opportunity of examining, that at certain spots on the Australian coast the great mass of his dredgings consisted of the entire disks and fragments of *Orbitolites complanata*, with fragments of Corallines (chiefly, I believe, the *Corallina palmata* of Ellis).

figuring an eight-tentacled polype as extending itself from one of its (supposed) open cells. It was under the influence of his authority that, when I first published (Quart. Journ. Geol. Soc., 1849, p. 31) the results of my examination of the structure of the Australian *Marginopora* (*Orbitolites*), in specimens collected by Prof. Jukes, and kindly placed in my hands by Prof. Edward Forbes, I did not feel justified in calling its Bryozoic characters in question, though I expressed myself doubtfully as to its claim to that position. It was Prof. W. C. Williamson, as I have already pointed out (p. 5), who first asserted the Foraminiferal nature of *Orbitolites*, on the basis of its near affinity to the well-known *Orbiculina adunca*; describing, under the designation *Orbiculina tonga*, what are clearly small specimens (only ¼ of an inch in diameter) of *Orbitolites complanatus*, which he had obtained from shore-sand. This determination partly rested on the structure of the central "nucleus" of the disks, which had been wanting in my own specimens; and of this Prof. Williamson gave a very accurate description, which I was subsequently able to verify in the perfect specimens received from Prof. J. Beete Jukes himself, as well as from other sources,—some of these having been preserved in spirit, and containing the sarcodic body of the animal. It was on these specimens that I based the description of what I then distinguished as the "complex" type of *Orbitolites*, which I gave in my original Memoir on this genus (Phil. Trans., 1856). And having lately made a careful re-examination, both of the shelly disks and of the sarcodic bodies of their contained animals, collected by the naturalists of the Challenger on the slope and summit of the Fiji reef, I am in a position not only to confirm that description in every particular, but to add to it several particulars of much interest.

It is probable that the younger and more delicate forms of *Orbitolites complanata* habitually attach themselves to the surface of marine plants, the most perfect of those which I received from Prof. Jukes, whose surfaces were nearly flat, having been found thus attached; and some of them being so thin in proportion to their diameter, that I can scarcely think it possible that they could remain unbroken in the turbulent water of a reef-slope if not thus supported. The case is different, however, in regard to those more massive disks whose thickness increases as rapidly as their diameter, so that they become more or less deeply biconcave; for as such could only adhere at their margins, they must be liable to become easily detached; and as they are brought up alive by the dredge, they probably go through the later stages of their growth in the free condition. That such must be the case in regard to these large, irregular, "laciniate" forms, of which examples are figured in Pl. VII., is very obvious; and I learn that the specimens of these which contain the coloured sarcodic body were taken alive from sheltered nooks in rock-pools on the summit of the reef, while the dead specimens (distinguished by their absence of colour) were picked up on its surface.

It is of the disks of this species that the great bulk of the Challenger collection on the Fiji reef is composed; and these disks present a range of diameter from 0·04 inch.

or even less, to nearly 1 inch, and a thickness of from 0·012 inch to 0·100 inch. This range is less, however, in the disks brought up in the 18 fathoms' dredging, than in those collected nearer the surface, the average diameter of what seem to be the adult forms in the former not exceeding 0·7 inch; and there is an almost entire absence in them of those irregular outgrowths which are frequent in the large disks found on the summit of the reef. The disks are sometimes almost plane, with a slight central depression; but are more commonly decidedly biconcave. The central portion, consisting of the "nucleus" and the annuli that immediately surround it, is almost invariably the thinnest, and round this there is usually a progressive increase in the thickness of the next succeeding annuli. If this increase continues, the disk of course becomes thickest at the margin; but it not unfrequently ceases, so that the rest of the disk is plane; and sometimes, at about half the distance between the centre and the circumference, the thickness of each succeeding annulus diminishes, so that the marginal portion of the disk is no thicker than the central.

The concentric bands into which each surface of the disk (Pl. VI. fig 4) is marked out, are complete in the typical forms of this species, to the very margin of the nucleus; not the least vestige being here seen of any "orbiculine" spiral, but the *cyclical* plan of growth characteristic of the Orbitoline type being exhibited from the very commencement. The breadth of each zone averages about 0·003 inch, and the number of zones bears a pretty uniform relation to the diameter of the disk. In one of the largest disks that I have examined there are 166 zones, while the smallest has only three. Each zone is crossed by radial lines, which mark out areolæ that are usually somewhat rectangular in shape and sometimes approach a square, but are more commonly at least twice as long (in the radial direction) as they are broad, their long sides being nearly parallel to each other. The margin does not usually show any such convexities as are formed in *Orbitolites marginalis* by the projection of the columnar chamberlets; but the marginal pores are usually arranged more or less regularly in vertical rows, which are, however, often incomplete,—the two adjacent rows, in such cases, usually inclining towards each other. There is no constancy in the number of pores in the different vertical rows of even the same annulus; and there is no such regularity in their disposition as would mark out a horizontal stratification.

The "nucleus" is much larger in the typical forms of this species than in either of the preceding; and though it exhibits a considerable range of dimension, as shown in Pl. VI. figs. 1, 2, 3, yet even the smallest nuclei of those disks whose innermost annuli are formed on the "complex" plan are many times larger than those of *Orbitolites duplex*. Its two surfaces are generally flat, or nearly so, but are sometimes slightly convex. The pyriform primordial chamber *a*, as in *Orbitolites marginalis* and *Orbitolites duplex*, is surrounded by a large "circumambient" chamber; and this usually shows a partial division by an incomplete partition.

The circumambient chamber is completely enclosed peripherally by a circular wall; and this is traversed by a series of passages at regular intervals all around, each of which leads into a separate chamberlet,—the very first series of chamberlets thus forming a complete annulus. The sarcodic body which occupies the cavity of the nucleus, consists of a large pyriform primordial segment (Pl. V. fig. 18, *a*), from the small end of which proceeds the stolon-process that connects it with the circumambient segment *b*, *b'*. This last is very large, a portion of it (*c*) being usually in part separated from it by a partition in the shelly chamber (fig. 3, p. 13); and it buds off, all round its periphery, a succession of radial stolon-processes, of which one traverses each passage in the surrounding wall, to become the origin of one of the sub-segments forming the first annulus.

Each of the chambered zones by which the "nucleus" is surrounded, even from the first, consists of two *superficial* layers, between which is interposed an *intermediate* stratum.

The *superficial* layer of each annulus (Pl. VI. fig. 4) is made up of oblong chamberlets, the partitions between which correspond with the radial surface-lines. These partitions extend continuously across the annulus, so that the adjacent chamberlets have no lateral communication. And as the circular septa that form the end-walls of these superficial chamberlets are alike imperforate, the chamberlets of the successive annuli have no direct communication with each other. When, however, the chamberlets have been so laid open by grinding or by the application of acid (as at *f*, *f*), that their floors are brought into view, a pore is seen at either end; and each of these pores is shown by vertical sections to open into an annular gallery (*g*, *g'*, *g''*) that passes beneath it; so that, as each superficial chamberlet lies across the interval between two galleries, and communicates with both of them, an indirect connection is established, through their intermediation, between each annular gallery and that which is internal and external to it, and thus throughout the entire system. This will be best understood by looking at the disposition of the sub-segments of the *sarcodic body* which occupy the chamberlets, so as to form its surface-layer (Pl. V. fig. 11). These present themselves under a low amplification as narrow elongated blocks, very uniform in size and figure, arranged in concentric annuli; and when a portion of the layer is more highly magnified (fig. 13), it is noticeable that though these sub-segments generally alternate in position in successive annuli, this arrangement is by no means constant, there being no direct connection between them. Their relations to other parts of the sarcodic body are best brought into view by vertical sections (fig. 14), which show that every block of each of the superficial rows (*c*, *c'*) is connected by a pedicle at either end with one of the annular stolons (*a*, *b*, *b'*) that intervene between the superficial layers of sub-segments and the sarcodic columns (*d*, *e*) of the intermediate stratum. Each stolon thus gives off two series of pedicles: one to the row of sub-segments internal to it, and the other to the row external to it; and these usually (though not always) alternate in position.

An indirect communication is thus established, not only among all the sub-segments of the same annulus, but among those of all the annuli of each superficial layer.

The *intermediate stratum*, which, as already stated, constitutes the principal part of the thickness of the disk, is the distinguishing feature of this type of structure. When laid open by a section taken parallel to either surface, the appearances it presents differ according to the plane traversed by the section. For if this plane be that of the concentric annular galleries that lie immediately beneath the superficial layer, the section (Pl. VI. fig. 4, *g*, *g′*) lays open these galleries; in the floor of every one of which is a series of large rounded openings *h*, which are the summits of annular rows of nearly cylindrical chamberlets that lie beneath the galleries. In sections taken beneath these galleries, however, so as to pass either in or near the median plane of the disk, the concentric arrangement seems to have altogether given place to the excentric or "engine-turned" (*i*, *i*), the directions of the excentrics being opposite (as shown at *k*, *k*) in successive planes. There is no change, however, in the concentric arrangement of the rows of chamberlets; what is different being merely the mode of communication between them. These communications are in reality just what have been shown in fig. 3 (p. 13) to be characteristic of the Orbitoline type; each chamberlet communicating both with its own adjacent chamberlet, and also with the two chamberlets which alternate with it in the annulus external to its own, by a pair of passages. Now the columnar chamberlets forming the successive annuli of this intermediate stratum have vertical successions of pairs of such communications; but the two passages that form each pair, instead of lying in the same plane, alternate with each other vertically, so that no horizontal section can pass through both sets at once,—although it not unfrequently happens, in consequence of a flexure in the disk, that different parts of the same sectional plane show passages of opposite obliquities. And thus it comes to pass that each horizontal section lays open a series of oblique galleries, formed by the one-sided communications between the chamberlets of successive annuli; and that in a section taken in a plane either a little above or a little beneath, the direction of the obliquity is reversed. This arrangement, again, is better understood by reference to the sarcodic body of the animal, as seen in vertical section (Pl. V. fig. 14); for each of the cylindrical sub-segments of the nearer zone (*d*, *d*) is seen to communicate with two sub-segments of the zone *e* behind it, by two rows of stolon-processes; those which pass from each of the two contiguous columns in zone *d* towards the single column that alternates in position with them in zone *e* behind, inclining towards each other, so as to enter that column nearly in the same vertical line, though in different horizontal planes. By this arrangement each of the several pores (Pl. VI. fig. 4, *d*, *d′*, *d″*) that form the vertical rows at the margin of the disk, instead of opening, like the single pore of the simple type (fig. 2, p. 12), into both the chamberlets of the last-formed annulus between which it lies, opens into only one of them,—the pores of the same vertical series opening alternately into the chamberlets on either side.

The cylindrical chamberlets of the intermediate stratum, as seen in vertical section (Pl. VI. fig. 9, *e*, *e*), generally pass in a nearly straight, parallel and separate course through its whole thickness; but this is by no means constantly the case. For not only are there occasional communications between the adjacent chamberlets of the same row, but sometimes a chamberlet, after extending through only a part of the thickness of the disk, will merge, as it were, in the two chamberlets on either side of it, which, when no longer kept apart, incline towards one another, as shown externally in the direction of the rows of marginal pores (fig. 4, *d''*). The same departure from strict regularity is shown in the columnar sub-segments of the sarcodic body (Pl. V. fig. 14, *d*, *e*); adjacent columns of the same annulus inosculating not unfrequently with one another. But all the columns of any one annulus terminate above and below in the two annular stolons (*b*, *b*)' of their own annulus, which thus unite them into one continuous system.

By these varied methods every part of the labyrinthic cavitary system of this most complex type of Orbitoline structure is brought into free communication with every other part; so that a circulation of the protoplasmic body-substance may be constantly maintained, which shall diffuse through the whole of it whatever nutrient material is drawn in through the marginal pores, and also get rid, through those pores, of any effete matter which is unfit to be kept in the organism. Notwithstanding the extent to which *structural* specialisation is here carried in the shelly disk—as manifested in the separation of the superficial layers from the intermediate stratum—I have not been able to trace any indication whatever of a corresponding *functional* specialisation. There is not, so far as I have been able to make out, any differentiation of parts throughout the entire sarcodic body, every portion of it presenting the same aspect, and possessing the same attributes, as the rest. This homogeneousness is further manifested in two ways:—first, by the production, from any part of the disk, of outgrowths which present, under strangely irregular forms, its characteristic peculiarities of internal structure; and second, by the completeness with which injuries of any part of the disk are repaired, its cyclical plan of growth being renewed, and its discoidal form more or less perfectly restored.

Irregularities.—The tendency to form irregular outgrowths shows itself especially in the large and massive specimens, which, as already stated, were found living in the rock-pools on the summit of the Fiji reef; and may be taken to indicate an exuberance of formative power, that probably depends upon the higher temperature and greater abundance of food which the animals there enjoy. In Pl. VII. is given a series of portraits of such disks, all drawn to the same scale of four diameters; a full-sized disk of regular form being represented for comparison in fig. 3. The disk portrayed in fig. 1 exhibits an incipient "crumpling" of the marginal annuli, which shows their peripheral extension to have been more rapid than their radial, so that these annuli are thrown into irregular folds; whilst a small vertical outgrowth, having the character of a perfect half-disk, but very thick in proportion to its diameter, arises from the central portion, probably from its "nucleus." Similar central outgrowths are by no means uncommon, and sometimes show themselves at an early stage, as in the small disk which is represented in Pl. VIII. fig. 1, under a magnifying power of ten diameters. Another curious irregularity in a young disk is shown in Pl. VIII. fig. 3. Whether from accident or from some obstruction to the growth of the disk on its left side, the peripheral additions do not pass completely round the central portion, and the thick vertical crest seems to represent a fold of the peripheral annuli produced by the exuberance of their material. Another small specimen represented under the same power in Pl. VIII. fig. 11, has a very curious "twin" disk, which must have either begun as a "double monster," or (which the distinctness of the "nuclei" seems to render more probable) have been the product of the partial "fusion" of two originally separate disks, attached side by side to contiguous parts of the same surface; the vertical half-disk in either case being the joint product of the two mutually-encroaching horizontal disks, whose continued increase at their line of junction could only take place in this direction. In the large disk, represented in Pl. VII. fig. 2, the peripheral folds are much deeper than are those of fig. 1, but the central semi-discoidal outgrowth is smaller. There are, however, other considerable vertical outgrowths from the surface of the disk, the under side of which shows the same exuberant productiveness. In the large disk represented in fig. 4 the central outgrowth has the form of a small knob; this, however, instead of being a solid mass of shell-substance, has a properly "labyrinthic" interior, as is shown by the distribution of the pores characteristic of that arrangement over the whole of its surface (fig. 4, *b*). One of the peripheral folds extends itself as a vertical crest for some distance inwards, and four other incipient half-disks arise from different parts of the surface, of which two have united themselves together, as shown on a larger scale in fig. 4, *a*. Another large disk, represented in fig. 5, shows a general crumpling of the margin, without the formation of any well-marked vertical fold, with a small central knob and several irregular protuberances from the annuli forming the inner part of the disk. In the large disks represented in figs. 6 and 7, the crumpling of the peripheral annuli is very strongly marked by the production of vertical folds proceeding inwards towards the centre. In both cases the growth of the disk seems to have been regular, up to a certain epoch marked by the concentric elevation of the annuli, after which the crumpling appears to have commenced. Such epochs are often indicated, even in the normal disk, as shown in fig. 3; and it would not seem improbable that they mark some change in the external conditions of the disks, which may have lived attached in their earlier stages, and have been afterwards transferred by the action of the waves into situations more favourable to the production of these outgrowths.[1]

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[1] Other examples of this "laciniate" form, with a vertical section showing the divarication of two lamellæ, and the incompleteness of the partitioning of the last-formed annuli, will be found in Pl. XVI. of Mr. H. B. Brady's Report on the Foraminifera.

The examination of a large number of specimens of this type, which show every gradation between the regular smooth discoidal form (fig. 3) and the strongly "laciniate" forms represented in figs. 6 and 7, has satisfied me that the latter type has no claim to be distinguished *specifically*. Both in kind and degree the peripheral "laciniation" is subject to the widest extremes of individual variation; and there is neither constancy nor regularity of disposition in the outgrowths from the inner portion of the disks, those of the two sides of the same disks being generally quite dissimilar. It may be questioned whether they have even a greater claim to be distinguished as constituting a well-marked variety than have, for example, the deeply plicated specimens of *Waldheimia australis*, which are found adherent to the same blocks of stone as the smooth, with a series of intermediate forms establishing a gradational transition from the one to the other.[1]

Reparations.—There seems no more limit in this species to the reparative power than in those "simple" types in which its operation has been previously described; an entirely new disk, perfect in every part except its centre, being producible from a small fragment broken away from the margin of an older one, as shown in Pl. VIII. fig. 10,—which is the exact counterpart to Pl. I. fig. 7, though representing a much larger and older disk of this "complex" type, under a comparatively low magnifying power. So, in Pl. VIII. fig. 2, we have the exact counterpart to Pl. I. fig. 6; the former, which represents a repaired disk of *Orbitolites complanata* nearly half an inch in breadth, showing that a fracture across its diameter when about half its present size did not in the least interfere with its subsequent growth, and that, from the very first, new annuli were formed all along its fractured edge, as around its normal margin; so that, except in the modification of shape produced by the loss of half the earlier portion of the disk, no departure from the normal type is discernible. In fig. 8 the proportion of the disk lost by transverse fracture is smaller, so that the growth of peripheral annuli all round has more nearly restored the circular form. In fig. 6 this restoration has been yet more complete, though the early loss of a considerable proportion of the disk has given the nucleus an excentric position. In fig. 4 there seems to have been a marginal breaking away of several portions of the disk, leaving a very irregular outline; the broken portions have been filled-in, and the circular form has been almost exactly restored. In the specimen represented in fig. 9 a sort of notch has been cut out from the margin of an advanced disk, and this has been filled-in by an extension of the later-formed peripheral annuli. It is obvious that if the growth of this disk had proceeded much further the notch would have no longer shown itself at the margin. In the disk represented in fig. 5 the more considerable loss has been less completely repaired, the new growths from the two sides not having as yet met: but it is obvious that the addition of a few more peripheral

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[1] See pl. i. of the Monograph of the genus *Terebratula*, in Lovell Reeve's "Conchologia Iconica." The original of this plate—a block brought by Prof. J. Beete Jukes from Port Jackson—is in the British Museum.

annuli would completely fill up the gap, and that a continuance of subsequent growth would restore the circular figure. The specimen represented in fig. 7 is of peculiar interest, as showing the early stage of this reparation; to exhibit which more clearly the specimen has been laid open by grinding it down towards its median plane. An irregular fracture has obviously been sustained along nearly half the margin of this disk, previously to the formation of the last two concentric annuli; and these annuli can be traced along the entire length of the fractured margin (of which a portion is shown on a large scale in fig. 7 *a*), just as along the unbroken periphery,—except that while the arrangement of the chamberlets in these last two annuli is conformable to that of the annulus with whose unbroken margin they are continuous, these chamberlets lie *un*conformably along the broken edge to those of the preformed structure.

Relations to Simple Type.—We have now to consider the relations of the "complex" plan of growth which is characteristic of *Orbitolites complanata*, to the "simple" plan exhibited in *Orbitolites tenuissima*, *Orbitolites marginalis*, and *Orbitolites duplex*; and have especially to inquire whether there is any evidence of the genetic derivation of the higher type from either of the lower.

In describing *Orbitolites complanata*, I have purposely limited myself to that typical form which presents its characteristic features in their highest development, those features being (1) the origin of thedisk in a large and thick "nucleus"; (2) the immediate assumption of the *cyclical* plan of growth, as shown in the primal pullulation of chamberlets round the whole periphery of the nucleus, so as to form a complete annulus; and (3) the immediate assumption of the *complex* plan of growth, shown in the separation, even in the very first annulus, of the two superficial layers by an intervening stratum, as shown in vertical section in Pl. VI. figs. 9, 10. But I find a considerable number of disks, especially in the 18 fathoms' collection, which present that *intermediate* condition on which I laid great stress in my former Memoir (§§ 57, 58), as indicating that the "complex" type is only a more developed form of the "simple." In such disks the central portion is formed in every respect upon the "simple" plan, which afterwards gives place to the "complex," sometimes rather suddenly, but generally more gradually, at a variable distance from the centre. Such a "simple" condition may be inferred to prevail in the interior part of any disk, whose peripheral portion is shown to be "complex" by the multiple arrangement of its marginal pores, when its central portion is very thin, its nucleus small, its first formed annuli not complete, and the form of its surface-divisions circular tending to square, as in *Orbitolites duplex*: the passage to the complex type being marked by the rapid thickening of the disk, and the narrowing of the surface-divisions, so that they take-on the elongated form characteristic of the superficial chamberlets of *Orbitolites complanata*. This last change is well shown in Pl. V. fig. 11, which represents half of the sarcodic body of one of these sub-typical forms: the sub-segments of the *central* portion of the disk (which are the summits of "simple" columns) having exactly the same aspect when viewed from above, as have those of the "duplex" type (fig. 1), whilst those of its *peripheral* portion have the equally characteristic form of the sarcodic "blocks" (fig. 13), of which the superficial layers of the "complex" type are composed.

But it is in *vertical sections* of the calcareous disk (Pl. VI. figs. 5–10) that the passage from one type to the other, and the mode in which it is effected, can be most distinctly traced out. The absence of an intermediate stratum, and the "simplicity" of the plan of growth, are marked in the singleness of the annular canal, which lies in the middle plane of the section, as is seen in the whole of that portion of the disk whose vertical section is represented in fig. 5, which extends from *a*, the nucleus, to *b*, *b*, the *twenty-third* zone. In fig. 6, on the other hand, the singleness of the annular canal extends only to the first *three* zones; the zone *b*, *b* is formed on the "duplex" plan, the annular canal being still single, but the radial passage being doubled, so that there would at that stage have been a double row of marginal pores; whilst in all the later annuli the annular canals are double, and the intermediate portion becomes progressively thicker. In fig. 8, again, the *five* annuli, *a*, *a*, to *b*, *b*, that immediately surround the nucleus, are formed on the "duplex" type, the annular canals being single, but the radial passages double; whilst from *b*, *b* to *d*, *d* the annular canals are double, and the intermediate portion progressively increases in thickness. If, then, the growth of either of these disks had been checked within the first zone at which its annular canal becomes double, it would have been accounted as belonging to the "simple" type; and the wide variation that shows itself in regard to the stage of growth at which the transition takes place, sufficiently shows that these intermediate forms are not entitled to rank as constituting a separate group, but that their peculiarities are to be regarded as individual.

Looking, then, at the morphological relations of the "simple" and the "complex" types, we see that the passage from one to the other does not consist (as might at first sight appear) in the development of the two superficial layers of chamberlets as additions to the intermediate stratum, the latter representing the original disk; but in a separation of the two superficial layers of the original disk by the interpolation of the intermediate stratum between the duplicated annular galleries; it being in this duplication that the transition essentially consists. Under this aspect the previous duplication of the radial passages, which is the distinctive feature of the "duplex" type, is of peculiar interest; for while in itself quite conformable to the original "simplicity" of the Orbitoline plan, it is obviously a preparation for the assumption of the "complex."

In the first stage of that assumption, the three parts of each cylindrical chamberlet all lie in the same line, the annular galleries making no break in the continuity between the superficial and the interpolated portions of the columnar cavities, as is shown in the first zones beyond *b*, *b*, figs. 6 and 8. But as we pass towards *d*, *d*, we see a change taking place in the relative positions of the zonal septa of the three planes; those of the superficial layers being shifted half the breadth of a zone, so that the chamberlets of those layers lie over the zonal septa of the intermediate layer, and the zonal septa of the superficial layers over the annular galleries into which the cylindrical chamberlets of the intermediate stratum open at either end, as already described. When, by this shifting, the complex plan of growth has been fully established, all subsequent increase takes place in accordance with it.—The successive stages of this transition through the "sub-typical" to the "typical" form of *Orbitolites complanata* are diagrammatically represented on a larger scale in fig. 5.

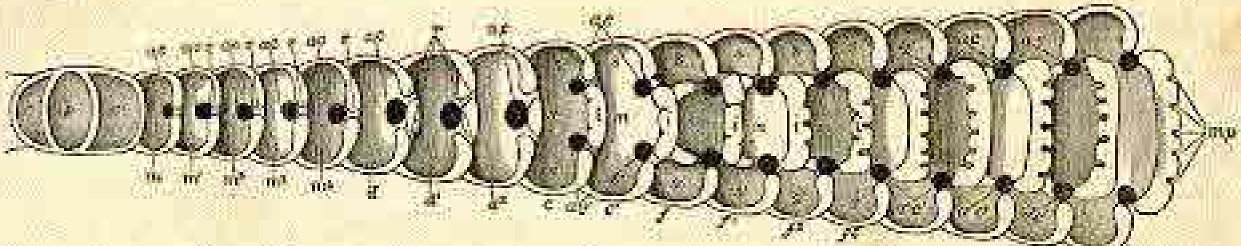

FIG. 5.—Diagrammatic representation of the progressive development of the Simple type of *Orbitolites* into the most Complex.

p, primordial chamber; *c*, *c'*, circumambient chamber; *m*, m^1, m^2, m^3, m^4, chambers of successive zones of *Orbitolites marginalis*, each having its single annular canal, *ac*, and its radial stolon-passage, *r*; *d*, d^1, d^2, chambers of successive zones of *Orbitolites duplex*, each having its single annular canal *ac*, and its double radial stolon-passage *r r*; *c*, *c'*, chambers of intermediate (fossil) form of *Orbitolites complanata*, each having a pair of annular canals *ac*, *a'c'*, with an interposed septum *i*, *i*, and having its superficial portions, *s*, *s'*, still in continuity with the median columns *m*, *m*; *f*, f^1, f^2, f^3, chambers of the typical form of *Orbitolites complanata*, each having its double annular canal, its median columnar portion *m*, separated from that of the next annulus by the interposed septum *i*, traversed by oblique pores, which appear as marginal pores, *mp*, at the edge of the disk; but the superficial chamberlets, *s*, *s*, and *s'*, *s'*, alternating in position with the median, and each of them communicating with the annular canals of two zones, as shown at *ac*, *a'c'*.

The morphological differentiation which thus shows itself in the sarcodic body of this "complex" type is thus of the very simplest character, involving (so far as our means of judgment extend) no functional differentiation whatever. Its first stage consists in a partial splitting of the single annular stolon of each zone (Pl. V. fig. 2, *c*, *c'*) throughout its entire length, and the vertical separation of its two halves from each other; their continuity being maintained, however, at certain intervals, so that, when drawn apart, they still remain connected by the cylindrical columns (*d*, *d*, fig. 14) which form the intermediate stratum. When these interpolated columns are looked at, not as parts of the regular annular system of sarcodic sub-segments, but as bands of adhesion between the two sarcodic semi-annuli that are drawn out by their separation, the frequent irregularities that may be remarked in their arrangement (p. 35) are at once understood as confirming this view of their homology. Each of the separated semi-annuli carries with it its own row of half columns (fig. 2, *a*, *a'*, *b*, *b'*); and these form the superficial planes of sub-segments (fig. 14, *c*, *c'*), which are at first in continuity with the interpolated shafts. And the displacement of these in the subsequently-formed annuli constitutes the second stage of this differentiation.

Even when it has been completely carried out, the connections of the superficial sub-segments remain exactly what they are in the "duplex" type. For there, as has been shown, each half-column springs from its own sarcodic annulus, and receives at its base a radial stolon from the annulus next interior to it; the connection between the successive annuli being made by the passage of two series of radial stolons from each annulus (Pl. V. fig. 2, *d*, *d*, *d*,'*d*'), into the two series of half-columns of the annulus exterior to it. And in the "complex" type, as a careful examination of fig. 5 (p. 40) will show, the pedicle by which each superficial sub-segment is connected with the sarcodic annulus lying beneath its *outer* extremity (see Pl. V. fig. 14) may be considered as its own proper base, whilst that which connects its *inner* extremity with the annulus next interior to it is the homologue of the radial stolon of the "duplex" type.

Now as the displacement, which at first sight conceals this homology, shows itself in the life-history of certain individuals of the type which are developmentally less advanced than the rest, it may be pretty safely affirmed to have taken place in the genetic history of the race. And we have a curious confirmation of this assumption in the fact that the fossil specimens of *Orbitolites complanata*, which are so abundant in the Paris Tertiaries, show an incompleteness in the process of differentiation, which stops at the stage at which the chamberlets of the superficial layers are still continuous with the cylindrical chamberlets of the intermediate stratum.

If then we were able to trace out the entire Palæontological history of the Orbitoline type, we should pretty certainly find a long succession of intermediate forms, gradationally leading up from the "simplest" to the most "complex"; the typical *Orbitolites complanata* of the present time being the most highly specialised form of it with which we are acquainted. But although its descent from some "simple" form can scarcely be doubted, yet we cannot fairly assume that either of the species previously described represents its ancestral type, and is capable of evolving itself under favourable conditions into the "complex" form. For I not only find a very constant limitation of size to prevail, alike in *Orbitolites marginalis* and in *Orbitolites duplex*, of each of which forms I have examined many hundred specimens; but I have met, in several of the largest examples of each, with that undivided or imperfectly partitioned condition of the peripheral annuli, which seems to indicate the feebleness (so to speak) of old age, rather than such an excess of vigour as would be needed to carry them on to a higher grade. It appears to me, therefore, that the two species just named are to be considered as perpetuating earlier types of the genus; whilst the occasional occurrence of the "simple" plan in the central portion of the disks of *Orbitolites complanata* marks a *reversion* to that earlier plan, which indicates a want of developmental power in the individuals presenting it. And a clue to this deficiency is, I think, to be found in that remarkable inferiority in the size of the "nuclear mass," which I have already spoken of (p. 38) as a constant feature in these sub-typical forms.

Whether such disks constitute a distinct *race*, or are merely *individuals* which have begun life as "starvelings" that do not inherit the characteristic vigour of the species, it can scarcely, I think, be doubted that they represent an ancestral form in which the "simple" *Orbitolites* was undergoing evolution into the "complex"; the early growth of *every* disk in that stage having probably been simple, as we still find it to be in *some*. In those, on the other hand, in which the perfected type has fully established itself, the earlier "simple" Orbitoline stage drops out, as the Peneropline and Orbiculine stages had previously done; so that the "complex" plan of Orbitoline growth now immediately succeeds the Milioline, in all those forms in which the primordial segment carries with it the full developmental capacity of its predecessor. It is not a little curious, however, that in the marginal annuli of even this highest type, a *reversion* to the undivided Peneropline condition should not unfrequently show itself, in an almost entire want of subdivision of the annular zones into chamberlets; the interzonal septa, however, being formed as usual, and being marked by multiple ranges of pores.

Geographical and Bathymetrical Distribution.—So far as is at present known, *Orbitolites complanata* inhabits only the shallow waters near shores, or on the slopes of reefs, in tropical or sub-tropical seas. It has been met with abundantly in such situations on the coast of Australia, on the Fiji and other reefs in the Pacific Ocean, and in the Philippine Sea; but, notwithstanding the abundance of *Orbitolites marginalis* and *Orbitolites duplex* in the Red Sea, this most highly developed type has not hitherto been found there. As already stated, its largest and most exuberant forms are found in surface-water; whilst it is among those brought up by the dredge from a deeper part of the littoral zone, that those "sub-typical" specimens occur in largest proportion which in the earlier stage of their growth present the "simple" type of formation.

Geological Distribution.—As already stated, the specimens upon which not only the *species* but the *genus* is constituted belong to the early Tertiary period: the Calcaire Grossier of the Paris basin, and corresponding (Middle Eocene) formations elsewhere, containing *Orbitolites complanata* in such abundance, that the rock in some situations is chiefly composed of its disks. These are often found 0·8 inch in diameter, thus equalling in size all save the very largest of those brought from the Fiji reefs. *Orbitolites complanata* seems also to occur in the Nummulitic Limestone of the north-west of India; but from the external similarity of its disks to those of *Orbitoides*, which genus also flourished at the same period, they cannot be certainly distinguished by the imperfect descriptions of them hitherto given. This difficulty of identification, which applies also to the genus *Orbiculina*, prevents it from being certainly stated at what Geological period *Orbitolites complanata* made its first appearance. It is reported as having been found in certain Jurassic strata; and the Cretaceous forms to which the generic name *Cyclolina* was given by d'Orbigny may perhaps be referable to it. But without a careful examination of their internal structure, it cannot be said with any certainty whether these were *Orbiculinæ* (as the prominence of their centre would seem to indicate) or true *Orbitolites*. It seems to have been in the comparatively shallow and probably warm waters of the Maestricht Chalk that the more specialised Orbitoline type first became conspicuous.

CONCLUDING SUMMARY, WITH A STUDY OF THE THEORY OF DESCENT.

Thus it has been shown, that whilst an examination of the central nucleus of the disk of *Orbitolites tenuissima* enables us to trace back the pedigree of the Orbitoline type to the very simplest "jelly-speck" that can form a porcellanous shell, an examination of the inner rings of certain disks of the highly specialised *Orbitolites complanata* makes it clear that this most "complex" of Orbitolites (the most heterogeneous in structure of all existing "porcellanous" FORAMINIFERA) has had its origin in the most "simple." And yet, as has been also shown, this progressive complication of the calcareous skeleton does not seem to involve either any corresponding differentiation of parts in the sarcodic body, or any such change in its physiological character as implies a higher or more special adaptation to the conditions under which these animals exist.

It was sagaciously remarked by Sir James Paget,[1] long before the Biological revolution wrought by the publication of the Origin of Species, that "the highest laws of our science are expressed in the simplest terms in the lives of the lowest orders of creation." And in accordance with this view, I propose to make this remarkable group of facts the subject of a "Study in the Theory of Descent," for which it presents the following specia advantages:—

First, that the remoter ancestry, instead of being indicated (as it commonly is in the developmental history of the higher organisms) by obscure and transitory phases, is here distinctly represented in the earlier stages of the completed form. Thus, if the development of a very young *Orbitolites tenuissima* were checked in its early Milioline stage, it would be accounted a *Spiroloculina*; if checked in its short Peneropline stage, it would be accounted a true *Peneroplis*; and if checked in its Orbiculine stage, it would be accounted a true *Orbiculina*. And so, if the development of the "sub-typical" variety of *Orbitolites complanata* were checked in its first stage, it would rank as an *Orbitolites*

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[1] Lectures on Repair and Reproduction, delivered at the Royal College of Surgeons in 1848.

marginalis; if checked in its second, as an *Orbitolites duplex*; and if checked in its third, as the earlier (fossil) form of *Orbitolites complanata*.

Second, that all these ancestral types are still living; and that, so far as we know the external conditions of their existence, they are precisely the same as those of the completed form.

Third, that the absence of any distinguishable differentiation in the parts of the sarcodic body of even the most "complex" Orbitolines, seems to make their physiological relation to their "environment" precisely the same as that still held by the whole series of ancestral forms.

In considering the genetic relations of these several forms, and the circumstances under which one has given origin to another, it is requisite to keep the distinction clearly and constantly before the mind, between *growth* and *development*;—the former consisting in the extension of the original fabric on the *same* plan, by the multiplication of *similar* parts; whilst the latter involves a *change* of plan, of which *dissimilarity* (consisting in the supersession of the original homogeneousness by heterogeneousness) is the essential feature. Thus, a *Cornuspira* that begins its life in the form of a conical tube coiled into a nautiloid spire, may expand itself, as it grows, into a flattened tube, rapidly increasing in the breadth of its mouth, without any greater change than we see in an *Amœba*, which, at one time an almost spherical lump of protoplasm, quickly flattens itself out into a disk with pseudopodial extensions. But if, instead of flattening itself out, the body of a *Cornuspira* should undergo constriction at intervals, as in fig. 6, and should form at each constriction a partial septum across its tube, we recognise a new departure that constitutes an advance in development; whilst as long as further additions are made upon this new (Spiroloculine) plan, the process is one of growth only. When,

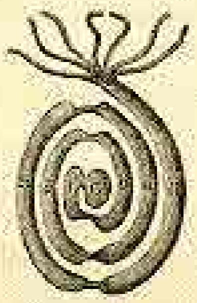

FIG. 6.—Diagrammatic representation of the sarcodic body of *Miliola*.

a, Primordial segment.
1-6, Successive segments, marked off by constrictions at intervals.

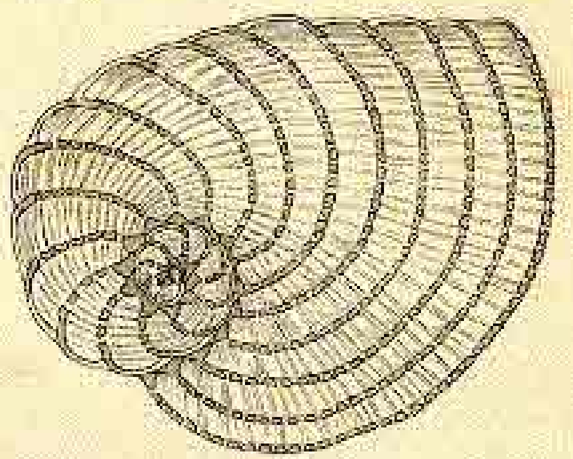

FIG. 7.—Shell of *Peneroplis*, showing its successive septa traversed by pores at regular intervals.

however, the flattening of the spire is followed by the formation of a complete septum across its mouth, traversed by a series of perforations at regular intervals, as in *Peneroplis* (fig. 7), another very decided advance in development is marked; and this might have been followed, as in the preceding case, by a second period of growth upon the newer (Peneropline) plan. But in our *Orbitolites tenuissima* we find it constituting only a transition-stage to the next developmental advance, namely, the subdivision of the chambers into Orbiculine chamberlets; after which, again, development gives place for a time to growth, every addition being a mere multiplication of similar parts. In *Orbiculina* it seems a matter of indifference whether the later growth continues the spiral of the earlier, or changes to the cyclical plan. But in *Orbitolites* the spiral is only a transitory phase; the multiplication of chamberlets producing such a rapid extension of each successive zone, as early to bring about a completion of the annuli, and the establishment of that cyclical plan of growth which is the distinctive feature of the Orbitoline type. When that type has once been reached, the increase of the disk in the horizontal plane to any extent, by the multiplication of its annuli of chamberlets, is a mere process of growth; but the production of the "complex" type from the "simple" involves, as we have seen, a degree of structural differentiation, which marks a great advance in development.

And yet, with all this, the physiological condition of the sarcodic body remains (so far as can be made out) essentially the same. The sub-segmented body of the spiral *Orbiculina* is nourished by the food-particles drawn in through its septal pores, precisely as is the segmented body of *Peneroplis*; and the arrangement of its sub-segments in complete annuli, instead of along the expanded mouth of a spire, cannot make any alteration in the mode either of the reception of nutriment, or of its transmission from the peripheral to the central portion of the body. The adult cyclical *Orbitolites tenuissima* or *Orbitolites marginalis* must feed in exactly the same manner as it did in its young (Orbiculine) spiral phase; and the multiplication of the rows of marginal pores in *Orbitolites complanata*, corresponding with the increased thickness of its disk, merely serves to increase its ingestive capacity, in accordance with the increased requirements of a more bulky body. The animal of each disk, whatever be its mode of obtaining nutriment, can benefit only by the food-particles which come in its way; and its pseudopodial extensions will draw-in these just as well, whether they issue from one, two, or multiple rows of pores,—just as will those of the Peneropline type, whether they issue from the single row of separate passages which traverse the narrow septal plane of the typical *Peneroplis*, from the partially-coalesced multiple passages of the widened *Spirolina*, or from the single large dendritic orifice formed by the complete coalescence of separate passages in the broad septal plane of *Dendritina*.[1]

The external conditions under which the FORAMINIFERA exist are so uniform, except as to temperature and depth of water—which seem to affect *growth* rather than *develop-*

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[1] See the account of these types given in my Third Memoir, *Phil. Trans.*, 1859, pp. 1–12.

ment, the multiplication of similar parts rather than differentiation into dissimilar,—that the *onus probandi* obviously lies on those who would find in them a *vera causa* for that advance of development, which shows itself in the *production* of the forms among which "natural selection" is to operate. A single dredging brings up three types of *Orbitolites*, all living and thriving on the same bottom, and therefore, it may be inferred, equally well adapted to their common "environment"; yet one is of the very simplest structure and limited size, whilst another is of extraordinarily complex structure, and of comparatively gigantic dimensions. And it is difficult to imagine that the "complex" structure of the large shelly disk of *Orbitolites complanata* can give it the least advantage in the "struggle for existence" over the small and "simple" *Orbitolites marginalis* which is living along side of it.

Again, while abundance of food and a favourable temperature might produce in the spiral shell of *Cornuspira* a large extension upon the same simple plan, we can scarcely attribute to any such influences the peculiar change that shows itself in the periodical interruption of growth by the formation of a partial septum, which converts it into a *Spiroloculina*. Still less would it give any account of the formation of the complete septum traversed by a row of pores, which marks the assumption of the *Peneroplis* type; or of the subdivision of the spirally-growing chambers into chamberlets, which lifts it upwards into an *Orbiculina*; or of the exchange of the spiral for the cyclical plan of growth, which converts it into an *Orbitolite*. For what possible advantage can be supposed to be gained by any of these modifications, when we find that all those intermediate types, which show them in various grades of advance,—as if arrested in their developmental progress,—maintain their ground under exactly the same conditions, as though none had passed them in the race?

Looking now to the other essential condition of the "environment" of *Orbitolites*,—the preying of higher marine animals upon them,—I find it difficult to conceive that any of the foregoing modifications of structure can give to either type the least advantage in the "struggle for existence." We know that the smaller FORAMINIFERA serve as food both to Echinoidea and to Asteroidea, since the stomachs of these animals are found to be full of them; and it is probable that the larger forms are eaten by Crustacea and Fishes. But it seems scarcely possible that such creatures can have any preference for a cyclical over a spiral form, or for a complex over a simple. The very fact that—like the vast variety of *Operculina* which I formerly described (Phil. Trans., 1859, p. 15) from Mr. Cuming's gatherings—they all abound in the same localities, seems to forbid the idea that any one form is better fitted for survival than another. Getting out of the way of enemies is obviously out of the question with FORAMINIFERA; and the Fishes whose teeth are adapted to browse upon hard Corals, would not be likely to pick out one species of Orbitolite from another, when even a practised Foraminiferalist cannot distinguish them without examination with a magnifying-glass.

Altogether, while I hold it utterly illogical to impute to "natural selection" a power of *originating* any varietal forms whatever (since it can only take effect upon varieties which have already come into existence), and find it difficult to conceive that it can have had any share in even *perpetuating* the particular types of Orbitoline structure which form the subject of this Report, the developmental advances by which they have been successively evolved seem to me to lie altogether beyond the power of any known influence of "environment" to account for. We have evidence, in the size and luxuriance of the specimens of *Orbitolites complanata* growing in the rock-pools of the reef, that a warm temperature and abundance of food may stimulate *growth*; but we have no evidence whatever that they can of themselves cause an advance in *development*; and it seems inconceivable that they should produce a complete change in the *plan* of a fabric. There must have been an inherent capacity for elevation in certain of these organisms, for any change in the "environment" to produce *developmental* advances; for without such capacity, no amount of warmth or food could do more than produce an increase of *growth* on the lower grade. And there must have been some fundamental difference between that primordial jelly-speck which could evolve itself in a long series of generations into the highest type of *Orbitolites*, and that which perpetuates the humble form of *Cornuspira* still living under precisely the same conditions. Moreover, the passage from the lower type to the higher has always taken place (so far as we know) through the same series of intermediate forms; and each of these—as already pointed out—continues to maintain its existence on its own grade. Finally, it would seem as if the developmental capacity of the primordial germ exhausted itself in the production of the most complex form of *Orbitolites*; there being no reason whatever to believe that it leads up to any higher form of organic structure.

The general pointing of this study seems, therefore, to be, that the evolution of the highly complex Orbitoline type from the simplest monothalamous Milioline, has taken place according to a definite *plan*, of which we have the evidence in the wonderful uniformity and regularity of the entire sequence of developmental changes; whilst we are entirely unable to account for those changes, without attributing to the subjects of them a capability of being affected by external agencies in modes so peculiar as to indicate a *previous adaptation*. The question whether the variations on which "natural selection" takes effect are *aimless*, or whether they have a *fixed direction*, has so important a teleological bearing, that I have thought it worth while to work out with considerable care an instance in which that fixity seems to me very conspicuous. And I would specially point to the doubling of the radial stolons in the "duplex" type (pp. 27, 28) as a change altogether meaningless in itself, but very significant when considered as *anticipatory* of that greatest of all the developmental advances—the duplication of the annular canals (p. 40)—which marks the passage from the "simple" to the "complex" type.

PLATE I.

PLATE I.

Structure of Calcareous Disk of *Orbitolites tenuissima.*

Fig. 1.—Surface of young disk, showing its excentric spiroloculine "nucleus," giving origin to successive zones of orbiculine chamberlets, which gradually increase in breadth with the opening-out of the spire, until they extend completely round the "nucleus"; after which the successive additions are made on the cyclical plan, as concentric annuli. Magnified 25 diameters.

Fig. 2.—A portion of three peripheral annuli, enlarged to 64 diameters, and partially laid open by the removal of the superficial lamella, so as to show the two annular septa *aa*, *bb*, the chamberlets *c*, separated by radial partitions, and the annular gallery *d*, into which all the chamberlets open at their peripheral extremities.

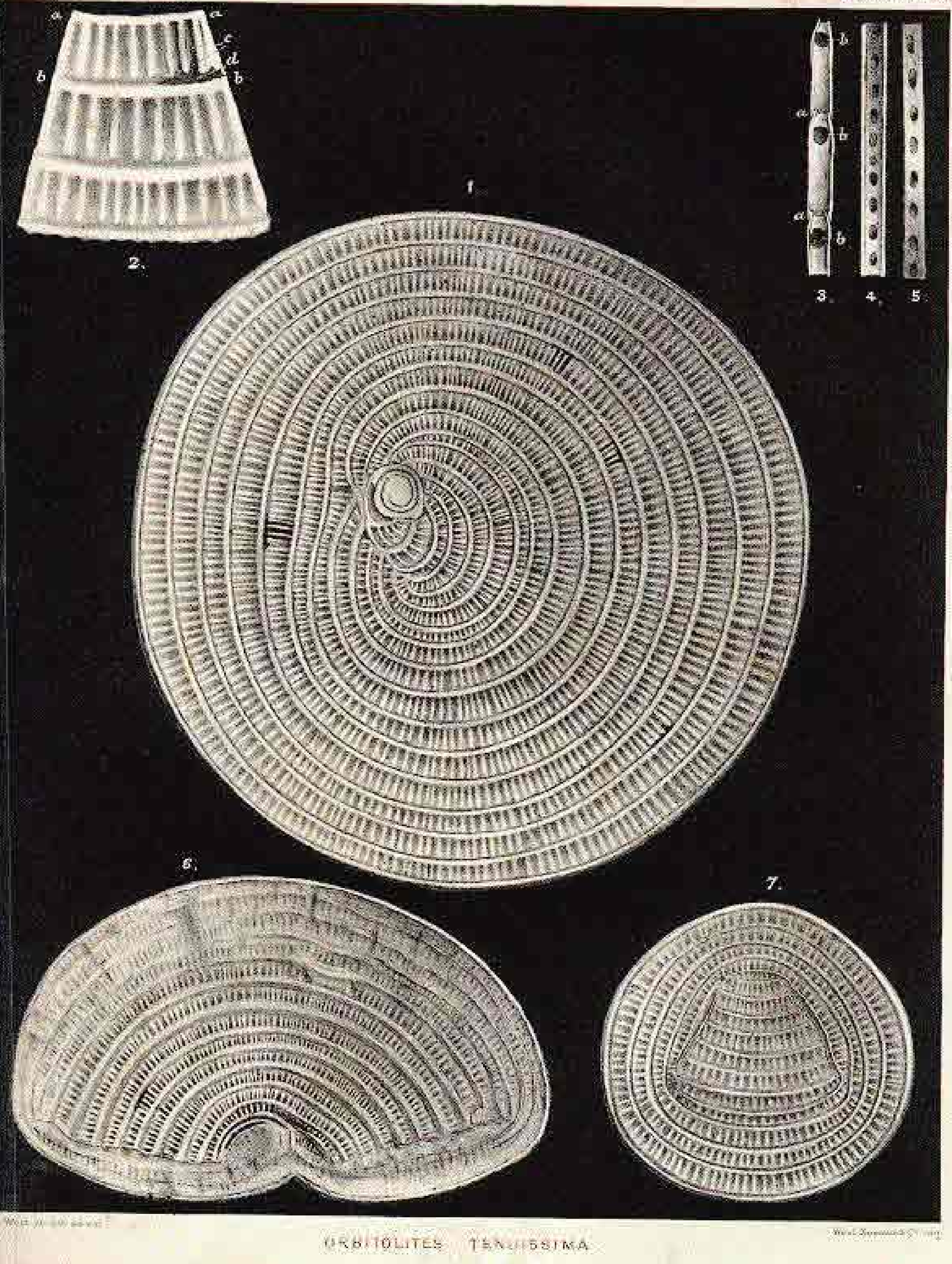
Fig. 3.—Vertical section of three annuli of the disk, taken in the radial direction, so as to traverse the chamberlets lengthways; *a*, *a*, junctions of two annuli with the annuli external to them; *b*, *b*, *b*, annular galleries traversing the septa between the chamberlets. At *a*, *a* are seen the openings through which the sarcodic cords that occupy the annular galleries send radial extensions into the chamberlets of the succeeding annuli. Magnified 64 diameters.

Fig. 4.—Internal aspect of a small portion of an annulus detached by fracture; showing the entrances to the chamberlets of that annulus through the septal plane. Magnified 64 diameters.

Fig. 5.—External or peripheral aspect of a portion of a marginal annulus, showing the passages through its septal plane, as marginal pores elongated in the plane of the disk. Magnified 64 diameters.

Fig. 6.—Portion of a disk, whose remainder, with the "nucleus," has been lost by injury previously to the formation of the last two annuli, which have extended themselves along the fractured margin, and into the nuclear space. Magnified 15 diameters.

Fig. 7.—Incipient production of an entirely new disk, with regularly concentric annuli, from a fragment of the peripheral portion of an old one. Magnified 15 diameters.



West, ad nat. del. et lith.

West, Newman & Co. imp.

ORBITOLITES TENUISSIMA.

PLATE II.

PLATE II.

Structure of Sarcodic Body and Calcareous Disk of *Orbitolites tenuissima.*

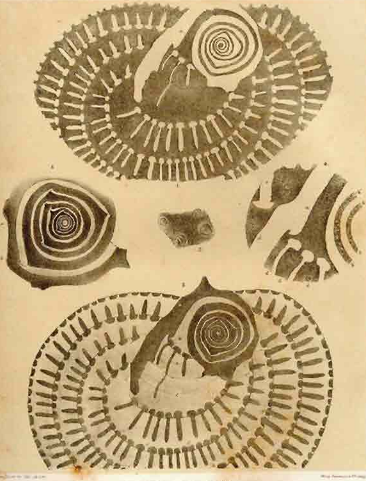
Fig. 1.—Sarcodic body of the central portion of the disk; showing the primordial segment giving off the spiroloculine coil, the sixth turn of which, *a*, begins to open out into a peneropline form, afterwards becoming divided into rows of orbiculine sub-segments, which are connected together laterally by the continuity of the sarcodic body through the gallery at the outer end of each row, and radially by the stolon-processes that pass through the septal passages, from the gallery of the inner row into the chamberlets of the outer. Nuclear (?) corpuscles are seen irregularly distributed through the sarcodic substance. Magnified 75 diameters.

Fig. 2.—Nuclear (?) bodies, as seen under a power of 450 diameters.

Fig. 3.—Section of first-formed portion of the disk, laying open the primordial chamber *a*, and the spiroloculine chambers, partially divided as at *b*, which coil round it. Magnified 125 diameters.

Fig. 4.—Portion of the sarcodic body shown in fig. 1, enlarged to 125 diameters, to show the distribution of the nuclear (?) corpuscles:—*a*, expanded extremity of the last spiroloculine coil; *b*, *b*, *b′*, *b′*, portions of preceding coils, crowded with nuclear (?) corpuscles; *c*, orbiculine sub-segment, with five corpuscles; *d*, *d*, *d*, *d*, orbiculine sub-segments, each with one or with two corpuscles.

Fig. 5.—Central portion of the calcareous disk, as seen by transmitted light:—*a*, expanded chamber formed by the termination of the spiroloculine coil, and closed-in by a peneropline septum traversed by four passages; *b*, second chamber, divided by radial partition into orbiculine chamberlets; *c*, third chamber, not here separated from the second by a septum, and having only one radial partition; *d*, *d*, fourth chamber, having at *d′*, *d′* lateral extensions which begin to enclose the spiroloculine coil; *e*, *e*, fifth chamber, with lateral extensions *e′*, *e′*, proceeding still further backwards; these chambers, and those that succeed them,divided by radial partitions into orbiculine chamberlets. Magnified 75 diameters.



ORBITOLITES TENUISSIMA.

PLATE III.

PLATE III.

Structure of Calcareous Disks of *Orbitolites marginalis* (figs. 1–7), and *Orbitolites duplex* (figs. 8–14), as seen by reflected light.

Orbitolites marginalis.

Fig. 1. Surface of disk. Magnified 16 diameters.

Fig. 2. Inner portion of the same, showing its excentric "nucleus" and the orbiculine arrangement of its earlier zones of chamberlets. Magnified 64 diameters.

Fig. 3. Peripheral portion of the same, viewed somewhat obliquely, so as to show at *a* the columnar arrangement of the margin. Magnified 64 diameters.

Fig. 4. Marginal view of two disks, *a* thin, *b* thick; showing the marginal pores elongated vertically, some of those in *b* being traversed by shelly bridges, which do not, however, completely divide them. Magnified 64 diameters.

Fig. 5. Interior view of a portion of an annulus separated by fracture from that which it enclosed; showing the vertically-elongated radial passages opening into its chamberlets. Magnified 64 diameters.

Fig. 6. Vertical section, taken in radial direction, of peripheral portion of disk, showing the single annular canal of each annulus, and the arcuate direction of the chamberlets. Magnified 64 diameters.

Fig. 7. Peripheral portion of disk, of which the upper surface has been ground away, so as to lay open the columnar chamberlets, the walls of whose last annulus form the fluted margin *a*. Magnified 64 diameters.

Orbitolites duplex.

Fig. 8. Surface of disk. Magnified 16 diameters.

Fig. 9 Horizontal section of a disk, taken beneath the plane of the annular canals, showing at *a* the openings into the lower series of columnar chamberlets, crossed by the annular septa; and at *b* the deeper plane from which the median stratum has been entirely removed. Magnified 50 diameters.

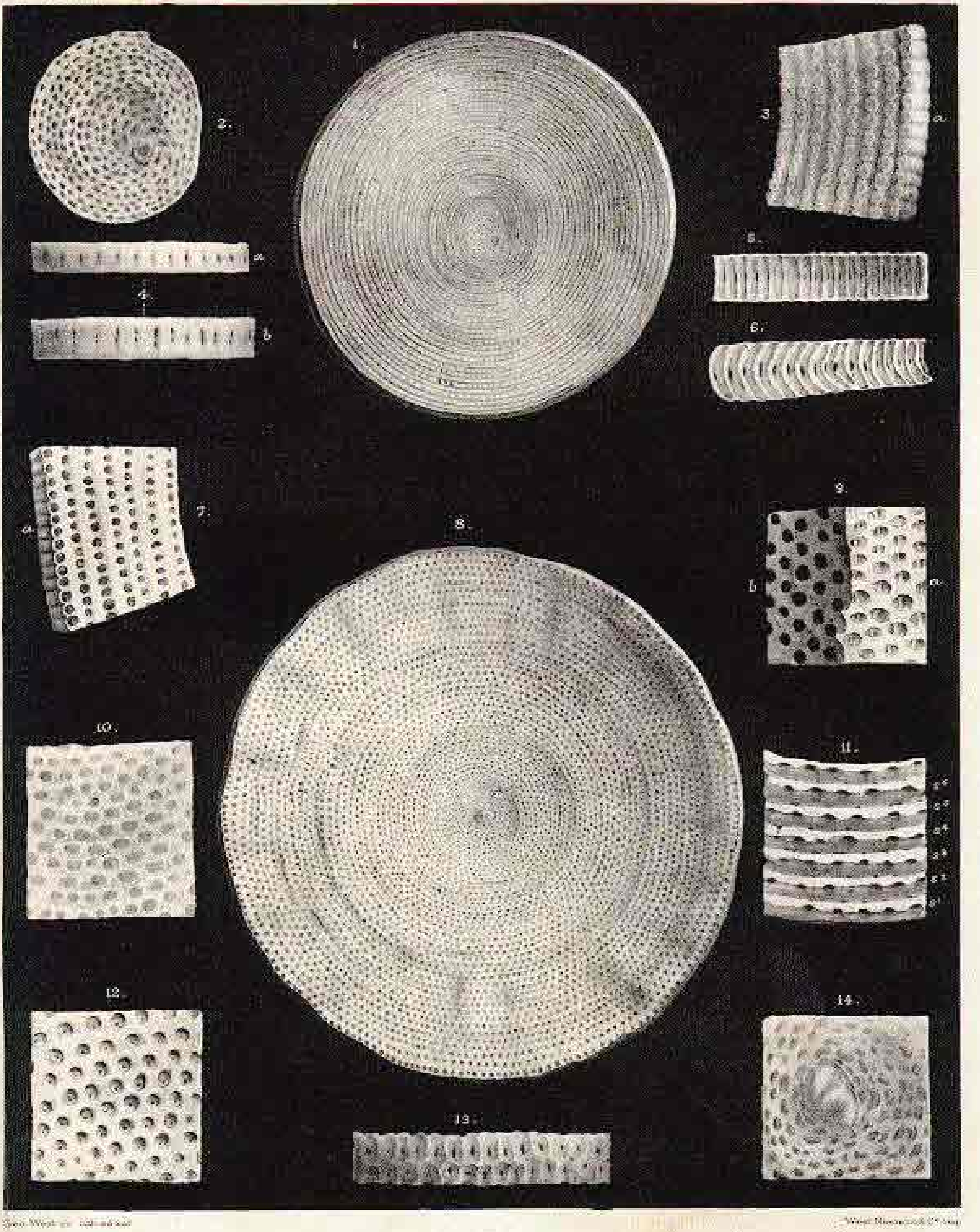
Fig. 10. Peripheral portion of the surface. Magnified 50 diameters.

Fig. 11 Horizontal section through the median stratum traversed by the annular canals, which are separated by the successive septa s^1–s^6; on the convex sides of these septa are seen the large passages leading obliquely downwards into the columnar chamberlets (*see* fig. 9) of their own lower series, while on the concave sides of the septa are seen the small radial passages that pass from each annular canal into the columnar chamberlets of the next annulus. Magnified 50 diameters

Fig. 12. Portion of disk laid open by removal of its upper surface, showing upper series of columnar chamberlets, with the pore in every one, which is the opening of the oblique radial passage from the annular canal of the preceding annulus. Magnified 50 diameters

Fig. 13. Margin of disk, showing the marginal pores arranged in two series, generally alternating in position, and separated by elevated ridges. Magnified 64 diameters.

Fig. 14. Central portion of disk, showing small "nucleus" and imperfect annulation of first-formed zones. Magnified 64 diameters.



Geo. West & Son lith. ad nat.

West, Newman & Co imp.

FIGS 1–7. ORBITOLITES MARGINALIS; FIGS 8–14. O. DUPLEX.

PLATE IV.

PLATE IV.

Structure of Calcareous Disks of *Orbitolites marginalis* (figs 1–5), and *Orbitolites duplex* (figs. 6–10), as seen by transmitted light.

Orbitolites marginalis.

Fig. 1.—Thin disk, mounted in Canada balsam, showing the general arrangement of its concentric annuli around an excentric "nucleus" and orbiculine interior. Magnified 30 diameters.

Fig. 2.—Interior portion of the same. Magnified 64 diameters.

Fig. 3.—Peripheral portion of the same. Magnified 64 diameters.

Fig. 4.—Thin section of inner portion of a disk, showing the communications between its chamberlets:—*a*, primordial chamber; *b*, circumambient chamber, leading by a single passage into next chamber, *c*, which opens by three radial passages into as many chamberlets forming the first zone *d*, and these into the chamberlets of the next zone *e*, the chamberlets of each zone communicating with each other laterally. The radial passages open at the outer side of each zone, as marginal pores, *f*, *f*. Magnified 90 diameters.

Fig. 5.—Sarcodic body occupying inner portion of disk:—*a*, primordial segment giving off *b*, circumambient segment, and this giving off the single segment *c*, from which proceed the stolon-processes that form the first imperfect zone of sub-segments *d*; from this, again, are given off the stolon-processes that form the more complete zone *e*; and each zone increases in length, until the ninth and tenth completely enclose the circumambient segment. At *f*, *f* are seen the sarcodic annuli which connect together the chamberlets of each zone, and the radial stolon-processes that issue from this to form the next annulus. Magnified 90 diameters.

Orbitolites duplex.

Fig. 6.—Section of disk through superficial plane, showing its "engine-turned" aspect. Magnified 16 diameters.

Fig. 7.—Section through median plane, showing annular canals laid open, and the large passages for the pedicles of the lower series of columnar sub-segments. Magnified 50 diameters.

Fig. 8.—Section through a somewhat deeper stratum, showing the successive septa, s^1–s^8, that divide the annular canals, with the columnar chamberlets *c*, *c*, into which they open beneath, and the oblique stolon-passages *st*, *st*, which pass to the chamberlets of each zone from the annular canal of the preceding zone. Magnified 50 diameters.

Fig. 9.—Surface-aspect of central portion of disk, showing at *a* the primordial chamber, and at *b* the circumambient chamber, the first-formed zones around which are irregular and incomplete. Magnified 64 diameters.

Fig. 10.—Section of central portion of disk through median plane, showing at *a* the primordial chamber, and at *b*, *b* the circumambient chambers, from one side only of which last are given off the stolon-passages that dilate into the first imperfect zone of chamberlets. The successive zones, however, complete themselves so as to enclose the "nucleus" much more speedily than in *Orbitolites marginalis*; so that the "nucleus" has but a slight excentricity. Magnified 90 diameters.

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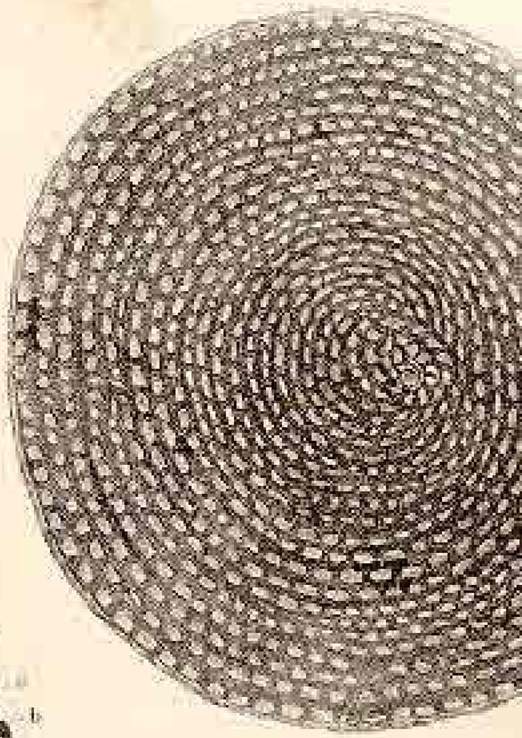

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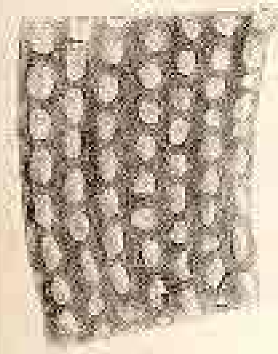

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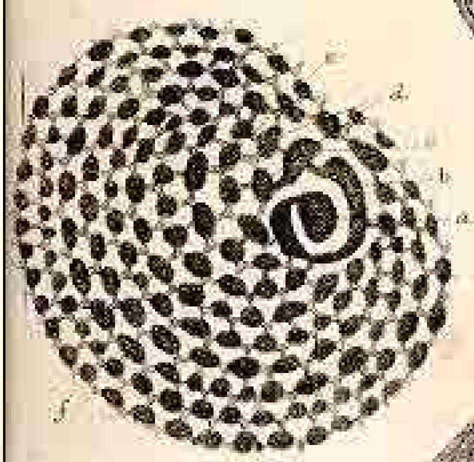

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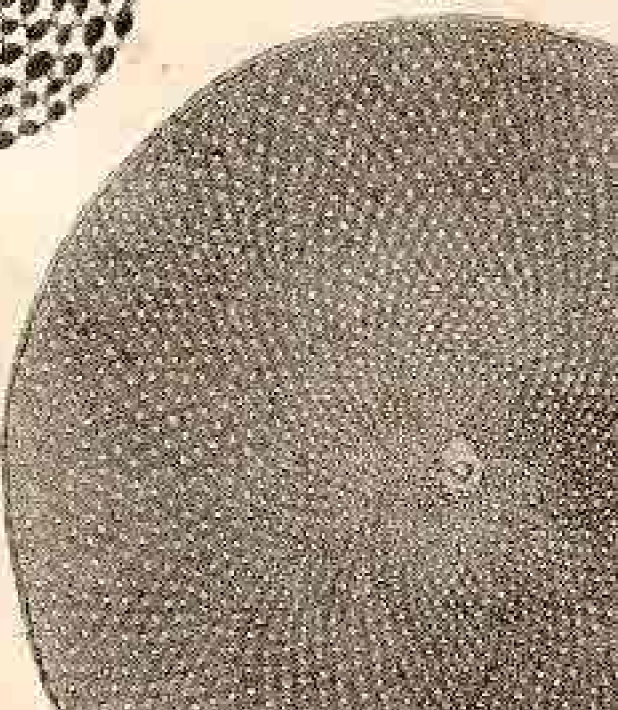

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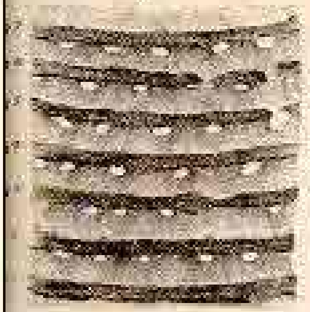

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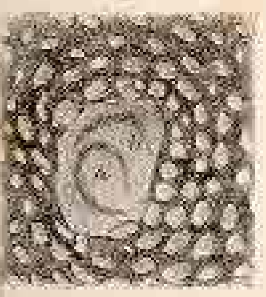

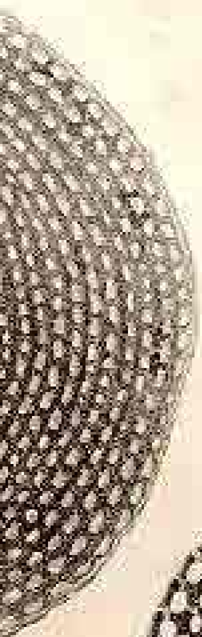

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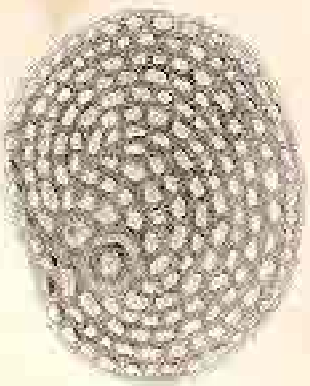

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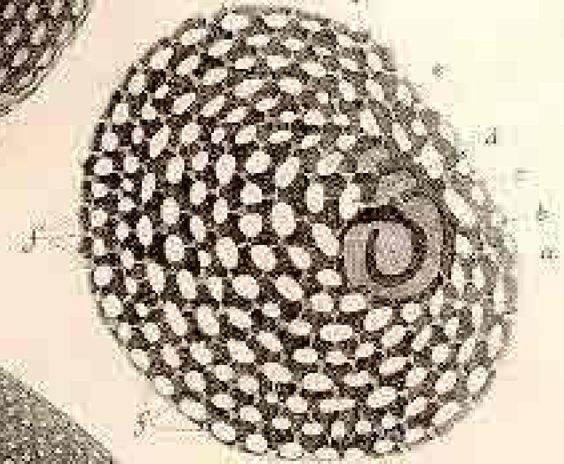

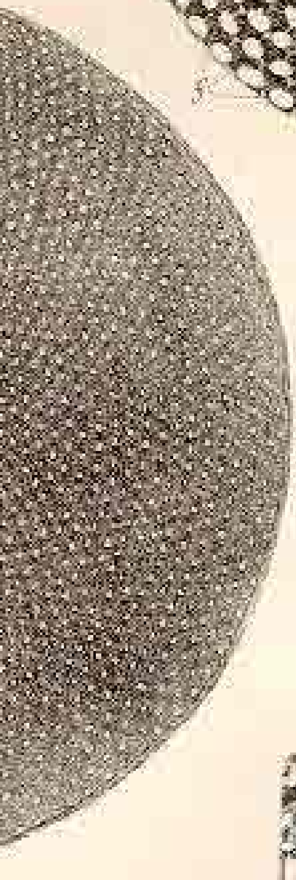

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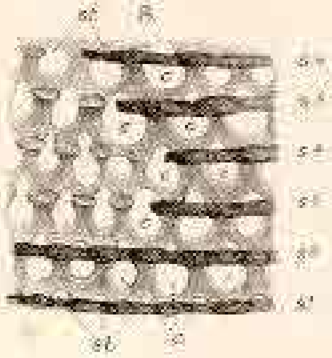

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West Newman & Co. imp.

FIG.S 1–5. ORBITOLITES MARGINALIS, FIG

6–10. O. DUPLEX

PLATE V.

PLATE V.

Structure of Sarcodic Bodies of *Orbitolites duplex* (figs. 1–10), and *Orbitolites complanata* (figs. 11–18).

Orbitolites duplex.

Fig. 1.—Decalcified body, showing the concentric arrangement of its columnar sub-segments. Magnified 25 diameters.

Fig. 2.—One of its separate annuli, showing at *a*, *a'* and *b'*, *b'* the upper and lower series of columnar sub-segments, with expanded summits, issuing from the annular sarcodic cords *c*, *c'*, from which also issue the two rows of stolon-processes *dd*, *d'd'* that go to form the succeeding annulus. Magnified 60 diameters.

Fig. 3.—Two of the columnar sub-segments more enlarged, to show the corpusculated character of the sarcodic substance. Magnified 150 diameters.

Fig. 4.—Thick-walled (parasitic ?) cells, *a*, *b*, *c*, of a deep red colour, lying irregularly in the sarcodic substance of certain specimens. Magnified 200 diameters.

Fig. 5.—Small sub-segments of central portion, surrounded by chitinous (?) wall. Magnified 150 diameters.

Fig. 6.—Sarcodic body of "nucleus," showing at *a* the primordial segment, which gives off the large circumambient segment *b*, *b'*, a partly-separated portion of which, *c*, gives off the first incomplete zone of sub-segments. Magnified 120 diameters.

Fig. 7.—Section of sarcodic body close to the median plane, showing the sarcodic annuli *c*, *c*, giving off obliquely the narrow bases of the columnar sub-segments. Magnified 50 diameters.

Fig. 8.—Lateral view of two sarcodic annuli *cc'* *cc'*, with their columnar sub-segments. Magnified 64 diameters.

Fig. 9.—Section of sarcodic body above the median plane, showing an increased diameter of the columnar sub-segments as compared with their narrow bases shown in fig. 7. Magnified 50 diameters.

Fig. 10.—Surface view of expanded summits of columnar sub-segments. Magnified 50 diameters.

Orbitolites complanata.

Fig. 11.—Decalcified body of sub-typical specimen, the inner part of which is formed on the "duplex" plan, as shown by the surface-aspect of its sub-segments, while the outer shows the aspect characteristic of the "complex" type. Magnified 25 diameters.

Fig. 12.—Surface-aspect of sarcodic sub-segments of inner part of sarcodic body, enlarged to 40 diameters, showing its exact correspondence to that of fig. 1.

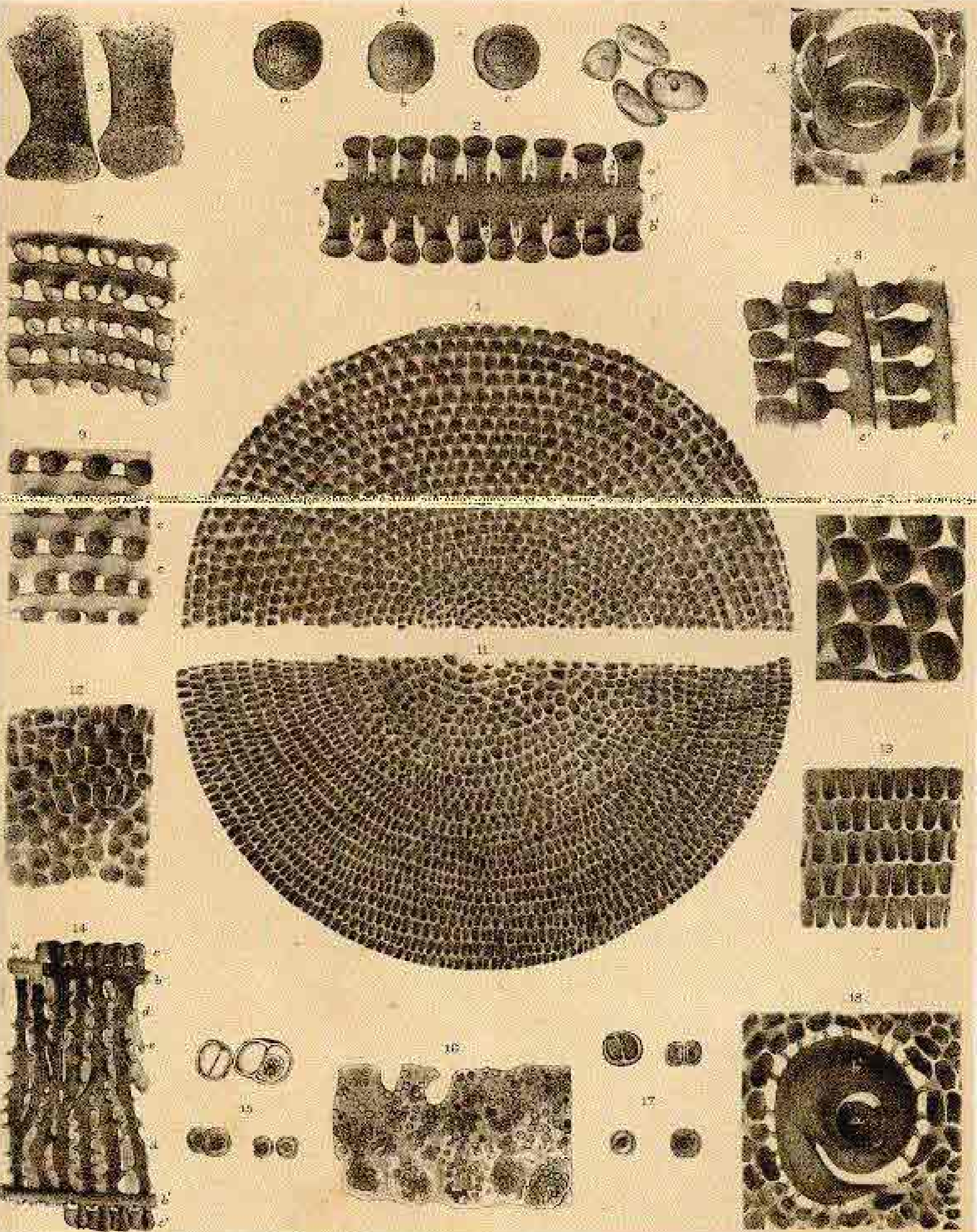
Fig. 13.—Surface-aspect of sarcodic sub-segments of outer part of sarcodic body, occupying the chamberlets of the superficial planes. Magnified 50 diameters.

Fig. 14.—Portion of sarcodic body of "complex" type seen in vertical section:—*a*, *b*, annular cords of upper series; *b'*, an annular cord of lower series; *c*, *c'*, sub-segments of upper and lower planes, each connected with two annular canals; *d*, *d*, columnar sub-segments of interposed stratum, communicating with those of next annulus, *e*, by oblique alternating stolon-processes. Magnified 150 diameters.

Figs. 15 and 17.—Parasitic (?) cells lying irregularly in sarcodic substance. Magnified 150 diameters.

Fig. 16.—Sarcodic substance of annulus and superficial sub-segments, containing spherical corpuscles, closely aggregated together in some parts, separate in others. Magnified 150 diameters.

Fig. 18.—"Nucleus" of typical form, showing at *a* the primordial segment, which gives off the large circumambient segment *b*, *b'*, with its partly detached portion *c*, round the entire margin of which are given off stolon-processes that give immediate origin to a complete annulus of sub-segments. Magnified 84 diameters.



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FIGS. 1–10. ORBITOLITES DUPLEX. FIGS. 11–18. O. COMPLANATA.

PLATE VI.

PLATE VI.

Structure of the Calcareous Disk of *Orbitolites complanata*, as seen by reflected light.

Figs. 1–3.—Three young typical specimens, showing the large size of the "nucleus" (originating in the primordial chamber *a*), and the completeness of even the very earliest annuli of chamberlets. Magnified 35 diameters.

Fig. 4.—Ideal representation of a typical disk, laid open in various modes to show its interior structure:—*a*, primordial chamber; *b*, circumambient chamber; *c*, *c*, concentric annuli of oblong superficial chamberlets; *d*, marginal pores of peripheral annulus; *d′*, *d″*, corresponding pores of inner annuli, once marginal, but now connecting the interior with exterior annuli; *e*, *e*, vertical section in radial direction, showing intermediate stratum distinct from superficial layers; *f*, *f*, floors of superficial chamberlets, with an aperture at either end of each; *g*, *g*, annular canals running beneath these floors, with large apertures leading to the columnar chamberlets of the intermediate stratum; *g′*, similar canals near the other surface of the disk; *g″*, similar canals laid open through the plane on which they give off the two passages to each superficial chamberlet; *g‴*, annular canals cut through in vertical section; *h*, passage of horizontal section through summit of intermediate stratum, showing the tops of the columnar chamberlets; *i*, *i*, *i*, and *k*, *k*, *k*, passage of horizontal section through two different planes of intermediate stratum, showing connection between columnar chamberlets of successive zones, by oblique passages running in opposite directions.

Fig. 5.—Vertical section, taken in the radial direction, of a "sub-typical" example, whose earlier development has taken place on the "simple" plan:—*a*, cavity of "nucleus"; from *aa* to *bb* the annular canal single in each zone; from *bb* to *cc* the annular canals double in each zone, and separated from each other by an interposed stratum, the chamberlets of which are generally continuous with those of the superficial planes, much irregularity in this respect showing itself between *cc* and *dd*. Magnified 50 diameters.

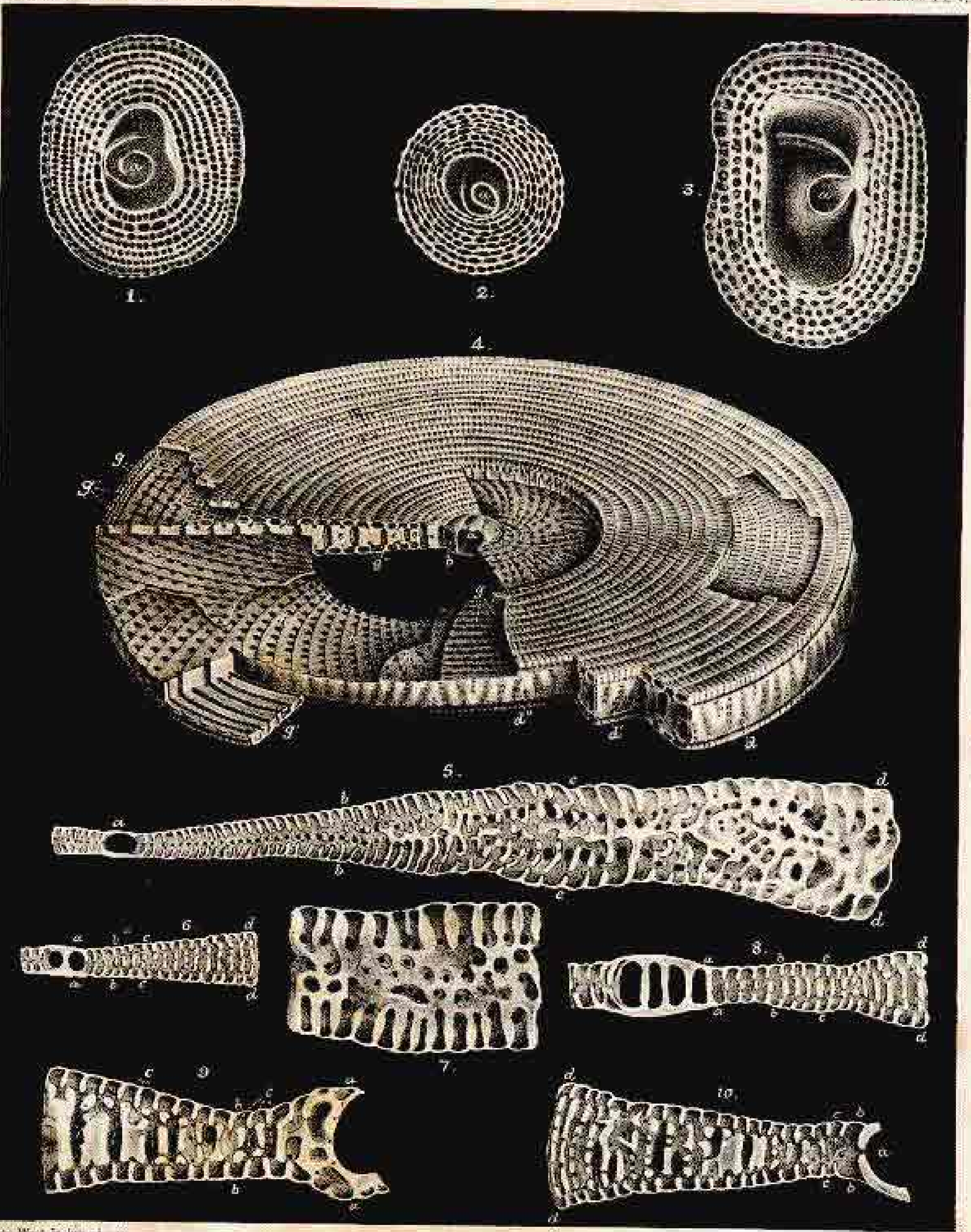
Fig. 6.—Central portion of a disk, the first three zones of which, between *aa* and *bb*, are formed upon the "simple" type, each having but a single annular canal and one row of septal passages; at *bb* the "complex" type is assumed, the annular canals being doubled, and separated by an interposed stratum; but the columnar chamberlets of this stratum that lie between the annular canals are continuous from *bb* to *cc* with the chamberlets of the superficial layers, this continuity giving place between *cc* and *dd* to the alternation in their positions characteristic of the most typical Orbitoline disks. Magnified 50 diameters.

Fig. 7.—Tangential vertical section of a typical disk, taken near the thick margin; showing the two layers of superficial chamberlets, the double series of annular canals, and the interposed stratum traversed by the radial passages that open on the periphery as marginal pores. Magnified 50 diameters.

Fig. 8.—Vertical section of a disk, of which the first five zones, *aa* to *bb*, are formed on the "duplex" type, each having but a single annular canal, but a double series of radial passages; between *bb* and *cc* the annular canals are double, and the chamberlets of the interposed stratum are continuous with the superficial chamberlets; while from *cc* to *dd* the superficial chamberlets alternate in position with those of the interposed stratum. Magnified 48 diameters.

Fig. 9.—Vertical section of inner part of typical disk, showing the circumambient chamber, *aa*, immediately surrounded by annuli of the complex type, having the two superficial layers of chamberlets, *b*, *b*, completely dissociated from the columnar chamberlets, *c*, *c*, of the interposed stratum. Magnified 48 diameters.

Fig. 10.—Vertical section of inner part of typical disk, showing the circumambient chamber, *a*, communicating by only a single passage with the "simple" chamberlets of the first annulus *b*; but this at once passing at *c*, by the doubling of the annular canal, into the "complex," which is thenceforth maintained, *c d*, with a progressive increase in the thickness of the disk. Magnified 48 diameters.



Geo. West & Son lith. ad nat.

West, Newman & Co. imp.

ORBITOLITES COMPLANATA.

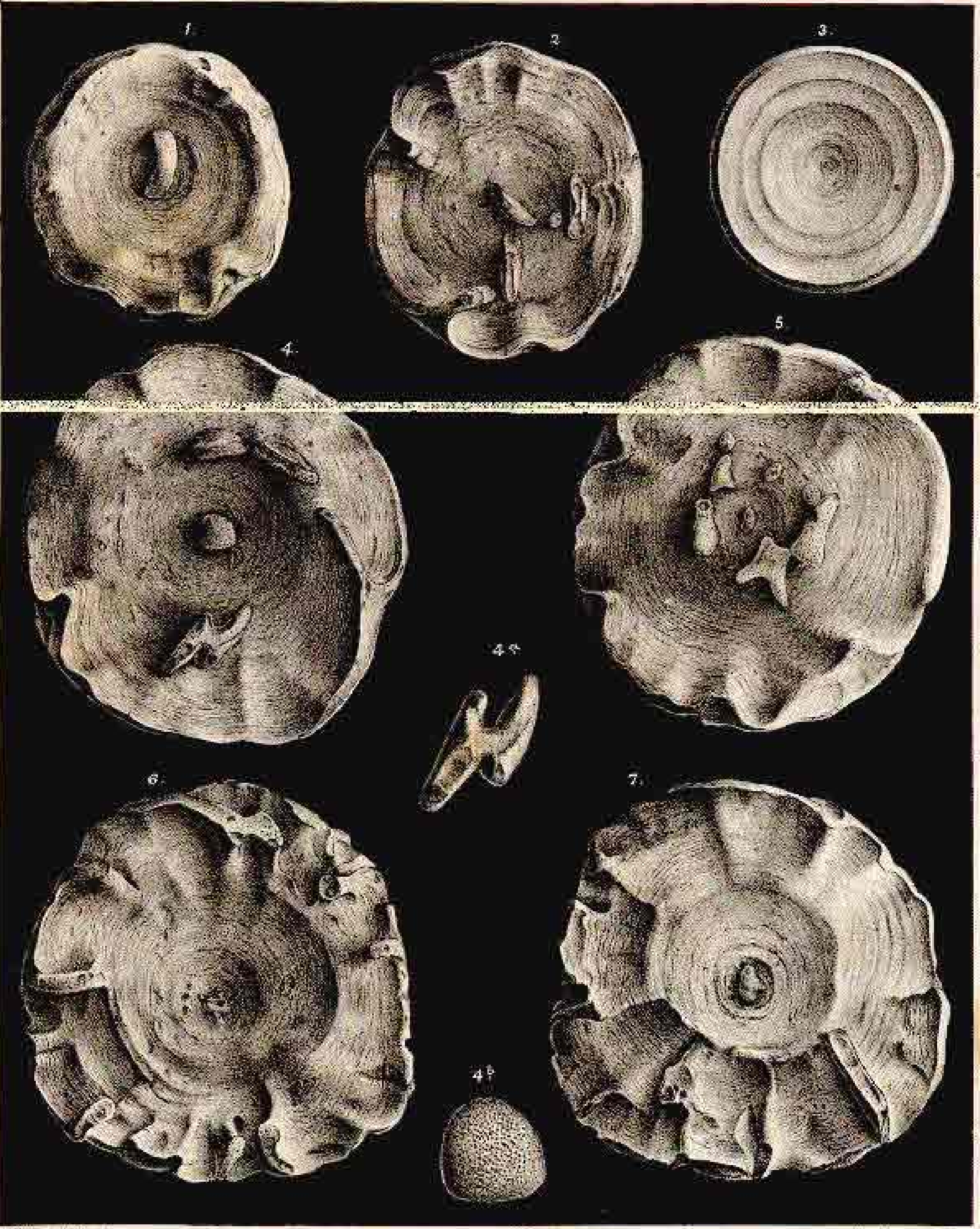
PLATE VII.

PLATE VII.

Laciniate specimens of *Orbitolites complanata.*

All the disks represented in this Plate are magnified four diameters; and, with the exception of fig. 3 (which represents a *normal* disk of the massive type), show in a greater or less degree the "laciniation" of margin, which seems to depend—like the irregular outgrowths from the central and intermediate portions—on an excess of productive power.

Figs. 4 *a* and 4 *b* show, under a higher power, the central and one of the intermediate outgrowths seen in fig. 4, so as to exhibit the pores which correspond to the marginal pores of the regular annuli.



Geo. West. del. lith ad nat.

West, Newman & Co. imp.

ORBITOLITES COMPLANATA. (VAR. LACINIATA.)

PLATE VIII.

PLATE VIII.

Irregularities and Reparations of disks of *Orbitolites complanata.*

Fig. 1.—Young disk with vertical crest growing from central portion. Magnified 10 diameters.

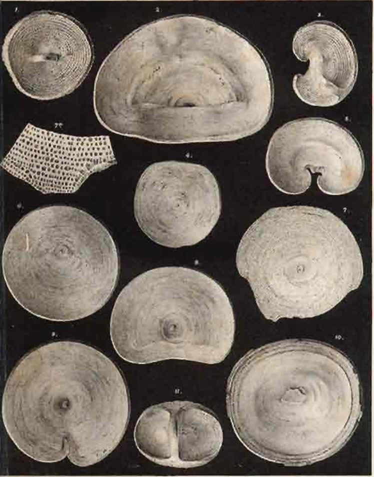
Fig. 2.—Reparation of disk that had been broken across at an early stage. Magnified 8 diameters.

Fig. 3.—Irregular growth of young disk, with vertical crest. Magnified 10 diameters.

Figs. 4–9.—Reparations of disks fractured in various ways, all tending to reproduce the discoidal form. Magnified from 4 to 6 diameters.

Fig. 10.—Production of complete disk around marginal fragment of older disk. The outer annuli of this disk are deficient in radial partitions. Magnified 6 diameters.

Fig. 11.—Double monster, probably formed by fusion of two originally separate individuals. Magnified 10 diameters.



ORBITOLITES COMPLANATA. — IRREGULARITIES.