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From Voyage of H.M.S. Challenger
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THE
VOYAGE OF H.M.S. CHALLENGER.

ZOOLOGY.

REPORT on the ANATOMY of the PETRELS (*Tubinares*), collected during the Voyage of H.M.S. Challenger. By W. A. FORBES, B.A., F.L.S., F.G.S., M.B.O.U., Fellow of St. John's College, Cambridge, Prosector to the Zoological Society of London.

I. INTRODUCTORY.

MATERIALS for the knowledge of the structure of the soft parts of the class Aves, when the members of that group indigenous to a country have been examined, are for the most part only to be obtained through the medium of zoological gardens, by the inhabitants of these, on their decease, coming into the hands of some person competent to examine them. In spite of the increased facilities of communication of the present day, and the greater experience of those in charge of living zoological collections, there still remain many groups of birds which as yet it has been found impossible to obtain or keep in a living state. Such birds in consequence can only be adequately studied from spirit-specimens, and these also it is frequently very difficult to obtain, especially if the species wanted are of large size, or inhabit little explored and inaccessible countries.

The group of PETRELS is one that has till the present been hardly at all examined anatomically, as but few species inhabit the European seas, and even these, on account of their peculiar habits, are rarely to be obtained in the flesh, either in a living or dead state. The majority of the group, inhabiting the little visited oceans and islands of the Southern Hemisphere, have been known simply from skins or skeletons, the great size of many of them rendering bringing their bodies home in spirit impracticable to any ordinary collector. Nor have we as yet succeeded in obtaining or keeping any in a living state, except on one or two rare occasions.

When therefore H.M.S. Challenger was starting on her voyage of circumnavigation it

seemed that an excellent opportunity would be afforded for obtaining material to fill up the blank that thus existed in our knowledge of the Petrels. At the suggestion of my lamented predecessor Prof. A. H. Garrod, at that time Prosector to the Zoological Society, the naturalist staff was requested to pay special attention to forming a collection of these oceanic birds in spirit, so as to be available for anatomical examination. The result was a very considerable collection indeed of the birds in question, all excellently preserved, and including nearly all the most important and interesting of the known genera. These were handed over, when the collections were being broken up for working out, to Professor Garrod for examination. Unfortunately he had hardly commenced to work seriously on them before he was struck down by the lingering illness which eventually proved fatal to him. During that time, whenever well enough to do so, he continued to work away at his favourite subject, and many of his drawings made then, chiefly relating to the conformation of the syrinx in these birds, are now before me. An unfinished MS. paper of his written about that time, treating on the anatomy of the Diving Petrel (*Pelecanoides*)—a form the Procellarian affinities of which were then doubtful—was sufficiently complete and important to justify, in the writer's opinion, its publication in the reprint of Professor Garrod's papers which has since been edited by him.

Succeeding to Professor Garrod's position at the Zoological Gardens early in 1880, I applied immediately to the late Professor Sir Wyville Thomson to be allowed to retain so much of the material collected by the Challenger as was likely to prove of service to me in my researches on the anatomy of birds, and I especially asked to be allowed to retain the collection of Petrels, with the object of drawing up a report thereon for the present series of papers. I must take this opportunity to record my best thanks to Sir Wyville Thomson for the very ready way in which he acceded to both my requests. Having commenced work on the specimens of Petrels collected by the Challenger it seemed desirable to make my report on the structure of that group as perfect and complete as possible, and during the past two years I have therefore taken every opportunity of acquiring specimens of them fit for dissection. By these means I have been enabled to examine several species and genera of these birds not represented in the Challenger collection, though that collection has formed the groundwork of my investigations.

I herewith give a complete list of those species that I have been enabled to examine in the flesh. All not otherwise indicated were collected by H.M.S. Challenger. And I must take this opportunity to thank my friend Mr. Osbert Salvin, F.R.S., who reported on the collection of Tubinares made in skins during the voyage,¹ for his kind assistance in naming the spirit-specimens under my charge, as well as for much subsequent assistance in points of nomenclature, and for valuable material that would not have otherwise been available.

¹ Zoology of the Voyage of H.M.S. Challenger, vol. ii. part viii. pp. 140-149 (Report on the Birds—XI. On the Procellariidae collected during the Expedition). Also Proc. Zool. Soc., 1878, pp. 735-740.

LIST OF MATERIAL EXAMINED.

Name of Bird.	Number of Specimens.	Remarks.
OCEANITIDÆ—		
<i>Oceanites oceanicus</i> ,	3	One from the Smithsonian Institution.
<i>Garrodia nereis</i> ,	4	One from the Godeffroy Museum in Hamburg. The other three old specimens from the Museum of the Royal College of Surgeons.
<i>Pelagodroma marina</i> ,	1	
<i>Fregetta grallaria</i> ,	2	One a skinned trunk.
„ <i>melanogastra</i> ,	2	From the Godeffroy Museum.
PROCELLARIIDÆ—		
<i>Halocyptena microsoma</i> ,	1	(I must thank Mr. Salvin for his kindness in allowing me to dissect his spirit-specimen of this extremely rare bird, previously only known from the type-specimen in the Smith- sonian Institution.)
<i>Procellaria pelagica</i> ,	3	Prosector's stores.
<i>Cymochorea leucorrhœa</i> ,	5	Two, one a chick, from the Smithsonian Institu- tion. Three from Prosector's stores.
<i>Bulweria columbina</i> ,	1	O. Salvin, Esq.
„ <i>macgillivrayi</i> ,	1	Received from Canon Tristram (skinned trunk only).
<i>Æstrelata mollis</i> ,	1	An old specimen from the College of Surgeons.
„ <i>lessoni</i> ,	1	
„ sp. inc.,	1	
„ <i>brevirostris</i> ,	8	All young (two from the Transit Expedition).
<i>Majaqueus æquinoctialis</i> ,	3	One young.
<i>Puffinus obscurus</i> ,	4	
„ <i>brevicauda</i> ,	3	
<i>Pagodroma nivea</i> ,	1	
<i>Daption capensis</i> ,	2	One from the Zoological Society's Gardens.
<i>Æiropetes</i> ¹ <i>antarcticus</i> ,	2	
<i>Thalasseca glacialis</i> ,	1	
<i>Fulmarus glacialis</i> ,	2	Zoological Society's Gardens.
<i>Ossifraga gigantea</i> ,	2	One, a nestling, from the Transit Expedition.
<i>Prion vittatus</i> ,	1	
„ <i>banksi</i> ,	2	One from Celebes (O. Salvin, Esq.), one from the College of Surgeons.
„ <i>desolatus</i> ,	4	One a chick.
<i>Pelecanoides urinatrix</i> ,	7	Two young.
<i>Diomedea brachyura</i> ,	2	
„ <i>exulans</i> ,	2	
<i>Thalassiarche culminata</i> ,	1	
<i>Phœbetria fuliginosa</i> ,	1	A nestling.

In all thirty-one species, represented by seventy-four specimens and belonging to twenty-two different genera. Besides the above, which only represent entire birds, there were a number of separate heads, which have been cleaned, and will be found enumerated below in the list of osteological material in this group examined by me.

¹ For the characters of this new genus, *vide infra*, p. 59.

II. PREVIOUS LITERATURE ON THE ANATOMY AND CLASSIFICATION OF THE TUBINARES.

I propose under this head to briefly notice the more important papers or memoirs that have appeared dealing with the structure and classification of these birds. Titles of several less important ones not mentioned here may be found duly recorded in the third instalment of Dr. Coues' Ornithological Biography,¹ Procellariidæ, pp. 1021-1033.

1826. One of the very earliest contributions to the anatomy of the Petrels we owe to the voyage of circumnavigation made by the "Coquille." Garnot, in the account of that expedition,² gives some brief anatomical notices chiefly relating to the digestive organs of several Tubinares. The species dissected are, unfortunately, not referred to by scientific names, but they appear to be *Phæbetria fuliginosa*, *Thalassæca glacialis*, a *Prion*, *Fregetta melanogastra*, and *Pelecanoïdes urinatrix*, as well as another species I cannot determine ("Petrel de la Mer Pacifique").

In 1827 L'herminier³ described the general character of the sternum of the Tubinares, which formed his twenty-eighth family of birds, and proposed to divide the group up, on sternal characters, into three sections—(1) the smaller Petrels (*Procellaria*, *Cymochorea*, &c.) with the posterior margin of the sternum more or less entire; (2) the Albatrosses, with the sternum with two large and shallow excavations posteriorly; and (3) the Petrels proper, with four posterior sternal excavations. As regards the general position of the group, he remarks:—"Ces oiseaux . . . par la forme de l'appareil sternal, sont intermédiaires aux mouettes et aux pélicans." On plate iv. of the plates illustrating his memoir, two figures of the sternum of a *Puffinus* are given.

1838-39. W. Macgillivray, in Audubon's Ornithological Biography,⁴ describes and figures the alimentary canal and trachea of two species of Petrels, namely, *Oceanites oceanicus* (vol. v. pp. 645-646) and of *Procellaria pelagica* (vol. iv. pp. 313-315).

In the second part of the same author's Manual of British Ornithology⁵ are given a few notes on the visceral anatomy of the British species of the group.

In the same year J. F. Brandt, in his Beiträge zur Naturgeschichte der Vogel,⁶ called attention to the existence of a peculiar ossicle, connected with the lachrymal and palatine bones, and hence called "ossiculum lacrymo-palatinum," which he had discovered in many of the Tubinares and also in *Fregata aquila*.

1840. It is to Nitzsch, perhaps the most acute and original ornithologist that ever lived,

¹ Bull. U. S. Geol. Surv., vol. v., No. 4, Washington, 1880.

² Voyage autour de la Monde, Zool., tom. i.; Recherches anatomiques relatives a divers oiseaux marins, pp. 603-612.

³ Recherches sur l'appareil sternal des Oiseaux, pp. 79-81, vol. iv., Paris, 1827.

⁴ Edinburgh, 1839.

⁵ London, 1842, pp. 258-264.

⁶ Beiträge zur Kenntniss der Naturgeschichte der Vögel, St. Petersburg, 1839, pp. 4-9.

that we are indebted for nearly our whole existing knowledge of the important subject of the pterylosis of birds. In his classical, though posthumous, *Pterylographie* the Nasutæ seu Tubinares form the second group of his order Natatores, and the pterylosis of the group is described at some length. Further details of Nitzsch's observations are recorded below (*infra*, p. 14) in the space devoted to the consideration of the pterylographical characters of these birds. So far as I am aware nothing else was contributed by Nitzsch to our knowledge of this group.

In the same year as that in which the *Pterylographie* appeared, Rudolph Wagner, a disciple of Nitzsch's, contributed to the tenth volume of Naumann's *Vögel Deutschlands*¹ some remarks on the anatomical structure of three genera of Tubinares included in that work, namely, *Procellaria*, *Fulmarus*, and *Puffinus*. These consisted of short notes on the skeleton and the thoracic and abdominal viscera, and, as far as they go, are accurate enough. The general similarity in structure of the members of this group examined, as well as of *Diomedea*, is noted, as well as many points of resemblance to the Laridæ, and particularly *Lestræis*.

In the year 1844 MM. Hombron and Jacquinot communicated to the Academy of Sciences in Paris a paper entitled "Remarques sur quelques points de l'anatomie et de la physiologie des Procellariidées, et essai d'une nouvelle classification de ces oiseaux." An abstract, by the authors, is published in the *Comptes Rendus* for that year.² The material for their paper was obtained, I may remark, during the expedition of the French ships "Astrolabe" and "Zélée," commonly known as the Voyage au Pôle Sud. Basing their classification on the form and structure of the beak, palate, and tongue, they divide up the group as follows:—

1. Borders of mandibles excavated by a longitudinal furrow dividing them into inner and outer cutting surfaces. Tongue small, one-third the length of beak, sagittate, posteriorly and laterally denticulate.

Three genera—*Diomedea*; *Puffinus*, subdivided into *Puffinus* proper (*anglorum*, *obscurus*, *fuliginosus*?, &c.) and *Priofinus* (*cinereus*, *æquinoctialis*, *arcticus*?); and *Thalassidroma* (*pelagica*, *leachii* [= *leucorrhœa*], *oceanica*, *fregetta* [= *grallaria*], *marina*.

2. Edges of upper mandible with transverse lamellæ. Tongue as long as the beak, large and thick, only free at the apex.

One genus, *Prion*, divided into five sub-genera—*Prion* s.s., *Daption*, *Fulmarus*, *Ossi-fraga*, and *Priocella* (for *Priocella garnoti* = *Thalassæca glacialoides* of this paper).

3. Mandibles simple, with no double cutting-edges or transverse lamellæ, but with two slight, elongated "teeth"; palate smooth or nearly so; tongue of intermediate length.

One genus, *Procellaria*, separated into two groups, one with the beak quite short (*nivea*, *desolata*, *brevirostris*), the other with it long (*antarctica*, *lessoni*, *hæsitata*, Forst. [= *Adamastor cinereus*]).

¹ *Loc. cit.*, pp. 555–656, 587–588, 614–617.

² *Loc. cit.*, tom. xviii. pp. 353–358.

These points are illustrated in the atlas to the Voyage au Pôle Sud (pl. xxxii.), the classification adopted being explained in the text (vol. iii. pp. 143-152) published some years later.

The genus *Pelecanoïdes* is expressly excluded from the Petrels by these authors, according to whom it is closely allied to the Little Auk (*Alle nigricans*) of our northern seas.

1849. Gray and Mitchell, in the Genera of Birds,¹ make the Procellariidæ the fourth family of their Anseres. They are subdivided into the Diomedeinæ (of one genus) and the Procellariinæ, of which latter five genera are recognised (*Prion*, *Pelecanoïdes*, *Procellaria*, *Thalassidroma*, and *Puffinus*). The most characteristic generic characters of these are figured on plate 178.

1857. Bonaparte in his Conspectus² gives a list of the then known genera and species of the Procellariidæ, which he divides into three sub-families, Diomedeinæ (*Diomedea*), Procellariinæ, and Halodrominæ. The Procellariinæ again are divided into five smaller groups, designated by letters as follows :—

A. Fulmareæ—

Ossifraga, *Fulmarus*, *Adamastor*, *Daption*.

B. Œstrelateæ—

Œstrelata, *Cookilaria*, *Pterodroma*, *Thalassæca*, *Pagodroma*.

C. Prioneæ—

Prion, *Halobæna*.

D. Procellariææ—

“**Unguibus compressis*”; *Bulweria*, *Oceanodroma*, *Thalassidroma*, *Procellaria*.

“***Unguibus depressis*”; *Fregetta*, *Pelagodroma*, *Oceanites*.

E. Puffinææ—

Majaqueus, *Thiellus*, *Nectris*, *Puffinus*.

1866.—In this year Dr. Elliott Coues completed his Critical Review of the family Procellariidæ commenced in 1864.³

This is the most complete account yet published of the synonymy and distribution of the species of this group, which is divided into 24 genera, containing 92 species (17 of these being doubtful). Following Bonaparte, the same three sub-families are adopted, the Procellariinæ, as before, being subdivided into five groups.

The genera composing these are as follows :—

Section Procellariææ—

Oceanodroma, *Cymochorea*, *Halocyptena* (gen. nov.), *Procellaria*, *Oceanites*, *Fregetta*, *Pelagodroma*.

¹ *Loc. cit.*, iii. pp. 646-650.

² *Conspectus generum avium*, tom. ii. pp. 184-206.

³ *Proc. Ac. Nat. Sci. Philad.*, 1864, pp. 72-91 (part 1), and pp. 116-144 (part 2); *loc. cit.*, 1866, pp. 25-33, (part 3), pp. 134-197 (parts 4 and 5).

Section Puffinæ—

Majaqueus, Adamastor, Thiellus, Nectris, Puffinus.

Section Œstrelatæ—

Œstrelata, Pagodroma, Daption.

Section Prionæ—

Halobæna, Pseudoprion, Prion.

Section Fulmaræ—

Fulmarus, Thalassæca, Ossifraga.

Although the names of these five sections are the same as Bonaparte's, yet the genera included in them are, it will be seen, different, the arrangement in many respects being more natural.

1867. Eyton in his *Osteologia Avium*¹ describes briefly some of the more salient features of the osteology of *Ossifraga gigantea*, *Diomedea exulans* and *fuliginosa*, *Puffinus major* (and another undetermined species), and *Thalassidroma oceanica* (= ? *Oceanites*). The skeletons of the *Ossifraga*, *Diomedea exulans*, and *Thalassidroma* are figured, with details of some of the bones.

The same year witnessed the publication of M. Alphonse Milne-Edward's great work on fossil birds.² Pages 301–341 of the first volume are devoted to the consideration of the osteology of the living Longipennes, composed of the Gulls (*Laridæ*) and Petrels (*Procellariidæ*). The Petrels are considered to be, as regards their osteological characters, allied most closely to the Gulls, with some resemblances to the Steganopodes. “Par quelques-uns de leur caractères, les Procellarides se lient aux Totipalmes. Ainsi on ne peut se refuser à reconnaître une grande ressemblance entre la constitution de la charpente osseuse des Frégates, des Phaétons, c'est-à-dire des Totipalmes grand voiliers et celle des Pétrels ou des Puffins. Cette analogie a d'ailleurs été parfaitement saisie par L'herminier, qui cependant n'avait étudié que la conformation de l'appareil sternal” (*loc. cit.*, pp. 302, 303).

A complete skeleton of *Prion vittatus* is figured on plate l. fig. 1, with numerous details of the bones of *Puffinus cinereus*—skull (pl. xlix. fig. 12), leg-bones (pl. li.), pelvis and humerus (pl. lii.), sternum and scapular arch (pl. liii.).

Hydrornis natator (pp. 362–365, pl. lvii. figs 18–22), from the Miocene deposits of Langy, is perhaps allied to the Shearwaters (*Puffinus*), but the remains found (a tarso-metatarsus, and a femur of doubtful ownership) do not suffice to decide the point certainly.

Professor Huxley³ places the Petrels with the Gulls, Divers, and Auks in the

¹ London, 1867, pp. 221–225.

² Recherches anatomiques et paléontologiques pour servir à l'histoire des oiseaux fossiles de la France, Paris, 1867–1868.

³ On the Classification of Birds, Proc. Zool. Soc., 1867, pp. 415–472.

group Cecomorphæ of his Schizognathous series. Respecting their palate we read—“The Procellariidæ differ from the families which have just been enumerated (Gulls, Divers, Grebes, Auks, and Penguins) in the great expansion of the maxillo-palatines which become thick and spongy, and so closely approach the middle line that, in the Albatrosses, only a very narrow cleft is left on each side of the vomer. The front part of the vomer itself is much more strongly bent downwards than in the Gulls; and the ascending process of the palatine bone is greatly produced, and becomes ankylosed with the vomer. *Procellaria gigas* [i.e., *Ossifraga*] holds a sort of intermediate place between the Gulls and the Albatrosses, the maxillo-palatines being less swollen, and the clefts between them and the vomer far larger than in *Diomedea*. In this species again the basipterygoid processes are present, though I have not been able to observe them in other Procellariidæ” (*loc. cit.*, pp. 430, 431). [As regards this last sentence, as will be seen below, such basipterygoid processes are the rule and not the exception in this group.] In illustration of these remarks, views of the palate of “*Procellaria*” *gigantea* and *Diomedea exulans* are given.

Of the Cecomorphæ, “the Procellariidæ are aberrant forms, inclining towards the Cormorants and Pelicans amongst the Desmognathæ” (*loc. cit.*, p. 458).

1871. G. R. Gray, in the Hand-list of Birds,¹ places the Procellariidæ between the Uriidæ and the Laridæ in his order Anseres. They are divided into three sub-families, corresponding to those already adopted by Bonaparte and Coues.

J. Reinhardt, in the same year, in his paper on the “Os crochu,” or uncinat bone, in the skull of birds,² records its presence in nearly all the genera of this family that he has examined. In a note on p. 339 he corrects Professor Huxley’s statement as to the usual absence of basipterygoid facets in the Petrels, such being only absent in the Albatrosses and Procellarinæ (“Stormsvælerne”), present in all the rest.

1872. Carl T. Sundevall³ makes the Tubinares the fourth cohort of his order Natatores. He adopts the same three sub-families as Bonaparte, Coues, and Gray.

1873. Reinhardt describes⁴ and figures two peculiar ossicles, of the nature of sesamoids, developed at the elbow-joint of these birds in the tendon of origin of the *extensor metacarpi radialis longior*. The existence of such an ossicle in the genus *Puffinus* had already been described by Meckel,⁵ and Reinhardt finds two similar ones developed in the Albatrosses, as well as in the genera *Æstrelata*, *Puffinus*, *Majaqueus*, and *Adamastor* of the Procellariinæ. In *Æstrelata fuliginosa* and *bulweri*, *Diomedea*

¹ *Loc. cit.*, vol. iii. p. 102.

² Om en hidtil ukjendt Knogle i Hovedskallen hos Turakoerne (*Musophagides*, Sundev.) med nogle Bemærkninger om de lignende Knogler hos andre Fuglefamilier; Videnskab. Medd. Naturh. For. Kjöbenhavn, 1871, pp. 326–341, pl. vii.

³ *Methodi naturalis avium disponendarum tentamen*, Stockholm, 1872, pp. 140–143.

⁴ Om Vingens anatomiske Bygning hos Stormfugle-Familien (Procellariidæ s. Tubinares), *l.c.*, 1873, pp. 123–138; also Gervais’ *Journal de Zoologie*, vol. iii. pp. 139–144, 1874.

⁵ *Traité général, &c.*, vol. iii. p. 144, Paris, 1829.

chlororhyncha, and *Phæbetria fuliginosa*, he states that the smaller of these ossicles is wanting, though the larger is still developed. In a table he proposes the annexed classification of the Procellariinæ.

I. Wing-ossicles present. Twelve rectrices.

a. Puffinæ—

Æstrelata, Puffinus, Majaqueus, Adamastor.

II. Wing-ossicles absent.

First primary longest.

More than twelve rectrices.

b. Fulmaræ—

Ossifraga, Fulmarus, Daption.

Twelve rectrices.

Margin of beak without lamellæ.

Pagodroma.

Beak with lamellæ.

c. Prionæ—

Halobæna, Prion.

Second primary longest.

d. Procellariæ—

Procellaria, Oceanites.

A. H. Garrod, in the same year, shows¹ that the Petrels being "holorhinal" must be separated from the "schizorhinal" Laridæ and their allies. He further proposes² to divide the Petrels or Nasutæ into two groups, the "Storm-Petrels," with a formula AB.XY and no cæca, and the "Fulmaridæ," with formula AB.X and two short cæca. *Bulweria* alone has a formula A.X and is therefore quite different from the Storm-Petrels. In both groups the great pectoral muscle is double, as in many of the "Ciconiiformes," and there are two carotids.³ The Nasutæ form the second cohort of his "Anseriiformes," consisting of them and of the Anseres, which latter include the Anatidæ, Spheniscidæ, Colymbidæ, and Podicipitidæ.

1876. P. Pavesi, in his Studi anatomici sopra alcuni uccelli,⁴ has given a few details on the visceral anatomy of *Diomedea exulans*, especially as regards the form of the stomach and the presence of spines on the laryngeal eminence, continuous laterally with a zone of similar papillæ developed round the commencing œsophagus.

¹ Proc. Zool. Soc., 1873, p. 37; Collected Papers, p. 128.

² Loc. cit., pp. 641, 642; 1874, p. 122; Collected Papers, pp. 204 and 220, 221. The passage on pp. 641, 642, describing the muscles of the Petrels, is unfortunately misprinted in the original paper. It is given in a corrected form, as altered by the writer, in the reprint of Professor Garrod's papers, p. 204. The two birds called in Garrod's text *Procellaria pelagica* (?) and *Procellaria fregata* (?), the "Storm-Petrels" on which his observations were based, were probably in reality *Oceanites oceanicus* and *Garrodia nereis* (cf. Proc. Zool. Soc., 1881, p. 736).

³ Loc. cit., 1873, p. 470; Collected Papers, p. 175.

⁴ Ann. Mus. Civ. Gen., vol. ix. pp. 66-82.

1879. Dr. Hans Gadow, in his paper on the digestive organs of birds,¹ describes the alimentary viscera of the Tubinares, apparently based upon an examination of the four genera *Puffinus*, *Fulmarus*, *Procellaria*, and *Diomedea*. The arrangement of the intestinal folds is "orthocœlic," the intestine being disposed in eight folds lying close to and parallel with each other. In their orthocœlic character the Tubinares agree with the Steganopodes and Erodii, differing from the "cyclocœlic" Pelargi, Raptatores, and Laridæ.

1881. In a posthumous paper,² published in the "In Memoriam" volume of his works, the late Professor A. H. Garrod describes the anatomy of the Diving Petrel (*Pelecanoïdes urinatrix*), based upon an examination of specimens collected during the Challenger's voyage. *Pelecanoïdes* has no *ambiens* muscle, in which respect it differs from all the other true Petrels, and resembles *Bulweria* alone of them in its formula A.X. The main vein of the leg, the femoral vein, is superficial to, instead of deep of, the tendon of the femoro-caudal muscle, a peculiarity hitherto only observed in the genus *Dacelo* amongst the Kingfishers. "The Procellariidæ may be divided into the Storm-Petrels or Thalassidrominæ, and the true Petrels or Œstrelatinæ, the former differing from the latter in possessing the accessory semi-tendinosus muscle." These two groups therefore correspond to those already distinguished by Garrod in his former paper as the "Storm-Petrels" and the Fulmaridæ.

As regards the systematic position of the Petrels it is said—"I may mention that since writing my paper 'On Certain Muscles of Birds, and their value in classification,' I have changed my views as to the affinities of the Procellariidæ. In that communication I place the family amongst the Anseriformes; now it is evident to me that it is with the Ciconiiformes that they are most intimately related. Reason for my change of opinion will be found in what here follows." Unfortunately the paper was never completed, and the reasons mentioned not stated in consequence.

In a paper read before the Zoological Society on June 18th of the same year³ I proposed to make the so-called *Procellaria nereis* of Gould, the *Procellaria fregata* of Professor Garrod's earlier papers, the type of a genus to be called *Garrodia*, it being not a true Petrel at all, but one of the allied group without cæca and with a formula AB.XY, the Thalassidrominæ of Garrod, which includes besides the genera *Oceanites*, *Fregetta*, and *Pelagodroma*, the family so formed constituting my Oceanitidæ.

1882. Lastly, in the concluding part of the Atlas to the great work on Madagascar,⁴

¹ Versuch einer vergleichender Anatomie des Verdauungs-systemes der Vögel, Jen. Zeitschr. f. Naturw., Bd. xiii. (n.f. vi.), pp. 92-171, 339-403, pls. iv.-ix., xvi.

² 85. Notes on the Anatomy of *Pelecanoïdes (Puffinuria) urinatrix*, loc. cit., pp. 521, 522.

³ Proc. Zool. Soc., 1881, pp. 735, 736.

⁴ Histoire physique, naturelle et politique de Madagascar, publiee par Alfred Grandidier, xv.; Histoire naturelle des oiseaux, x. iv., Atlas iii., Paris, 1881. Plates 293, 294, 297, 298, 299, 300.

MM. Grandidier and A. Milne-Edwards have given figures of the skeletons and separate bones of *Prion vittatus*, *Puffinus chlororhynchus*, and *Thalassidroma oceanica*.

III. COMPARATIVE ANATOMY OF THE TUBINARES.

My object in working out the present report has been, not to produce a detailed description of the structure of any particular Petrel, but to describe the most important deviations from the ordinary avian type met with in this group, and to compare the members of it with each other, and with other groups of birds, in those points of their structure in which experience has shown birds to differ from each other.

Some of the modifications here described are of great physiological and morphological interest, whilst the numerous differences in points of detail displayed in the different sections and genera of the Tubinares lead one to expect that the future study of systematic ornithology will be not a little elucidated by the labours of the anatomist, wherever he, as in the present case, has material at his command sufficient for something like an adequate study of a natural group on the basis of structural differences more important than those that can be discerned from the superficial inspection of an ordinary skin.

In the present section the external characters, pterylosis, and visceral anatomy are first described; these are succeeded by an account of the myology, to which follows a description of the tracheal structures, and of certain other points in the anatomy of the soft parts. An account of the osteology concludes the whole.

1. EXTERNAL CHARACTERS AND PTERYLOSIS.

There are some points in the external characters of the Tubinares that may be noticed here, because in ordinary skins they can only be made out with difficulty, owing to changes and distortion in the process of drying.¹

The order Tubinares derives its name from the character, prevalent throughout the group, of the external nares, which are prolonged into a more or less lengthy cylindrical tube, lying usually on the dorsal surface of the beak, and opening by one or two apertures (*cf.* figs. 1, 32, and 33, *infra*, pp. 12 and 59). The exact disposition and degree of development of these tubes vary in the different members of the group.

In the Oceanitidæ, and the smaller species of Procellariidæ (belonging to the genera *Procellaria*, *Cymochorea*, and *Halocyptena*), the nasal tubes quite coalesce, lying on the dorsal surface of the beak for about its basal half; the tube so formed rises rather

¹ I need not do more here than refer to the peculiar bill of the Tubinares,—the peculiarity arising from the subdivision, into more or less distinct plates, of the corneous covering of the mandibles,—as it is sufficiently described in systematic works on ornithology.

abruptly from the forehead, and is truncated anteriorly, the single aperture so formed looking upwards and forward (*vide* Pl. I. figs. 1–5). In the Oceanitidæ (*e.g.*, fig. 8) the aperture viewed from in front is nearly circular, and with scarcely any appearance of a median septum. In the Procellarian genera, on the other hand (fig. 9), the aperture is more oval and distinctly double, owing to the median septum (formed by the coalesced inner walls of the narial tubes) being much less deeply, in a lateral view, excavated anteriorly, and so appearing to a greater extent superficially. The other Procellariinæ repeat this form of nostril, though the septum becomes much thicker, so that the nostrils open in them by two perfectly distinct apertures (*vide* fig. 7, where the nostrils of *Bulweria* are shown). They might thus be said to be “platyrrhine,” in opposition to the “catarrhine” Oceanitidæ and other genera already mentioned. It is in *Bulweria* and *Majaqueus* perhaps, that the nasal septum is broadest and most superficial; in *Prion* it is well developed; in the remaining genera it is less near the external opening, but always quite evident. In the genus *Puffinus* the septum is also broad, but the narial tubes are so obliquely truncated that they hardly rise above the lateral outline of the beak; their openings are ovals, with their longer axis vertical or (*Puffinus obscurus*) oblique inwards.

In *Pelecanoïdes* the nasal tubes are short and swollen externally; the septum is distinct, but not broad; and the apertures, which are sinuated ovals directed antero-posteriorly, look almost vertically upwards, their lateral outline being nearly parallel with the axis of the upper jaw.

FIG. 1.—Base of Beak of *Diomedea exulans*, to show the form and position of the nostril.

In the Diomedeinæ the nasal tubes are quite separate from each other, lying just at the lower margin of the “culminicorn.” They are usually described as tubes with a distinct circular complete aperture, but on looking at this carefully, there may be seen (*vide* fig. 1) in front and below this tubular opening a deep cavity leading backwards and continuous behind, over the edge of the apparent outer boundary of the aperture, with the general cavity of the tube, an infolding of the outer

wall of the latter forming the apparent outer wall of the tubular aperture.

The nasal tubes of the Petrels are formed, it may be observed, by the elongation of the cartilaginous walls of the nasal capsules. The upper and lower turbinal cartilages are well developed; the alinasal turbinal cartilage, on the other hand, is represented only by a slight ingrowth from the internal nasal wall. Such, at least, is the condition of these parts in *Majaqueus*, the only form I have examined as regards these structures.

The legs are always bare of feathers for some little distance above the tarsal joint, the metatarsal scutellation extending upwards over the joint some little way, but disappearing where the leg is covered by the feathers, and there replaced by simple skin.

The scutellation of the tarsi presents different characters in the Procellariidæ and Oceanitidæ respectively. In the former, in all the forms, the legs, which are often much compressed below the lower limit of feathering, are covered pretty uniformly by small scutellæ of hexagonal shape (*vide* Pl. I. fig. 5, *a*). In the Oceanitidæ, on the other hand, though the back and more or less of the lateral aspects of the leg are so covered, the front of the leg is either, as in the genera *Oceanites* (Pl. I. fig. 1, *a*) and *Fregetta* (Pl. I. fig. 4, *a*), "ocreate," being covered for nearly all its length by a single long scute, or, as in *Garrodia* and *Pelagodroma* (figs. 2, *a*; 3, *a*), has a series of strong, well-marked, obliquely transverse scutellæ, extending on to the external and internal faces of the leg for some distance.

The hallux in the Tubinares is always extremely small, and in the genus *Pelecanoides* quite absent. When present it consists only of a single joint (*vide infra*, p. 53, and Pl. VI. fig. 14), which, even when best developed, is very small and covered by a short, nearly straight, spur-like claw, which projects externally, some little way above the level of the other digits, and, being very small, may easily be passed over. In the Oceanitidæ this nail is extremely minute, considerably more so than in the Procellariidæ of similar size, but is always present¹ and very straight and spur-like. In most of the Procellariidæ it is larger and more curved: it is best developed proportionately, perhaps, in *Pagodroma*.

In the Albatrosses the hind-toe is so minute that these birds are usually described as being three-toed, but this is not really quite correct. In *Phæbætria* the hallux externally only just appears, being represented merely by a slight pimple-like elevation, with a very minute claw. On dissecting away the skin, the pimple is seen to be connected with two minute bony nodules, the basal one, which represents the metatarsal, more globular, the apical one more pointed and covered by the minute claw. They are only connected by connective and fibrous tissue to the tarso-metatarsus,² and are separated from each other by a considerable interspace, the whole having a total extent of only 3 mm. (*vide* fig. 2, *a*).

In *Thalassiarche (culminata)* and *Diomedea (brachyura* and *exulans)* this hallux is still more rudimentary, and there is not a trace of a nail outside. Still, on careful

FIG. 2.—Rudimentary Hallux of the Albatrosses, of the natural size, except *a*.

<i>a. Phæbætria fuliginosa</i> , showing the two ossicles, connected together by fibrous tissue, the distal one being covered by a minute claw, which appears	outside the skin (represented in section).
<i>b. Diomedea exulans</i> .	
<i>c. Diomedea brachyura</i> .	
<i>d. Thalassiarche culminata</i> .	

¹ Mr. Dresser erroneously describes it as wanting in *Oceanites* (Birds of Europe, vol. viii. p. 503).

² The existence of the rudimentary hallux in *Phæbætria fuliginosa* was first, I believe, pointed out by Dr. Kidder in his account of the birds of Kerguelen's Land, Bull. U. S. Nat. Mus., vol. i. p. 22.

inspection, there is a slight elevation visible on the area usually occupied by the hallux, and on dissecting away the skin a single minute ossicle, of triangular shape, is to be found attached to the tarso-metatarsus and surrounding structures by fibrous tissue. This single bone probably represents the metatarsal element. In *Diomedea exulans* it has a length of 0.2 inch (5 mm.); in the other two species, particularly in *Thalassiarche*, it is much smaller, not exceeding here 2 mm. in length (*vide* figs. *b-d*). I have been unable to find it at all in *Pelecanoïdes*, even in quite young birds.

The anterior three toes are well developed, and are completely webbed, the web however not extending to the hallux. The claws are well developed; in the Procellariidæ they are always more or less curved, compressed, and sharp-pointed (*vide* Pl. I. fig. 5, *b*, *Procellaria pelagica*), whilst in the Oceanitidæ they become lamellar, depressed and flattened, a shape that attains its maximum in the genus *Fregetta* (*vide* figs. 1-4, *b*). Hence an inspection of the legs alone of a Petrel will show, by the character of the tarsal scutellation and the form of the claws, whether it is one of the Oceanitidæ or of the Procellariidæ.

Pterylosis.—The pterylosis of this group seems to be, on the whole, very uniform throughout, both in the form of the tracts and the structure of the feathers.

The number of rectrices and remiges is not absolutely constant however, and there are also some slight differences in the form of the dorsal and lumbar tracts.

As regards the number of rectrices in the Tubinares, twelve is the ordinary number in both families, and this is never reduced,¹ and only in a few instances exceeded. *Fulmarus* and *Daption* have fourteen tail feathers, as already pointed out by Nitzsch, and the same is the case in *Thalassaca*; *Ossifraga* has as many as sixteen. *Aeipetes antarcticus* (in both the specimens examined by me) has, on the other hand, unlike *Thalassaca*, the normal number of twelve.

The number of primary remiges is always ten, but that of the secondaries varies. The number of these in the Oceanitidæ is always ten: in the Procellariidæ it is never, even in the smallest forms (*Pelecanoïdes*, *Cymochorea*, *Halocyptena*, *Procellaria*), less than thirteen. *Bulweria* has twenty, which is about the average number throughout the group, increasing however in the larger forms to twenty-nine (*Ossifraga*, *Thalassiarche*), thirty (*Diomedea brachyura*), and even, in the largest of all, *Diomedea exulans*, to thirty-seven.² The pollex never has the claw so often present in birds on that digit.

As regards the distribution of the tracts of contour feathers, I may quote Nitzsch's general description (*Pterylography*, Ray. Soc. Ed., pp. 143, 144):—"In this family the tract-formation of *Lestris* is elevated into the type of a group, undergoing scarcely any change in the form of the inferior tract, but showing some little modification in the dorsal

¹ Nitzsch (*Pterylogr.* Ray Soc. Ed., p. 141) thought that the smaller species of Petrels had but ten tail feathers, but such is not in reality the case.

² Nitzsch even describes the species as having as many as forty secondaries. The total alar expanse of the specimen I counted this number in was 9 feet 7½ inch.

tract. We find, therefore, on the head a uniformly dense plumage, from which the two principal tracts issue. The latter are separated from each other by the two lateral neck-spaces, which extend high up, nearly to the head. The inferior tract is divided near the head, becomes of considerable breadth whilst still on the neck, and passes in this condition on to the breast, the surface of which is covered by each band in a rather broad, parallel-sided form, emitting no branch as far as the margin of the *musculus pectoralis major*. Here it is divided by a space starting from the knee-covert in such a manner that a short continuation of the tract, which is to be regarded as an outer branch, passes near the knee into the lateral space of the trunk, runs on over the thigh, and soon afterwards terminates. The other, inner branch, which represents the main band, then proceeds on the belly, turns in a somewhat arcuated form outwards, dilates considerably in the middle of the bow, and terminates near the anus. . . . The dorsal tract is at first broad, becomes narrower towards the middle of the neck, then expands at the shoulder, and divides at that point, or from the middle of the scapulæ, into two limbs. In most of the Tubinares these limbs pass uninterruptedly into the posterior half of the dorsal tract; and this circumstance forms their family character as distinguished from the Longipennes. In the present group the posterior half of the dorsal tract encloses a longitudinal space as far as the caudal pit, dilates a little outwardly on the pelvis, and thus usually becomes united with the very oblique lumbar tracts, and grows rather strong in the simple uropygial band, also covering the base of the oil-gland."

Nitzsch had no opportunity of examining the pterylosis of *Pelecanoïdes*, nor any of the Oceanitidæ. His remarks were based on examination of *Fulmarus glacialis*, *Daption capensis*, *Ossifraga gigantea*, *Procellaria pelagica*, *Halobana cærulea*, *Puffinus obscurus*, and *Diomedea exulans* and *chlororhyncha*. Nitzsch points out certain peculiarities in the latter genus, the most important of these being the division of the dorsal tract into two quite separate parts—an anterior stronger part, ending in an interscapular fork, and a posterior, weaker, dilated part. The lumbar tracts he describes as weak and uniserial. I find this division of the dorsal tract to hold good in *Diomedea exulans* and *brachyura*, as well as in *Thalassiarche culminata*, though the break is not very obvious, and chiefly marked by the difference in strength of the feathers. In a nestling of *Phæbetria*, however, there is no such break apparent; though the dorsal tract anteriorly is stronger, it passes behind into the posterior part, and the same condition, as is pointed out by Nitzsch, obtains in *Ossifraga*. The lumbar tracts also can hardly be strictly described as uniserial, as they tend to coalesce, by rows of interposed contour-feathers, with the external borders of the dorsal tract, no very obvious demarcation separating the two.

Pelecanoïdes and the Oceanitidæ quite conform to the general type of the group, and indeed the only at all obvious difference in this, beyond those already mentioned, lies in the greater or less amount of the connection between the lumbar and dorsal tracts, this being almost *nil* in *Cymochorea* and *Procellaria*, and considerable in the larger forms,

Majaqueus, *Puffinus*, &c. The knee-gap may become so deep as to completely divide the inferior tract into two parts below (*e.g.*, *Pelagodroma*, *Prion*, and, according to Nitzsch, *Halobana*).¹

The hypopterygium is usually well-developed, with long feathers, and the humeral tracts are very strong and broad.

The contour-feathers always have an after-shaft, though in the Diomedeinæ it is extremely small, most so in *Diomedea exulans* where it is reduced to a short tuft, about half an inch long, of five or six nearly simple, straight plumes. In the smaller Albatrosses it is larger, and in the rest of the group, including *Pelecanoïdes*, it is of good size.

All the forms have their spaces as well as tracts covered by down-feathers, which may become very long and close-set, especially in *Pagodroma*.

The oil-gland is always large, globular, with its surface covered above at the base—which is also partly covered by the termination of the uropygial band of the dorsal tract—by scattered semi-plumes, and with a tubular mamilla, provided with a good tuft of down-feathers. The tuft and gland are never absent. In the Oceanitidæ and smaller forms (*Cymochorea*, &c.) the tuft of feathers simply encircles the apex of the gland, but in the larger ones it sends a median prolongation across it as well, so as to divide the surface of the mamilla into two lateral parts, separated from each other by the median row of feathers, and each with its opening or openings. The number of these varies in the different forms of the group, as already indicated by Nitzsch (*loc. cit.*, p. 144). *Diomedea exulans* has about half a dozen small ones in each half, arranged in a crescent. *Diomedea brachyura* and *Thalassiarche* have numerous small apertures opening into a single large circular common opening. The Fulmars, except *Aeipetes*, have several apertures in each half, as have *Daption* and *Pagodroma*, *Ossifraga* having as many as five. *Majaqueus* has four; *Æstrelata* three. *Aeipetes*, *Pelecanoïdes*, *Bulweria*, and the smaller Procellariidæ, as well as the Oceanitidæ, have apparently only two pores, one in each half of the gland.

The very young birds, I may remark, are, in all the species I have seen, covered with a thick coating of fluffy grey down, which is pushed off as usual at the ends of the contour-feathers when the latter appear. There are apparently no intermediate changes of plumage, the first plumage of the young bird being similar to that of the adult,² a condition of things very unlike that in the Gulls (*Laridæ*) with which the Tubinares have so often been associated. Besides the long down on the tracts corresponding to the future tracts of contour-feathers, the young birds have a shorter downy covering distributed pretty uniformly, as in the adults, over the intervening spaces, and between the feathers of the tracts.

¹ Nitzsch lays some stress on the angle, whether acute or obtuse, made by the lumbar tracts at their junction with the dorsal; but the difference in the direction of the two parts is not, as seen in entire birds, so obvious as would be judged from Nitzsch's figures (*loc. cit.*, pl. x. figs. 2, 3), which were probably made up from the examination of skins only. The lumbar tracts, where the connecting rows of feathers are best developed, seem always to run outwards and backwards from the dorsal tracts, as shown in his figure of *Puffinus obscurus*.

² *Diomedea exulans* may be an exception.

2. ALIMENTARY CANAL AND ITS APPENDAGES.

The Tubinares as a group agree very closely together in the form of stomach and intestines possessed by them, which have peculiarities not occurring in any other groups of birds, and it is only in the variations in form and structure of the tongue, in the nature of the armature of the mucous membrane of the mouth, and in the presence or absence of cæca that the various forms differ in any important degree from each other.

The mucous membrane of the palate usually presents, in the Tubinares, several series of longitudinal rows of pointed, retroverted papillæ, which no doubt serve in the capture and retention of the prey by these birds. The most ordinary arrangement of these may be understood from Plate II. fig. 21, where the palate of *Æstrelata lessoni* is represented.

The palate is cleft for about half its length by a narrow median fissure, fringed on each side by a row of small spines, which dilates behind into the opening of the posterior nares, which is similarly fringed. Behind this, separated by a small interval, is the linear median aperture of the Eustachian tubes. From the anterior extremity of the median fissure runs forwards, to near the end of the beak, a sharp median ridge, with four or five strong, conical spines developed on it posteriorly. This ridge is separated by a deep groove on each side from the margins of the beak. Along a line corresponding to that of the palatine bones, and extending for an extent equal to that of the median fissure, there is developed on each side a second longitudinal row of retroverted and pointed spines, much longer and stronger than the more median series. In front of the posterior-narial aperture there runs between the two longitudinal series an oblique series of smaller spines, whilst behind the Eustachian aperture is a second transverse series, concave anteriorly.

In all the species of the genera *Æstrelata*, *Bulweria*, and *Majaqueus* examined by me the same condition obtains, the larger species, however, as that figured, frequently developing one or two rows of smaller spines lying parallel to the external longitudinal row, one outside, and the other between it and the median fissure. *Puffinus* is similar, but the anterior median keel is smooth, and almost without spines, and the palate to the sides of the Eustachian aperture becomes covered with small spines.

In *Cymochorea* and *Procellaria*, as in *Halocyptena*, the palate is much as in *Æstrelata*, but with all the spines smaller and feebler, particularly those on the palatal ridge. In the first genus at least the pre-narial ridge is nearly smooth, and between the palatine row of spines—only developed posteriorly—and the median a stronger row is developed, so that there are here altogether three pairs of longitudinal spines above.

In the Oceanitidæ the palate is much the same, but the palatine row becomes very weak and nearly obsolete, whilst the intermediate row is the strongest, considerably, of all.

The prenarial ridge may be slightly toothed or nearly smooth: it always ends, however, at the commencement of the median fissure, in a slightly raised prominence, divided into two lateral parts, in a way not seen amongst the Procellariidæ. (*Vide* Pl. II. fig. 19, giving an enlarged view of the palate of *Oceanites oceanicus*.)

Pagodroma resembles *Æstrelata*, but all the spines have become much smaller and weaker, and this is still more the case in *Daption*, where they have almost entirely disappeared save round the posterior nares. The line of the interior margins of the premaxillæ and of the palatines is marked by a distinct raised ridge, and the edges of the upper mandible, from the angle of the mouth as far forwards as the dertrum, are marked by a series of slight, closely-set, raised ridges, oblique forwards and outwards. It is by a great development of these that the peculiar fringed bill of the genus *Prion*, reminding one of that of a duck, is produced. In *Prion* (*t.c.*, fig. 23, *Prion banksii*) the palate is almost smooth throughout, with the exception of a distinct prenarial ridge, and some indications of the palatine series of spines posteriorly (not represented in the figure): the median fissure and narial opening are however, as usual, bounded by small spines. From a point corresponding to the angle of the mouth forwards to a little behind where the dertrum forms the cutting edge of the bill, the margins of the mouth are bounded by a well-developed fringe of closely-set lamellæ, reminding one much of the plates of a whale's baleen. These lamellæ are developed from the mucous membrane of the mouth, and are probably entirely epidermic in origin; in the cleaned skull there is no trace of their presence (*vide* Pl. VI. fig. 4). They are best developed a little way in front of their posterior termination of the fringe; here the lamellæ are nearly vertical thin plates, set on at right angles to the axis of the beak, but curved both forwards and outwards. Anteriorly they become more oblique forwards, and much shorter. Outside of them the cutting edge of the beak is produced downwards for a little way, so that a groove is formed between the beak and the pectinated fringe.

When the lower bill is in position, the more posterior and strongest of the lamellæ completely occupy the slight space left between the cutting edge of the two jaws, lying with their free ends curved outwards in a slight groove outside the lower mandible formed by the reflection from it of the feather-covered skin. Anteriorly this groove disappears, and the fringe simply lies against the outer surface—which is quite smooth, and not, like that of the duck or flamingo, correspondingly grooved for the reception of the lamellæ of the fringe—of the lower jaw, which in front it does not even reach. In the larger-billed *Prion vittatus* these lamellæ are even more developed, whilst in the smaller-billed *Prion desolatus* they are less so: *Prion banksi* is so completely intermediate in this respect that I see no reason for the adoption of Dr. Coues' genus *Pseudoprion*.¹ The only other

¹ Proc. Ac. Nat. Sci. Phil., 1866, p. 164, where that writer has also described the structure of these fringes at length.

Petrel in which the beak is fringed in a way similar to that here described is *Halobæna cærulea*, of which, however, as yet I have been unable to examine more than skins.

The existence of a peculiar fringe of lamellæ along the margin of the mouth has often been insisted on as an argument for placing *Phanicopterus* amongst the Lamellirostres, but the development of, at least, a very similar arrangement in *Prion* and *Halobæna*, birds of a very different group again, ought to show that an adaptive contrivance of this kind may be, apparently, independently developed without great difficulty and yet with many features of common resemblance, in different birds without necessitating any immediate genetic connection between its possessors.

In *Fulmarus* (Pl. II. fig. 22) a rudimentary fringe of the upper mandible is present, a little more developed than in *Daption*; in other respects it conforms to the type of *Æstrelata*, the spines, however, being very small and rudimentary. *Ossifraga* is similar in all essential points, but the palate is longer, and, at least in young birds, more spinulose. In *Acipetes* and *Thalassæca* the pectination of the mandible can only just be traced; the palate is much longer and narrower in shape than in *Fulmarus*, the spines smaller, and the palatine ridges better marked.

In *Pelecanoïdes* (Pl. II. fig. 20) the palate is quite smooth throughout, with no ridges or spines, except on the area round the posterior nares, which is pretty uniformly covered with sharp elongated spines of fair size.

In the Diomedeinæ the palate is comparatively smooth. There is a long prenarial ridge, only with slight indications of spines at its most posterior part. The spines bounding the narial and Eustachian apertures are well-marked, those on the palate small and best developed towards the posterior end of the prominent palatine ridges. Between the latter and the median fissure are developed, especially in *Diomedea exulans*, additional spines of small size, as well as a short row outside their most posterior part. Outside the tongue, between it and the inner margin of the jaws, the mucous membrane of the floor of the mouth has on each side a well developed series of stronger spines.

The tongue, as may be seen by a glance at Plate II., where the chief variations of its form are represented, is by no means constant in shape in the Tubinares.

In the Oceanitidæ, (*vide* fig. 5, *Oceanites*), and the genera *Cymochorea* (fig. 9), *Procellaria*, and *Halocyptena* of the Procellariidæ, the tongue is of triangular shape, fairly fleshy basally, but tapering and becoming thinner anteriorly, its extremity being pointed and more or less membranous, so as to easily be destroyed by rough usage. Its posterior margin, or base, is somewhat concave, and fringed by a row of small retroverted pointed papillæ. This is the form of tongue found, more or less modified, through the entire group.

In *Æstrelata* (fig. 15),¹ *Majaqueus*, *Bulweria*, and *Puffinus obscurus* the tongue

¹ I have figured (fig. 16) on Plate II. a tongue of different form from any other known to me as occurring in the group of Petrels. It has been labelled "*Æstrelata brevirostris*," but does not agree with the other species of that genus

becomes more fleshy, and slightly grooved above, especially anteriorly. The sides moreover are edged by a series of large triangular backwardly directed papillæ, extending forwards for about the back half of the length of the tongue, but in *Puffinus* to nearly its apex. In *Puffinus brevicauda* (fig. 18) there are, in addition, four longitudinal fairly regular rows of such papillæ developed on its dorsal surface, those nearest the middle line being the biggest.

In the species of the genus *Diomedea* (fig. 7) the tongue is also similarly covered above, pretty uniformly, with spines, best developed on the dorsum a little behind the apex of the organ, but is much shorter in form, being of an elongated cordate shape. In *Phæbetria* (fig. 8), on the other hand, the tongue is much more pointed and elongated, being free for about its apical two-thirds, and with the dorsal surface glabrous, the spines being confined to its basal margin. In a nestling of this species the tongue has much the same shape, but is covered for the greater part of its extent above by spines, as in *Diomedea*: these must therefore disappear as the bird reaches maturity. In *Thalassiarche* the tongue is somewhat intermediate in shape, though most resembling that of *Phæbetria*. *Pagodroma* (fig. 14) has a very elongated, tapering tongue, with its base and lateral margins for about their posterior quarter spinulose. The tongue of *Daption* (fig. 12) is much broader and more fleshy; the spines are small, and almost confined to its base, with only a few very obsolete ones towards the posterior angles laterally. It is only free for a little more than a quarter of its length. *Prion* (fig. 13) is similar, but the tongue is more fleshy, and the spines are smaller and quite confined to the base: the apex is also only free for a very small extent. In *Prion vittatus* the tongue becomes extremely large and fleshy, occupying the whole of the wide space between the rami of the mandible. *Aeipetes antarcticus* (fig. 11) has a tongue very like that of *Pagodroma*, but of course larger and less elongate: that of *Thalassæca glacialis* is very similar, but longer a little than that of *Aeipetes*. In all these forms the tip is blunt or emarginate, with a slight dorsal groove apically. *Fulmarus* has a more fleshy tongue of the same type, with a distinctly emarginate end, and a more evident groove, extending for two-fifths of its length.

In *Ossifraga gigantea* (fig. 10) the tongue is very elongated,—three inches long,—and narrow proportionally. Its apex is slightly emarginate, and there is a deep groove for about two-fifths of its length, and traceable further back to the base of the tongue. The base has a fringe of pointed spines, which are continued, of smaller size, along the lateral margin for some way, there being some very much smaller spines developed inside them on the borders of the tongue for about an inch, though not reaching the posterior angles of the organ by half that extent.

(*lessoni* and *mollis*) examined by me nor with any of my young specimens of the so-called *Æstrelata brevirostris*, these resembling rather the species just named. This tongue is remarkable for having no spines laterally, those of the base being well developed, and for its narrow and deeply grooved form and slightly emarginate tip. In spite of its label, it belongs, I strongly suspect, to some species of the Laridæ.

In *Pelecanoïdes* (fig. 6) the tongue is fleshy, and fairly parallel-sided, tapering apically. It is but little free, and occupies most of the interspace between the mandibular rami. Its base is notched, and provided with some largish spines, which continue forwards for about the basal half, or more, of the lateral margins. On the dorsal surface there is always a peculiar lanceolate mark, apparently due to a difference in the nature of the mucous membrane covering the tongue over this area.

The œsophagus—which in the Albatrosses, as already described by Pavesi, may be surrounded at its commencement with a zone of spines, continuous below with the spines covering the laryngeal eminence—is always capacious and distensile, but possesses no crop. Inferiorly, in the thorax, it passes without any marked constriction or other difference into an enormous proventriculus, which is a thin-walled bag, reaching down nearly to the posterior extremity of the abdominal cavity, which it largely occupies, lying to the left side of the stomach proper and the mass of the intestines. This great proventricular bag is twisted back on itself apically, and then, becoming slightly narrower, passes by a small aperture into the stomach proper or gizzard. This aperture is therefore to the right of, and anterior to, the great “fundus,” which lies freely in the posterior part of the abdominal cavity, covering there the terminal portion of the intestine and cloaca. Internally, the proventricular glands are seen to cover pretty uniformly the whole surface of the mucous membrane, with the exception of a more or less narrow zone, which lies between this glandular part and the stomach proper, corresponding pretty nearly to the narrower, ascending part of the bag as seen from outside (*vide* Pl. II. figs. 1 and 2). The extent of this very deep “zonary” proventriculus (*pr.*) is always very considerable in the Petrels, being of course, *cæteris paribus*, larger in the larger than in the smaller species. In *Majaqueus* its extent is 4·0 inches; in *Pelecanoïdes*, 1·85 inches; in *Fregetta grallaria*, 1·2 inches.

The stomach proper (*g.*) is always small and more or less globular, with fairly muscular walls and provided with the usual central tendinous sheets, so that it may fairly be called a gizzard. Its situation is peculiar, lying always above and to the right of the proventricular fundus, and with its pyloric part so flexed on itself that it looks backwards instead of forwards as in all ordinary birds (*vide* Pl. II. figs 1, 2), in this respect somewhat resembling the stomach of *Struthio*. In *Struthio*, however, the pyloric aperture is on the deep (dorsal) side of the stomach, nearly in the middle line, and so concealed when the viscera are viewed from the abdominal aspect. In the Tubinares the pyloric aperture, on the other hand, is quite superficial, lying at the inferior (posterior) end of the gizzard in the angle formed by the two parts of the bent proventriculus.

The gizzard, which is nearly always found full of the horny beaks of *Cephalopoda*, is lined internally by an “epithelium,” which is usually dark in colour, and frequently of almost corneous texture, with a more or less corrugated or wrinkled free surface (*vide* Pl. II. fig. 4, where the epithelial lining of the everted gizzard of *Fulmarus*

glacialis is represented¹). In the Oceanitidæ and Diomedeinæ this epithelium is softer; its character in other Petrels is but an exaggeration or reproduction of that existing in some other birds, particularly that occurring in such storks as *Xenorhynchus*.

The displacement of the pyloric orifice of the gizzard to the left necessitates a corresponding change in the commencing duodenum, so that this at first ascends in an upward curve towards the right before it returns to form the backwardly-directed loop, characteristic of Aves and Mammalia, round the pancreas (Pl. II. fig. 1, p.).

This peculiar upward curve of the commencing duodenum, the singularly small inverted stomach, and enormously deep proventriculus are all peculiar, so far as I am aware, to the group of Tubinares, though universal amongst them, and no other bird yet examined has, so far as I know, a similar disposition of these viscera.²

The intestinal cæca are entirely absent in all the Oceanitidæ, but are, with one exception, present, though of small size, in the Procellariidæ. They are always short and globular, and closely connected to the intestine, so as to appear as mere nipple-like projections from it. Plate II. fig. 3 represents those of *Majaqueus* slightly enlarged. They are usually situated quite close to the cloaca, the large intestine in nearly all the Tubinares being quite short; the length of the cæca themselves rarely exceeds .25 inch, except in the very largest species (*vide* table, p. 23). In five specimens (one a nestling) of *Cymochorea leucorrhœa* that I have examined, I find only a solitary cæcum, lateral in position, developed, owing apparently to the abortion of its fellow. As Mr. Swinhoe in his description of *Cymochorea monorhis*³ also records the cæcum as single, it is probable that the existence of such a single cæcum is a character of the genus *Cymochorea*. It is not unusual, I may observe, in a group of birds in which the cæca are of small size, and probably of no physiological importance, to find specimens or species with the normal number of cæca reduced by one. I may give as instances *Mergus albellus* (*cf.* Hunter, *Observ.*, vol. ii. p. 325; and Garrod, *Coll. Papers*, p. 220) amongst the Anseres, and *Plotus anhingæ* (Garrod, *l.c.*, p. 345) amongst the Steganopodes, not to mention all the Ardeidæ amongst the Herodiones. In *Halocyptena*, in the only specimen yet examined, I could find no trace of any cæca at all, so that the tendency to their disappearance already observable in

¹ The figure of Carus and Otto (*Tabulæ Anat. Comp. Illustr.*, part 4, t. vi. figs. 15, 16) of the epithelium of the gizzard of *Fulmarus glacialis* does not at all faithfully represent what I have seen in two (quite fresh) specimens of that bird, nor have I ever in other Petrels seen epithelium of such a corneous and pavement-like nature as that figured by them. I have, therefore, had one of my specimens carefully drawn of the natural size. In this place it will be well to recall the still more highly developed gastric epithelium of some of the Fruit-pigeons (*Phœnorhina goliath* and *Carpophaga latrans*) described by Verreaux and Des Murs, Viallanes and Garrod (*vide antea*, Report on the Birds, pp. 152-154).

² The description of these parts in the Little Auk (*Alca alle*) given by Professor Owen (*Anat. Vert.*, vol. ii. p. 163), and originally due to Home (*Lect. Comp. Anatomy*, i. pp. 283, 284, 1814) does not all apply to that bird (*cf.* the figure and description given by Macgillivray in Audubon's *Ornithological Biography*, iv. pp. 306-309), and probably refers to some member of the Tubinares.

³ Ibis, 1867, p. 387. I have examined the type of this species, which is now in Mr. Seebohm's collection, and find it to be a true *Cymochorea*.

Cymochorea seems here to have progressed further still. The intestines are not capacious, but the commencing duodenum may be slightly dilated.

The following are intestinal measurements :—

	Small Intestine.	Large Intestine.	Cæca.	Total length of Intestine.
<i>Oceanites oceanicus</i> ,	...	...	—	10·0
<i>Garrodia nereis</i> ,	...	...	—	8·5
<i>Fregetta grallaria</i> ,	...	...	—	13·0
„ <i>melanogastra</i> ,	...	...	—	8·0
<i>Pelagodroma marina</i> ,	...	...	—	12·2
<i>Procellaria pelagica</i> ,	8·0	1·0	·075	...
<i>Cymochorea leucorrhœa</i> ,	9·9	·6	·1	...
<i>Prion desolatus</i> ,	19·5	...	...	...
„ <i>banksi</i> ,	17·0	·25	·2	...
<i>Daption capensis</i> ,	33·0	1·4	(?)	...
<i>Thalassœca glacialisoides</i> ,	48·25	1·4	·2	...
<i>Aeipetes antarcticus</i> ,	50·2	1·2	·3	...
<i>Ossifraga gigantea</i> ,	94·0	2·0	·5	...
<i>Fulmarus glacialis</i> ,	53·5	1·5	·25	...
<i>Puffinus obscurus</i> ,	17·0	·5	·2	...
„ <i>anglorum</i> ,	23·0	1·0	·2	...
„ <i>brevicauda</i> ,	24·0	1·25	·25	...
<i>Majaqueus æquinoctialis</i> ,	54·4	1·75	·25	...
<i>Estrelata lessonæ</i> ,	42·0	...	·25	...
<i>Bulweria columbina</i> ,	—	—	·25	12·0
<i>Pelecanoides urinatrix</i> (a),	16·25	...	·2	...
„ „ (b),	15·0	1·5	·2	...
<i>Diomedea exulans</i> ,	121·4	4·0	·8	...
„ <i>brachyura</i> ,	89·0	2·0	·3	...

The liver is usually about equilobed, the lobes not being large, and rather triangular in shape. In the Albatrosses, however, the right lobe becomes elongated and distinctly bigger. The gall-bladder, developed on the right hepatic duct, is always present so far as my observations extend. The hepatic ducts (Pl. II. fig. 1, *r.h.d.*, *l.h.d.*) open close together into the ascending arm of the duodenal loop, close to the pancreatic ones, of which there are usually two or three in *Majaqueus*. In the specimen of *Thalassœca glacialisoides* dissected the left hepatic duct divided, soon after leaving the liver, into two branches, each of which opened separately into the duodenum, so that altogether this received three ducts from the liver. The vitelline rudiment is not to be found in the adult birds. The *bursa fabricii*, in young birds at least, is a well-developed large sac, with thick glandular walls, and a small opening into the cloaca. The spleen is circular, or nearly so.

3. MYOLOGY.

The myology of the Tubinares presents many features of interest, as will be seen from the following description. The species of the group, broadly speaking, resemble

each other very much in the details of their muscular structure, though in the fore-limb the structure of the *biceps* and the termination of the *tensor patagii* tendons, and in the hind-limb the presence or absence of the *ambiens* and the accessories to the femoro-caudal and *semi-tendinosus*, present characters available for taxonomic purposes.

Anterior Extremity.

Pectoralis primus.—This muscle is always largely developed in the Tubinares, as might have been expected from their great powers of flight. It is peculiar in that it is always *easily divisible into two quite separate layers* superimposed on each other, besides which it gives off thin fan-like cutaneous branches. A similar disposition of the *pectoralis primus* in two distinct layers is very characteristic of many of the Ciconiiform birds of Garrod, occurring in all the Storks and Cathartidæ, and in *Phaëthon*, *Fregata*, *Plotus*, *Sula*, and *Pelecanus* amongst the Steganopodes. A tendency to a similar condition, though the two layers are only separable with difficulty, may be seen in the Ardeidæ, Falconidæ, and *Scopus*.

The *superficial* layer of the *pectoralis primus* arises (*vide* Pl. III. figs. 1 and 2, *p.* 1*a*) from the posterior and lateral margins of the body of the sternum, from the margin of the sternal *carina*, and from the inferior border and external surface of the clavicles. In the latter position it is divisible into two layers, one arising from the extreme margin, the other and deeper from the surface, of those bones. The common insertion into the large humeral crest is very tendinous behind, more fleshy anteriorly, these two parts being somewhat divided by the thick tendon of the deep layer of the muscle (*vide* Pl. III. fig. 1, *p.* 1*a*).

The *deep* layer of the *pectoralis primus* arises chiefly from the body and keel of the sternum outside the origin of the *pectoralis secundus*,—from which it is separated by a strong fascia,—from the tip of the furcula, and from the fascia over the second pectoral, especially anteriorly, where a large air-space separates these two muscles in the interval between the furcula and coracoid (Pl. III. figs. 1 and 2, *p.* 1*b*). Its tendon is thin anteriorly, strong and cylindrical posteriorly, and is inserted, as already described, between the two parts of the tendon of the superficial layer which arches over it.

The muscle is perforated a little anteriorly to its posterior border, and in front of the strong tendinous band dividing it, by a group of vessels and nerves destined for the supply of the muscles and skin incumbent on it. The most posterior of its fibres do not apparently join the main tendon of insertion, but are lost in the loose fibrous tissue occupying the axillary region.

There is a large cutaneous branch given off by the superficial layer close to its insertion, which runs back over the humerus, and is distributed as a fan-shaped expansion to the outer branch of the pectoral tract. Another cutaneous branch comes off from the

anterior end of the muscle on the breast close to the *symphysis furculæ*, and goes to the skin of the lower and anterior aspect of the neck.

Pectoralis secundus.—This muscle is also well developed, but though broad is usually short, extending for not more than one-third, one-half, or sometimes two-thirds the length of the sternum. In *Pelecanoïdes*, however, it is much longer, extending to nearly the end of that bone, and in *Procellaria*, *Garrodia*, *Fregetta*, and *Pelagodroma* its extent is nearly as large, in which cases it extends beyond the posterior margin of the deep layer of the first pectoral.

It arises from the antero-superior part of the *carina sterni*, and from the body of the bone external to that, from the greater part of the coraco-furcular membrane below the *pectoralis tertius*, from the *symphysis furculæ*, and from a greater or less extent of the antero-inferior border of the coracoid bone. Its insertion is by the usual tendon on the superior aspect of the humerus, behind the much smaller tendon of the third pectoral.

In the Albatrosses the *pectoralis secundus* is unusually short, and broken up into four quite separate parts, which unite before passing the shoulder-pulley. This arrangement is clearly shown in fig. 2 of Plate III. representing the muscle in *Diomedea brachyura*. In the other Petrels, the muscle is much more homogeneous, and only separable by dissection into its various component parts.

Pectoralis tertius.—This muscle (Pl. III. fig. 2, p. 3) is always well developed in the Tubinares, in the form of a broad, thin band, more or less parallel with the coracoid, occupying the superior half of the broad space between that bone and the furcula, its fibres arising chiefly from the strong membrane between these bones, sometimes with additions from the anterior margin of the coracoid, or from the body of the sternum close to the middle line.

Tensor patagii brevis and longus.—These muscles have always a common, rather thin and flat fleshy belly, arising from the extreme upper end of the clavicle, and receiving, in addition, special small slips from the surface of the great pectoral. From this fleshy belly spring two tendons, of which one always forms the marginal patagial tendon, and must therefore be considered as the *tensor patagii longus*. Both the tendons are connected, close to their origin, by fibrous slips to the humeral crest, from which indeed they might be said to arise, receiving then the main muscular belly. The connection of the marginal tendon with the humerus is always provided with a small tract of strong elastic tissue (*vide* Pl. IV. fig. 7, *t.p.l.*), and another such tract of longer extent is found on its course opposite the bend of the elbow (Pl. IV. figs. 3 and 7).

In other respects the development and distribution of these tendons differs much in different groups of genera, and their arrangement will therefore be here considered *seriatim*.

It is in the Oceanitidæ that the disposition of the tendon of the *tensor patagii brevis* (*t.p.b.*) is simplest, it here, in all the four genera, passing straight downwards

as a thin band, parallel to the humerus, to be lost on the fascia covering the outer side of the forearm. In *Procellaria*, *Cymochorea*, *Halocyptena* and *Pelecanoïdes* (vide Pl. IV. fig. 6) it is nearly equally simple, but as it passes over the superficial belly of the *extensor metacarpi radialis longior* (*e.m.*) it gives off to it a small tendinous slip, which lies on the wristward side of the main tendon.

In the genus *Prion* (Pl. IV. fig. 1) the condition of things is slightly more complicated. The superficial belly of the *extensor m.r.l.*, (*e.m.*) is quite tendinous throughout, with no fleshy fibres at all; where the *tensor patagii brevis* (*t.p.b.*) crosses it the two tendons are firmly fused together, and there is also a well-developed wristward slip sent off from the main tendon of the *tensor patagii* to meet the extensor tendon beyond this junction. The main *tensor* tendon where it crosses the extensor muscle is quite free from it in most cases, though occasionally a few fleshy fibres may arise from its anterior margin to join the deeper belly of the *extensor m.r.l.*, (*e.m.*). In a specimen of *Prion banksi* the wristward slip goes mainly to the deep belly of the extensor, sending off a thin band to the more superficial one. From the point of junction of the wristward slip with the extensor tendon, a thin fan-shaped tendinous fascia is sometimes sent off to the patagium generally.

In *Æstrelata brevirostris* (Pl. IV. fig. 2) the condition of things is similar, but the patagial fan is more strongly developed, and the tendinous superficial part of the *extensor metacarpi* is split, proximad of the *tensor patagii*, one part arising superficially to, the other (*e.m.**) deep of, the prominent supracondylar humeral process.

In the genus *Æstrelata* proper—as represented by *Æstrelata lessoni* (Pl. IV. fig. 4), *Æstrelata mollis*, and an undetermined species—the arrangement differs considerably from that observed in *Æstrelata brevirostris*.¹ The *tensor patagii brevis* tendon, which is more or less fused above with the marginal *tensor patagii longus* tendon (*t.p.l.*), develops at its junction with the superficial tendon of origin of the *extensor* (*e.m.*)—this being, as in *Æstrelata brevirostris*, double—a small, elongated ossicle (*a*) from which arise not only tendinous fibres—some of which form a patagial fan, whilst others join the marginal tendon directly—but also a number of muscular fibres which form the belly of the superficial part of the *extensor*. The *tensor patagii brevis* continues on in the usual manner to the ulnar fascia. No bony nodule, it is to be observed, is

¹ The condition above described as obtaining in *Æstrelata brevirostris* was exactly the same in all the specimens, eight in number, dissected. Unfortunately all these were young birds, though the largest must nearly have attained its mature plumage, and was probably able to fly. In other young birds in the group that I have examined the disposition of these elbow tendons is always exactly the same as in the adults, and even when these last develop ossicles here, such ossicles can be found, in a cartilaginous condition, in quite young birds. I have no reason therefore to suppose that the differences described here as existing between *Æstrelata brevirostris* and the other species of that genus are due to any difference in age.

[P.S.—Since the above was written, Mr. R. Ridgway has been kind enough to examine, at my suggestion, the skins of this species in the Smithsonian Institution, and finds, as he informs me, no difference in the development of the ossicle between this and the other species of the genus. The question, therefore, requires further material to elucidate it.]

found in the tendon of the superficial part of the *extensor* where it arises from the humerus.

In *Majaqueus* (Pl. IV. fig. 7), *Bulweria*, and *Puffinus* the *tensor patagii brevis* (*t.p.b.*) tendon is not fused with the much broader and stronger *tensor patagii longus*, but is a distinct, very slight, slip, lying between this and the humerus.

At the elbow it joins the superficial ossicle (*a*), developed at the junction of the *tensor patagii* with the *extensor* tendons. In *Puffinus* (*brevicauda* and *obscurus*) this thin *tensor patagii brevis* is split below into two slips, one joining the deeper of the twin tendons of origin of the superficial *extensor*, whilst the other is inserted on the supracondylar process. The ossicle is larger than the corresponding one of *Æstrelata*, and of somewhat smaller form; from it spring both tendinous fibres for the patagial tendon, and fleshy fibres for the superficial belly of the *extensor* (*e.m.*); from it also, or from the fibres of the last muscle, passes off a thin tendinous fasciculus (*f.*) to the ulnar fascia. Proximad of this larger ossicle is a smaller, more circular, one (*a'*), which is developed in the more superficial of the twin tendons already described a little beyond its origin, where it plays over the supracondylar process. This second ossicle is very small in *Bulweria*.

In the genera *Pagodroma*, *Daption*, *Fulmarus*, *Thalassæca*, *Aeipetes*, and *Ossifraga*, no bony nodules are developed, but the arrangement of these tendons at the elbow becomes very complicated. Their arrangement in *Ossifraga*, with which the others are almost identical, is represented in Plate IV. fig. 5.

The *tensor patagii longus* (*t.p.l.*) tendon divides near the elbow into two parts, one continuing as the marginal patagial tendon, provided with the usual cushion of elastic tissue opposite the bend of the arm, the other receiving the much thinner *tensor patagii brevis* (*t.p.b.*). The united tendon so formed becomes somewhat diffused distally, and more or less fused with the superficial tendon of origin of the *extensor metacarpi radialis longior* (*e.m.*), from which it is continued onwards to the ulnar fascia by two well-defined bands. Between the most wristward of these and the marginal tendon of the patagium there is developed a narrow vinculum.

In addition to this the main tendon of the *tensor patagii* which has a clear, well-defined edge on its humeral side, where it crosses the *extensor* muscle, sends a small special slip of tendon (*t.p'*) to the deeper of the two bellies of that muscle.

In the Diomedeinæ the arrangement (Pl. IV. fig. 3) more resembles that of the Puffinæ, as here also two ossicles are developed with nearly the same relationships to their surroundings as in that group. The *tensor patagii brevis* (*t.p.b.*) is separate from the *tensor patagii longus* (*t.p.l.*) till near the elbow, the marginal tendon of the latter muscle having received, a little before, the very long and thin tendinous biceps slip (*b.s.*).

The relations of the ossicles are very nearly as in *Majaqueus* (*vide* the figures), but

the tendinous band to the ulnar fascia—which represents the morphological termination of the *tensor patagii brevis*—arises in the Albatrosses nearer the middle of the fibrous tissue lying between the two ossicles. As in the *Œstrelatæ* and *Puffinæ*, the tendon of origin of the superficial part of the *extensor metacarpi (e.m.)* is double, and in the figure an arrow is introduced between them to show this double nature. The proximal and smaller of these two ossicles is developed, as before, in the more superficial of these twin tendons. The larger of the two ossicles is somewhat different in shape in the Albatrosses and Petrels, being more hammer-shaped in the latter group.¹

The presence of these peculiar wing-ossicles is thus confined to the *Diomedeinæ*, and to the genera *Majaqueus*, *Puffinus*, *Bulweria*, and *Œstrelata* (in which last there is only one), and, according to Reinhardt (*s.c.*, p. 133) *Adamastor*, of the *Procellariinæ*. In the genus *Fregata* there is a similar small bony nodule developed at the point where, as in the Petrels, the inner part of the *tensor patagii longus* tendon meets the tendon of the superficial belly of the *extensor metacarpi*, and from it radiate out tendinous fibres to the patagial margin. I have observed similar ossicles, developed at points of intermittent straining, in several other birds, as *Larus argentatus* and *glaucus*, *Fratercula arctica*, and *Merops*.

These bones must be considered to be of the nature of sesamoids, which, as is well known, are often developed in the tendons of muscles at the points of greatest strain. Their occurrence therefore in different groups of birds is by no means a proof of any genetic connection between such.

Biceps.—This muscle, in all *Tubinares*, is remarkable for its excessive reduction, the muscular bellies being small and short, and the tendon of insertion excessively narrow and thin (*vide* Pl. IV. figs. 1, 4, and 6, *b*).

It is best developed perhaps in the *Diomedeinæ*, where as usual it arises by two heads, a coracoid and humeral (*vide* Pl. III. fig. 5, *c.*, *h.*), both, however, being largely tendinous, and soon uniting. From the coracoid head is given off a very narrow slip, chiefly tendinous with a few fleshy fibres only, which runs down in the patagium, and joins the margin of the patagium formed by the *tensor patagii longus* close to the elbow (Pl. III. fig. 5, and Pl. IV. fig. 3, *b.s.*).

In the *Oceanitidæ* the *biceps* muscle is very slender. It has the two usual heads of origin, the tendons of these being often closely united together by fibrous tissue, and ending in a small short, common belly. This apparently gives off no “biceps-slip” at all.²

¹ Cf. also the figures of these ossicles given by Reinhardt (*s.c.*, p. 128).

² The dissection of these parts in this group of birds is attended with considerable difficulty, partly owing to the smallness of the various parts involved, partly to the great accumulations of fat round the tissues, making the true nature of these very difficult to determine in spirit specimens. It would be very desirable to dissect out these parts in fresh specimens.

In nearly all the other Procellariidæ, including *Pelecanoides*, the *biceps* becomes modified in a peculiarly interesting way. The coracoid head alone forms the muscle proper, whilst the humeral head, becoming detached from the coracoid head, goes *entirely* to the *tensor patagii longus* tendon, which it joins as a short, cylindrical tendon close to the shoulder (Pl. III. fig. 4, *h.*). It is, therefore, functionally a "biceps-slip," though it differs from the ordinary "biceps-slip" found in so many birds,¹ in that it arises independently from the humerus, and is not a part of the true *biceps* muscle, although it is supplied by the same nerve as that which goes to the coracoid head. In *Diomedea*, it is to be observed, the "biceps-slip" is derived from the *coracoid* head alone, whereas in the other Procellariidæ this slip represents the shorter or *humeral* head of the normal muscle.

Only occasionally have I seen (*e.g.*, in specimens of *Procellaria pelagica*, *Cymochorea leucorrhœa*, *Æstrelata lessoni*, and *Prion banksi*) a very small tendinous slip derived from this humeral head, which may be either continued downwards with the nerves and vessels to the elbow, where it is apparently lost in the general fascia, or joins the tendon of the true "biceps" (*Procellaria*, *Cymochorea*).

Supposing this latter to represent a more primitive condition, now nearly or quite lost in most of the species, the *biceps* muscle must originally have been two-headed, with a patagial slip derived from its humeral head. This slip gradually increased at the expense of the other tendon of the humeral head, till eventually the latter disappeared altogether, the *biceps* proper (*i.e.*, that flexing the forearm) being then reduced to its coracoidal moiety.

Expansor secundariorum.—This peculiar muscle² is wanting altogether in the Procellariidæ. It occurs, however, in the Oceanitidæ, though in a form different from any previously observed, being attached to (or derived from) thoracically the surface of the *pectoralis major* muscle (*vide* Pl. III. fig. 3).

Its small belly is attached to the few last secondary remiges (*S.*) at the elbow, and the thin tendon (*e.s.*) runs parallel to, but behind, the humerus, to the axilla, where it is joined by a similar but shorter tendon, which is derived from the most posterior feathers of the humeral tract, the so-called "scapularies" (*Sc.*). The common tendon then runs forwards, being superficial to the extensor and flexor muscles and the nerves and vessels of the forearm (*v.n.*), to be attached to the surface of the first pectoral (*p. 1*) close to its insertion into the humerus. In no other instance, so far as I know, does the *expansor secundariorum* become thoracically attached to the *pectoralis primus*, though it may be so to the *teres*, *coraco-brachialis longus*, or *coraco-brachialis brevis* muscles. Nor have I yet met with any other bird in which the tendon of this muscle is connected to the scapularies, which here it serves to expand as well as the secondaries.

The attachment of this muscle to the *pectoralis* suggests that the *expansor secundariorum* may originally have been formed from a cutaneous branch of the former

¹ Cf. Garrod, Coll. Papers, p. 324.

² *Ibid.*, pp. 323-324.

similar to others of the same function derived from it, which are still broad thin expansions of muscular fibres. In other birds this has either completely disappeared, or has developed thoracically new attachments to other muscles or to bone.

As regards the other muscles of the anterior extremity, the deltoid is always remarkable for its shortness, extending but a very small distance down the arm (*vide* Pl. IV. fig. 7, *d.*) frequently allowing the anterior belly of the *latissimus dorsi* (*l.d.*) to appear superficially below it. Only in *Phæbetria fuliginosa* (a nestling specimen) have I found the special tendinous slip of origin from the scapula which is found in so many birds.

The *triceps* has a well-marked tendinous attachment to the humerus superficial to the insertion of the *latissimus dorsi*. Its muscular belly arises from the scapula by fleshy fibres, and is comparatively short, its tendon, on the other hand, being long, and not joining the tendon of the *biceps* till over the elbow.

The *latissimus dorsi* is in two bellies, as in birds usually; of these the posterior is much the largest, the anterior being comparatively small and narrow.

Posterior extremity.

The *gluteus primus* is nearly always very small, scarcely or not at all covering the *biceps cruris* (*vide* Pl. V. fig. 1). It is larger in the Oceanitidæ, especially in *Oceanites* (*t.c.*, fig. 3, *gl.* 1) and *Garrodia*, where it does cover the *biceps* to some little extent anteriorly.

The *gluteus quintus* appears to be absent, or not differentiated off from the posterior fibres of the preceding, in all the Tubinares, except the Diomedeinæ, where it can be distinctly defined.

The *ambiens* is present and usually well-developed in all the Tubinares, except the genera *Fregetta* of the Oceanitidæ, and *Pelecanoïdes* amongst the Procellariidæ, in which it is quite absent.

In *Pelagodroma*, *Oceanites*, and *Garrodia* its fleshy belly is of fair size, but the tendon I have been unable to trace across the knee, it apparently terminating on the cnemial process of the tibia. In the other genera this tendon crosses the knee as usual, passing in front of the patella, when that is ossified, between the great cnemial process of the tibia and the end of the femur, and ends as usual in the leg.

The *femoro-caudal* is always present in the form of an usually not broad ribbon, inserted about half way along the femur (Pl. V. figs. 2-4, *f.c.*). It does not pass through, as it does in some of the Ciconiiform birds, a sort of pulley formed by the posterior angle of the pelvic bones.

The *accessory femoro-caudal* (Pl. V. figs. 2, 3, *a.f.c.*) is always present and well-developed, except in the genera *Bulweria* and *Pelecanoïdes* (*t.c.*, fig. 4), where it is quite

absent. It is fairly broad and ribband-shaped, overlapping the *semi-membranosus* in the Oceanitidæ at its origin, and inserted into the femur together with the femoro-caudal. In the genera *Fregetta*, *Puffinus*, and *Majaqueus* it is decidedly small.

The *semi-tendinosus* (*t.c.*, figs. 1-3, *s.t.*) muscle is always present and strong. It arises from the iliac bone round its most posterior angle, and has no connection at all with the caudal vertebræ. Anteriorly it slightly overlaps the *biceps*.

Excepting in the Oceanitidæ, it has no accessory head, so that all its fibres are inserted by a thin, broad tendon, quite distinct from that of the *semi-membranosus*, on to the tibia. In the Oceanitidæ, in all the species and genera, there is a strong and broad accessory head, arising from the femur, as usual, and joining the main belly of the muscle by an oblique tendinous raphè (*vide* Pl. V. fig. 3, *a.s.t.*).

The *semi-membranosus* (*t.c.*, figs. 1-3, *s.m.*) is always very large, of broad, flat, ribband shape, not so parallel with the *semi-tendinosus* nor so covered by it, as usual, its direction being more oblique than is that of the other muscle, and thus more parallel to that of the adductors. It arises from the posterior margin of the ilium, ischium, and pubis, from a little above the ischial prominence to within a small distance of the end of the pubis. Its insertion is by a thin, broad tendon, anterior to, and separate from, that of the *semi-tendinosus*.

Of the other muscles in the hind-limb the *biceps* always passes through a tendinous loop on its way to its insertion, as is nearly always the case with birds.

The *obturator externus* is never large, and is inserted near the femur head. The *obturator internus* is of peculiar shape, nearly oval, but with a slight indication of becoming triangular. The deep flexors of the toes and of the hallux blend, usually about half way down the leg, and their tendons may become ossified. Even when a hallux is present it receives no tendon at all from these muscles.

4. OTHER ANATOMICAL FEATURES.

There are always two carotid arteries situated in the hypapophysial canal. There are also two jugular veins, the right of which is frequently the largest.

The main artery of the leg is always the sciatic one, accompanying as it does the sciatic nerve.

In the genus *Pelecanoïdes*, as has already been described by Garrod (*cf. antea*, p. 10), the femoral vein, instead of being, as usual in birds, deep of the femoro-caudal muscle,—from the external border of which it then seems, in the ordinary course of dissection for the thigh-muscles, to emerge (Pl. V. fig. 2, *f.v.*),—is superficial to it, appearing at the external edge of the obturator externus, and then crossing the femoro-caudal superficially as represented in Pl. V. fig. 4, *f.v.*

In the Procellariidæ, except *Pelecanoïdes*, the two most anterior air-cells, which lie between the rami of the furcula at the entrance to the thorax, are not, as is usually the case in birds, fused together to form an interclavicular air-cell, but—at least in all the species in which I have examined into this point—remain partially distinct, being separated for the greater part of their length by a median septum formed by the coalescence of their internal walls—and double in consequence—but imperfect behind in the middle line, so that there is here a free communication between the two cells over the trachea. In the Oceanitidæ and *Pelecanoïdes* the ordinary structure prevails.¹

There are always large supra-orbital glands, which occupy depressions excavated for them in the top of the skull (*vide* Pl. VI. fig. 3), and open by a small duct into the nasal cavities. Similar glands occur in many birds, notably the Penguins, Colymbidæ, Auks, Gulls, and many others.²

As in all other Ciconiiform birds, there is no true penis developed.

5. TRACHEA AND VOCAL ORGANS.

The trachea in all Tubinares is a straight, simple tube, never convoluted in any way, and with the normal structure of this organ in birds. In some of the genera—*Fulmarus*, *Thalassæca*, *Aeipetes*, and *Ossifraga*—it is divided; as will be described in detail further on, to a greater or less extent by a median longitudinal septum, as in the Penguins alone of other birds so far as I know. The trachea has the ordinary long lateral muscle on each side, as well as a pair of well-developed sterno-tracheales, these arising from the costal processes of the sternum, as in so very many birds.

The constitution of the syrinx, or lower larynx, differs very considerably in the different genera and groups of the Tubinares as regards the number and modifications of form of the various tracheal or bronchial rings that enter into its composition. When as, *e.g.*, in the Gallinæ, the syrinx has no intrinsic muscles, the only guides for determination of the exact rings forming the syrinx are the variations in form of the rings themselves, according as to whether they are tracheal or bronchial, and the facts elucidated by a comparative study of these parts in a series of genera. Such a study of the syrinx in the Tubinares has made it evident to me that in this group at least the attachment of the intrinsic syringeal muscles (of which of course there are only a pair) to a particular bronchial semi-ring is constant, thereby affording a landmark by which the contiguous rings on both sides can at once be assigned to their proper position. The semi-ring that bears the muscle in the Tubinares is the fifth, the four bronchial rings (or semi-rings) above it, as well as a less or greater number of the

¹ In one of the three specimens of *Oceanites* examined, there appeared to be a division of the interclavicular air-cell into two, as in the Procellariidæ.

² Cf. Nitzsch's article, "Ueber die Nasendrüse der Vögel," Meckel's Archiv, 1820, pp. 234–269.

last tracheal rings, forming together the framework of the lower larynx. In most cases the last tracheal ring bears a well-marked antero-posterior pessular bar.

It is in the genus *Pelecanoïdes* (figs. 3, 4) that the typical construction of the syrinx

FIG. 3.—Syrinx of *Pelecanoïdes urinatrix*, from before.¹

FIG. 4.—The same, from behind.

of the Tubinares is seen in its simplest form ; it will, therefore, be described first on the present occasion.

The last tracheal ring is complete in front, and not modified in shape ; posteriorly it is produced downwards into a well-developed pessulus, so forming a complete three-way piece. The first bronchial semi-rings are united in front, where they are produced triangularly downwards ; behind, their inturned ends do not unite either with each other or with the pessulus, or with the second semi-rings. These last, as well as the third, fourth, and fifth, on which is inserted the muscle, are all similar in shape, and separate from each other ; they are closely approximated in front, gradually getting shorter posteriorly.

Garrodia, which may be considered typical of the Oceanitidæ, is anteriorly (fig. 5)

FIG. 5.—Syrinx of *Garrodia nercis*, from before.
a. The last tracheal ring, from below, to show the pessular bar.

FIG. 6.—The same, from behind.

almost the same as *Pelecanoïdes*, but the first, second, and third bronchial rings are complete (fig. 6). The last tracheal ring bears a complete pessulus (5, a).

¹ This and the succeeding figures of the syrinx of the *Tubinares* have been drawn as nearly as possible of one uniform size, irrespective of that of the originals, and are also slightly diagrammatic. The bronchial rings are numbered from 1-5 ; the tracheal are marked 0, 00, 000, &c., in the reverse direction.

A very similar type of syrinx prevails in the other Oceanitidæ, and is also that found in the genera *Procellaria* (figs. 7, 8), *Cymochorea* (figs. 9, 10), and *Halocyptena*. In all these the first few bronchial rings closely resemble in character tracheal rings, being nearly straight, closely apposed to each other, and more or less ossified. Anteriorly they may be united with one or more of the preceding tracheal rings, and very frequently the first two, or three are quite complete here in the middle line. There is always a well-developed

FIG. 7.—Syrinx of *Procellaria pelagica*, from before.

FIG. 8.—The same, from behind.

and complete pessular bar, supported behind by the last tracheal ring. With this bar one or more (sometimes three or four) of the bronchial rings may fuse by their coalesced ends posteriorly, forming a broad three-way piece; or these rings may be complete rings closely apposed, though apparently not anchylosed, to each other in the pessular bar. Different specimens vary slightly in the exact number and disposition of these bronchial rings, and sometimes are not exactly similar on the two sides.

FIG. 9.—Syrinx of *Cymochorea leucorrhœa*, from before.

FIG. 10.—The same from behind.

In *Prion vittatus* (figs. 11, 12), the first bronchial ring is either small or fused with the second, which is anteriorly entire: this is not the case with the three succeeding ones. The last three tracheal, and first two—or on one side three—bronchial rings form a pessular box, continuous anteriorly with the inturned anterior ends of the third semi-rings. The fourth pair takes no share in the formation of the box. In *Prion desolatus* there is only one complete bronchial ring, which may be the first, or the first

and second united; the others are incomplete, inturned anteriorly, and not co-ossified to form a box. There is a good pessulus borne by the last tracheal.

FIG. 11.—Syrinx of *Prion vittatus*, from before.

FIG. 12.—The same, from behind.

In *Pagodroma* (figs. 13, 14) the four first bronchial semi-rings are ossified and firmly united into a bony box behind; anteriorly, however, the first and fourth bronchial rings are free, whilst on one side the second and third are quite fused both before and behind. The last tracheal ring is free throughout.

FIG. 13.—Syrinx of *Pagodroma nivea*, from before.

FIG. 14.—The same, from behind.

Daption much resembles *Pagodroma*, there being a bony box, formed however by the fusion of the first three bronchials with the last tracheal ring. In neither of these genera is there any trace of a tracheal septum.

It is by a further development of the syrinx of *Pagodroma* that the peculiar one of the Fulmars is formed.

In *Thalassæca glacialis* (figs. 15, 16) the last two tracheal rings are ossified and fused together anteriorly, a median descending process being developed which lies

between the similarly ossified and fused first three bronchial rings. The fourth pair of rings is also ossified, but free from those that precede it, at least anteriorly. Posteriorly the first four bronchial and last four tracheal rings are firmly co-ossified into a large pessular box, whilst ossification in the median line (both before and behind) of a number of the cartilaginous tracheal rings above this forms the line of attachment for the median septum which divides the tracheal tube for an extent of about 1.25 inch.

In *Fulmarus glacialis* the syrinx is very similar; the four bronchial rings are anteriorly ossified, as are many of the tracheal rings in their median area. The tracheal septum is still more developed than in *Thalassæca*, extending for about the lower two-fifths of the trachea—a distance of nearly $2\frac{1}{2}$ inches.

The extraordinary syrinx of *Ossifraga* is a still further modification of this type (figs. 17, 18, 19). A number of the last tracheal rings (nine on one side, ten on the other,

FIG. 15.—Syrinx of *Thalassæca glacialoides*, from before.

FIG. 16.—The same, from behind.

in the specimen—a young one—figured) become completely ossified, as are the first four or five bronchial rings, of which only the first two are complete. The inferior part of the trachea is divided inferiorly for a short way into two quite complete and separate tubes; the posterior ends of the lowest tracheal rings being so much incurved that each actually, inferiorly, forms two complete rings, those of opposite sides being quite separate, whilst above, by the gradual diminution of their opposed interior halves, they become, when viewed from outside, simple rings of the normal tracheal type. On section, however, it is seen that their ends are still incurved to form a tracheal septum like that of *Fulmarus* and *Thalassæca*. This completely divides the trachea into two tubes for a space of about $3\frac{1}{2}$ inches, terminating above by a free semi-lunar border, concave upwards (fig. 19, *c, d*). In fig. 19 three sections are given of the inferior portion of the trachea made along the lines *a, b, c* in fig. 17, to show how the two tracheal tubes, separate below, gradually unite above.

Aeipetes antarcticus (figs. 20, 21), commonly placed in the genus *Thalassæca* with

FIG. 17.—Syrinx of *Ossifraga gigantea*, from before.

FIG. 18.—The same, from behind.

FIG. 19.—*a*, *b*, *c*, sections of syrinx and trachea of *Ossifraga* along the lines *a*, *b*, *c*, of fig. 17, to show the double nature of the tracheal tube below, and its complete division by a median septum above. *d*, trachea opened from the side, to show the median septum, dividing it into two parallel tubes, through the left of which a pointer is passed, below, and terminating above by a free margin.

Thalassæca glacialoides, completely differs in the structure of its syrinx from the last three species described, and is more like *Prion*. The two first pairs of bronchial rings

FIG. 20.—Syrinx of *Aeipetes antarcticus*, from before.

FIG. 21.—The same, from behind. The smaller figure represents a section of the trachea, to show the imperfect septum dividing it.

are complete anteriorly, the second being ossified, for a small extent only, in the middle

line. The lowest tracheal ring is quite simple anteriorly, and posteriorly it sends forwards a pessuliform process, anchylosed in front with the second bronchial rings. Two pairs of the bronchial semi-rings (3, 4) are ossified at their posterior extremities, but not fused in any way. The penultimate tracheal and preceding rings are, as in *Fulmarus*, &c., ossified posteriorly in their median (narrowest) portion only to bear the tracheal septum. This, however, is not (*vide* fig. 18, *a*) a complete septum, but is incomplete, the incurved posterior ends of the rings not reaching the anterior wall of the trachea by some little way. Its vertical extent is small, ceasing about .85 inch above the bronchi.

The peculiar genus *Bulweria* is, perhaps, as far as regards tracheal structure, nearer the small Storm-Petrels (*Procellaria* and *Cymochorea*) than any other group, judging at least from my examination of the syrinx of *Bulweria macgillivrayi*. In this specimen¹ the rings are asymmetrical,—there being only three, instead of four, bronchial rings between the pessular ring and that which bears the muscle on the left side, apparently owing to the suppression of the second bronchial ring, as may be seen in the figures (figs. 22, 23),—and irregularly developed, tending thus to hide the typical form. The last

FIG. 22.—Syrinx of *Bulweria macgillivrayi*, from before.

FIG. 23.—The same, from behind.

three tracheal rings are, anteriorly, more or less united, there being a pessular bar developed on the inferior margin of the last ring. Posteriorly, the ante-penultimate of these is quite free and complete; the next is incomplete posteriorly, whilst the last is complete on the right side, but anchyloses on the left with the first bronchial laterally. The third bronchial rings on each side are complete, thus encircling the bronchi. The fourth is free and incomplete.

Puffinus (as represented by *Puffinus brevicauda*) presents a simple form of syrinx (figs. 24, 25), the two first bronchial rings being complete anteriorly, the succeeding two being only semi-rings. The two last tracheal are united with the two first bronchial behind, sending off a pessular process, which anteriorly, as usual, is continuous with the third semi-rings. In younger birds (fig. 26) the various rings concerned remain more distinct, the pessular bar, it is pretty clear, being largely formed by the third

¹ Some of the peculiarities here described may be due to its being a youngish bird. I have, unfortunately, as yet been unable to examine the syrinx of *Bulweria columbina*, which might throw some additional light on the subject of the peculiarities of this genus.

semi-rings anteriorly, their backward prolongation fusing behind with cartilaginous elements developed in connection with the posterior ends of the second semi-rings, and all ultimately fusing into the pessular box of the adult. In *Puffinus obscurus* there is a complete pessular bar, formed by the third bronchial rings. There is no pessular box, the bronchial rings being all free from each other.

FIG. 24.—Syrinx of *Puffinus brevicauda*, from before.

FIG. 25.—The same, from behind.

FIG. 26.—The same, from a younger bird, in which the bronchial and tracheal rings have not yet coalesced.

In *Æstrelata lessoni* (figs. 27, 28) the syrinx becomes much more specialised and ossified. The fifth bronchial rings are strong and curved, and to these are attached, by fan-shaped insertions of tendon, the vocal muscles. The five preceding rings (which must therefore be the last tracheal and first four bronchial) are narrow, closely united,

FIG. 27.—Syrinx of *Æstrelata lessoni*, from before.

FIG. 28.—The same, from behind.

and ossified over a rhomboidal space in the middle line anteriorly. Behind there is a pessular box formed by these rings, and the four preceding tracheal ones in addition, the first two of these having a median patch of ossification. There is a well-developed and ossified pessular bar.

Æstrelata mollis is quite similar, except that the box is composed of one ring less.¹

In *Diomedea brachyura* and *exulans* the calibre of the trachea diminishes very considerably below the place of insertion of the *sterno-tracheales*. The syrinx (figs. 29, 30) is strong and well ossified. The fifth bronchial semi-rings on which end the fanned-out tendinous insertions of the intrinsic muscles are strong and much arched. The four preceding bronchial rings, as well as the last tracheal, are ossified anteriorly and posteriorly, and (with the exception in *Diomedea exulans* of the fourth bronchial) co-ossified anteriorly into a strong box, with which the penultimate tracheal ring is also connected in the middle line. Behind, the last two tracheal and first bronchial rings are co-ossified forming a broadly triangular pessular bar or box, whilst one or more (5) of the preceding tracheal rings have patches of ossification mesially.

FIG. 29.—Syrinx of *Diomedea exulans*, from before.
About natural size.

FIG. 30.—The same, from behind.
About natural size.

In *Thalassiarche culminata* (of which I have only examined one) all the five bronchial rings, including the muscular one, are firmly co-ossified together, and free from the rest. There is no complete pessulus, the bony box formed by the rings terminating posteriorly in a straight and free margin, which a cuneate bar, formed by the intumed anterior ends of the fourth bronchial rings, does not reach. The syrinx of *Phæbetria* as yet I only know from a young specimen, in which the bronchial rings below the first are incomplete anteriorly, whilst behind there is a box formed by the last two tracheal and first four bronchial rings.

Majaqueus is very like *Diomedea* in its syrinx, the penultimate tracheal ring, however, being ossified anteriorly, as well as its five successors, which remain free in

¹ I regret not having as yet been able to examine any adult bird of *Æstrelata brevirostris*, all my specimens being young and consequently with the tracheal rings unossified and generally distinct. There is a box formed by the fusion behind of at least three of the bronchial rings with the last, or two last tracheal ones. The second, third, and fourth bronchial rings are united together anteriorly, the third rings joining the pessular bar.

front. The second bronchial ring is the last entering into the composition of the triangular pessular box behind, the third and fourth rings remaining free.

In *Diomedea brachyura* and some of the allied species, the bronchi seem to be, according to the late Mr. Swinhoe's notes, long and convoluted, in a way reminding one of that which occurs in *Ciconia nigra*. I have not observed such convolutions in any Albatross or other Petrel dissected by myself. I herewith append the descriptions given by Swinhoe of this peculiarity.

Diomedea brachyura.—"In the male of this Albatross the bronchi on leaving the trachea bulge considerably as they run horizontally, then contract, and bend forwards and downwards, and lastly, turning sharp round, rise upwards and bulge again before entering the lungs" (Swinhoe, *Ibis*, 1863, p. 431).

"A female *Diomedea brachyura* had the swollen and convoluted trachea which I thought before was peculiar to the male" (*t.c.*, 1867, p. 227).

Diomedea nigripes.—"In this species the trachea of the female is simple, but that of the male is terminated by large, swollen, convoluted bronchi. In a male specimen, procured in May, the bronchi ran down right and left, almost straight for about $1\frac{7}{16}$ inches, then took a bend forward for a short space, and narrowed, and lastly bending inwards and upwards, bulged largely and entered the lungs" (*l.c.*, 1863, p. 432).

In five adult males of *Diomedea derogata* examined, all had contorted bronchi. These "bulge and go downwards and sideways, then bend under the ribs on each side into a large globe, pressing between itself and the ribs as each enters the lung at the back" (*Proc. Zool. Soc.*, 1873, p. 785).

6. OSTEOLOGY.

M. Alphonse Milne-Edwards having described at length, with figures, the osteology of the Tubinares in his classical work on fossil birds (*vide supra*, p. 7), whilst other points of their osseous structure have been elucidated by Brandt, Huxley, Reinhardt, and others, as already mentioned in the introductory part, there is not the same necessity for dwelling here on this part of the organisation of the Petrels as was the case when describing the softer and more perishable parts. Moreover, no amount of detailed description of bones, however elaborate or well illustrated, can serve the purpose of scientific research so well as actual specimens, which can in most cases be comparatively easily obtained for, and permanently preserved in, museums.

My study of the osteology of the Tubinares has been chiefly based on the material enumerated in the subjoined list.

List of Osteological Material examined.

OCEANITIDÆ.

<i>Oceanites oceanicus</i> ,	.	.	.	.	Skeleton.
<i>Fregetta melanogastra</i> ,	.	.	.	.	Do.
<i>Garrodia nereis</i> ,	.	.	.	.	Bones of trunk, and of limbs.
<i>Pelagodroma marina</i> ,	.	.	.	.	Limb-bones.

PROCELLARIIDÆ.

<i>Cymochorea leucorrhœa</i> ,	.	.	.	.	Skeleton.
<i>Procellaria pelagica</i> ,	.	.	.	.	Do.
<i>Bulweria columbina</i> ,	.	.	.	.	Limb-bones.
<i>Œstrelata "grisea,"</i>	.	.	.	.	Skeleton.
" sp. inc. (also named <i>griseus</i>)	.	.	.	.	Do. } (Eyton Coll.).
" <i>lessoni</i>	.	.	.	.	Two skulls.
<i>Majaqueus æquinoctialis</i> ,	.	.	.	.	Skeleton.
<i>Puffinus anglorum</i> ,	.	.	.	.	Do.
" <i>obscurus</i> ,	.	.	.	.	Do.
" <i>brevicauda</i> ,	.	.	.	.	Do. (incomplete).
<i>Adamastor cinereus</i> ,	.	.	.	.	Skeleton.
<i>Daption capensis</i> ,	.	.	.	.	Skeleton (Eyton Coll.) and skull
<i>Aeipetes antarcticus</i> ,	.	.	.	.	Do. and two skulls.
<i>Thalasseæa glacialoides</i> ,	.	.	.	.	Do.
<i>Fulmarus glacialis</i> ,	.	.	.	.	Do.
<i>Ossifraga gigantea</i> ,	.	.	.	.	Do. and skull.
<i>Prion desolatus</i> ,	.	.	.	.	Do. and three skulls.
" <i>vittatus</i> ,	.	.	.	.	Skull.
<i>Pelecanoides urinatrix</i> ,	.	.	.	.	Skeleton, and sternum.
<i>Diomedea exulans</i> ,	.	.	.	.	Skeleton and skull.
" <i>brachyura</i> ,	.	.	.	.	Do.
<i>Thalassiarche melanophrys</i> ,	.	.	.	.	Do. (Eyton Coll.).
" <i>culminata</i> ,	.	.	.	.	Skull.
<i>Phœbetria fuliginosa</i> ,	.	.	.	.	Two skulls.

The skull (vide Pl. VI. figs. 1-6).—The rostrum is long, and strongly-hooked apically. It has no distinct hinge with the cranium proper, but the cranio-facial notch is large, and the nasal and premaxillary bones at their junction with the frontals so thin as to permit of a considerable amount of vertical movement of the beak.

The nares are large and "holorhinal," their posterior boundaries being concave, and not extending, by some way, as far back as the posterior ends of the nasal processes of the premaxillæ. In the Diomedeinæ the nostrils are widely separated, and distinctly lateral in position; in the other forms they are closely approximated, and near the culmen. The nasal septum is but little ossified, most so in the Diomedeinæ. There may be a couple of small ossifications in the floor of the nasal capsules near their anterior extremity, continuous anteriorly with the premaxillæ, united together in the median line, and externally abutting on the outer and lower wall of the nostril.

The skull above the orbits is always deeply excavated for the fossæ in which lie the nasal ("supra-orbital") glands. In the Albatrosses there is a strong raised external border to the fossa posteriorly, prolonged from the post-orbital processes, whilst externally this floor, here perforated by numerous apertures, is deeply excavated.

The post-orbital processes are large and strong. The temporal fossæ are well-developed, nearly meeting across the middle line in most, though in the Albatrosses separated by a considerable interval. The occipital plane is inclined downwards and forwards, but in the Albatrosses is nearly vertical. In these birds the digastric fossæ are continuous, meeting each other in the middle line, whilst in the other Tubinares they are separated to a greater or less extent by the wide, smooth, convex cerebellar eminence.

As might be expected, all these fossæ and their bounding ridges are much better developed in the large Albatrosses and Petrels (*Ossifraga*, *Majaqueus*, &c.) than in the small Procellariæ and Oceanitidæ, in which the skull is comparatively smooth, of much thinner texture, and with the cerebellar eminence occupying a much greater extent comparatively. The interorbital septum is well ossified in the larger species, most so in *Diomedea exulans*, whilst in the smaller ones it is very extensively fenestrated.

The lachrymal bone is always well developed, but varies in form in the different groups. In the Oceanitidæ and the small Petrels of the *Procellaria*-group it is T-shaped in form, the long arm of the T being horizontal, extending forwards from the body of the bone (which is nearly vertical) to articulate with the external descending process of the nasal bone, just behind the level of the end of the nostril. Between it and the rest of the skull lies a considerable oval fenestra, occupied by membrane in the recent state. The ascending process articulates with the frontal, forming a well-marked, backwardly-directed, antorbital process, whilst the descending process descends downwards towards the jugal arch, to which it may be united by ligament articulating internally with the considerable antorbital plate of the ethmoid ("ectethmoid," Parker).

In *Pelecanoides*, *Puffinus*, *Adamastor*, and *Majaqueus* it has the same relations, but is more triangular in form, and closely abuts on the cranium superiorly, the fenestra being reduced thus to a chink. In the Albatrosses it also remains separate from the skull, and the anterior limb is but little developed as compared with the vertical part, which is swollen, excavated by air-cells, and forms above a strong antorbital process. It loses its connection with the ethmoid. In the remaining genera the lachrymal does not exist as a free bone, being firmly anchylosed to the frontal above and the ethmoid anteriorly (Pl. VI. figs. 1, 3). It is hollow, with one large, and several small, external apertures.

In connection with the descending limb of the lachrymal bone there is often developed a peculiar ossicle, named by Brandt (*cf. supra*, p. 5), who was the first to describe its existence in *Diomedea brachyura* and *Puffinus major*, the "ossiculum lacrymo-palatinum," from its connection with those two bones.

Its nature and relations in the group have subsequently been more extensively investigated by Reinhardt (*vide supra*, p. 8), who calls it the "os crochu."

When best developed, as in the Albatrosses, the "ossiculum lacrymo-palatinum" is a small styliform ossicle of nearly cylindrical (as in *Thalassiarche culminata*, Pl. VI. fig. 7) or somewhat lamellar (*Phæbetria fuliginosa*, Pl. VI. fig. 8) shape, attached above by an articulation to the inner face of the descending limb of the lachrymal bone, and below connected by a ligament to the upper surface of the palatine bone. Seen from the side, in the dried skull (*vide* Pl. VI. fig. 1) the bone is visible below the malar arch. It lies, in the recent state, in a cavity between the nose and the roof of the mouth, in an oblique position, pointing downwards and inward. This bone is present in all the genera and species of Albatrosses examined by me, as well as in *Thalassiarche chlororhyncha*, as mentioned by Reinhardt. In the Oceanitidæ, in *Procellaria* and *Cymochorea*, as well as in *Daption* and *Pagodroma*, its place is taken by a narrow ligament in which there is no ossification at all. In *Bulweria*, *Pelecanoides*, *Fulmarus*, *Thalassæca*, and *Ossifraga* there is a similar ligament, with a small, more or less ossified nodule of bone lying in it, only connected by connective tissue with the surrounding bones. In *Aeipetes*, *Prion*, *Puffinus*, *Majaqueus*, *Adamastor*, and *Æstrelata* it is small and delicate, articulating with the lachrymal above, and ending freely (in the cleaned skull) below.

It is interesting to observe that a very similar bone, both as regards shape and position, occurs in the genus *Fregata* as already pointed out by Reinhardt, whose observation I have been able to verify. But it also occurs in forms so different from these as the Musophagidæ, many Cuculidæ, *Chunga* and *Cariama*, as well as in some Laridæ and Alcidæ, so that its presence is obviously of no particular taxonomic value. Professor Parker informs me that its precise morphological significance is at present rather uncertain.

The palate (*vide* Pl. VI. figs. 2 and 4) is always more or less incomplete below, the fissure dividing it being, by the less degree of inward development of the maxillary processes of the premaxillæ, and of approximation of the inward edges of the maxillo-palatines and palatine bones, longer and wider in the smaller than in the larger forms.

The maxillo-palatine processes are concavo-convex lamellæ, extensively fenestrated, pointing backwards, and with their inner edges appearing but slightly internal to the palatine bones. They remain free from each other in the middle line, and are also unconnected by ossification with the vomer or nasal septum. Hence the Tubinares are in this point strictly schizognathous birds. But in the Albatrosses, where the maxillo-palatines are very large and nearly vertical in position, the space between their inner edges is very narrow, and just in front of them the decurved end of the vomer fills up the intervening chink, especially in *Phæbetria fuliginosa*, where it is firmly fixed to,

though apparently not anchylosed with, the maxillary plates. The transition from this to a desmognathous type would therefore be but very slight.

The palatines in the smaller forms are of generally flat form, with their posterior angles rounded off, closely apposed together for a very short way behind the posterior nares, and with fairly developed descending and ascending plates, the latter being recurved posteriorly and anchylosed to the vomer. This latter bone (Pl. VI. figs. 5 and 6) is always broad behind, of generally depressed form, and strongly bent downwards in front, its pointed extremity appearing between the maxillo-palatine processes at about their anterior edge.

In the larger forms the vomer becomes enormously broad, and keeled both above and below. The palatines meet for a much more considerable distance posteriorly, greatest in *Fulmarus*, and their descending plate becomes more pronounced; at its anterior end the bones of opposite sides nearly meet. The ascending plate, too, becomes very large, more or less embracing the vomer at its base, and being separated, especially in the Albatrosses, only by a narrow chink anteriorly from the posterior end of the equally upturned maxillo-palatine. The posterior margin of the palatines is more or less concave. The pterygoids are nearly straight, slightly compressed, cylindrical bones, which articulate mesially partly with the basisphenoidal rostrum, partly with the truncated posterior ends of the palatines. Well-developed basiptyergoid facets are present in all the forms (*vide* Pl. VI. figs. 2 and 4), except the Diomedeinæ, the Oceanitidæ, *Procellaria* and *Cymochorea*.¹ The quadrate, as in most birds, is two-headed. Its distal end has two distinct articular cartilage-coated areas, separated by a depression. The most external of these is oblique from behind outwards, and is somewhat saddle-shaped, being convex from side to side, and concave antero-posteriorly. The inner facet has its axis directed forwards and inwards, nearly parallel to that of the pterygoid bone. It is divided by a prominent oblique trochlea into an inner, nearly flat, surface, of triangular shape, and a more external, deeply grooved one, also of saddle shape. As might be expected, these features are less obvious in the feeble and smaller, than in the stronger and larger, species of the group.

The foramen magnum is more or less reniform, with the major axis transverse, in the small species, whereas in the biggest it is oval, especially in *Ossifraga*, with the long axis vertical. The moderately sized species are here again intermediate in structure.

The mandible has no recurved angular process: its posterior end is more or less inturned and truncated behind, the truncated surface being of triangular shape. The articular surfaces are two in number, and, of course, of inverse shape to the corresponding facets on the quadrate bone. One or more pneumatic foramina enter the bone at this point.

Axial skeleton.—The number of vertebræ varies from thirty-eight to forty-two, but

¹ *Halocyptena* has not yet been examined in this respect: it probably resembles the last two genera named.

that of the cervical ones is always fifteen, as may be seen from the table appended (p. 47). In the Oceanitidæ, it will be observed, the number of cervico-dorsal vertebræ is twenty-one, in the Procellariidæ, it is twenty-two, with two exceptions, where there are as many as twenty-three.

The articular cup of the atlas is always incomplete superiorly, the odontoid process of the axis filling up the gap, and so completing the joint. The fifteenth cervical vertebræ has a well developed free rib, which may have an uncinæ process, and one or more of the preceding vertebræ—usually two, but sometimes as many as four (*Oceanites*)—have short V-shaped ribs, which do not anchylose with the vertebræ. Sometimes (*Oceanites*, *Prion*) the fourteenth cervical rib is longer, resembling in shape that of the fifteenth, but with no uncinæ process.

The dorsal vertebræ¹ are all free, except the last, or occasionally two last, which are anchylosed to those forming the sacrum. They usually have well-developed hypapophyses, especially anteriorly. These are particularly strong and well-developed in *Pelecanoïdes* as in other diving birds (e.g., *Uria*, *Alca*, *Podiceps*), extending there to quite the last dorsal vertebra. In the Diomedeinæ, on the other hand, they are quite absent, or merely represented, on the most anterior ones, by short expanded processes like those of the few last cervical vertebræ.

In nearly all the Tubinares, each of the dorsal vertebral centra has on its sides a distinct oval expression, of varying depth, at the bottom of which, in the largest species, open one or more small pneumatic foramina, to admit air to the interior of the bones. In the Albatrosses, however, these pneumatic depressions are absent, though air is admitted to the bones—which are highly pneumatic here—by a distinct, but small, aperture in each centrum. The transverse processes, too, are in these latter birds very much hollowed out for air cavities.

The ribs in the Oceanitidæ are peculiarly broad, and flattened out dorsally, to an extent not seen in any Procellarian.

In *Pelecanoïdes* the ribs are very long, and oblique in position, the more posterior ones most so, with the angles formed by their vertebral and sternal moities very acute. Thus the whole trunk almost becomes completely surrounded by a bony box, in a way well calculated to resist the pressure of the water when these birds dive. The same modification may be seen well-developed in the diving Alcidæ (*Uria*, *Alca*, &c.).

The uncinæ processes are well-developed and nearly straight. They are firmly anchylosed to the ribs.

As may be seen from the table, the number of ribs and uncinæ processes varies slightly, and the same is true for the sacral and caudal vertebræ. The latter have well-

¹ I count all those vertebræ which bear ribs, whether true or false, behind the first dorsal—defined as such by its rib being the first to articulate with the sternum—as “dorsal.” The succeeding rib-less vertebræ which are anchylosed together are “sacral,” the remaining free ones “caudal.”

developed transverse processes, and between their centres inferiorly small chevron bones, smallest anteriorly, larger and double posteriorly, are developed. The last of these may, apparently, anchylose with the body of the corresponding vertebra. The pygostyle is long and compressed. The diving *Pelecanoïdes* has, it will be noticed, a greater number of vertebræ (9) in its tail than the other forms.

TABLE SHOWING THE NUMBERS OF THE VERTEBRÆ, RIBS, AND UNCINATE PROCESSES.

Name.	Cervical.	Dorsal.	Sacral.	Caudal.	Total No. of Verte- bræ.	Ribs.	Uncinate Processes.
<i>Oceanites oceanicus</i> ,	15	6	9	8	38	8 (2 + 6)	5 (15C. 1 - 4D.)
<i>Garrodia nereis</i> ,	15	6	9	(?)	(?)	7 (1 + 6)	6 (15C. 1 - 5D.)
<i>Fregetta melanogastra</i> ,	15	6	9	8	38	7 (1 + 6)	5 (1 - 5D.)
<i>Cymochorea leucorrhoa</i> ,	15	7	10	7	39	8 (1 + 7)	6 (1 - 6D.)
<i>Procellaria pelagica</i> ,	15	7	9	7	38	8 (1 + 7)	6 (1 - 6D.)
" <i>Æstrelata grisea</i> " (a),	15	7	11	7	40	8 (1 + 7)	5 (1 - 5D.)
" " (b),	15	8	10	8	41	9 (1 + 8)	6 (1 - 6D.)
<i>Majaqueus equinoctialis</i> ,	15	8	11	7	41	9 (1 + 8)	6 (1 - 6D.)
<i>Adamastor cinereus</i> ,	15	7	12	7	41	8 (1 + 7)	5 (1 - 5D.)
<i>Puffinus anglorum</i> ,	15	7	12	8	42	8 (1 + 7)	5 (1 - 5D.)
" <i>obscurus</i> ,	15	7	11	8	41	8 (1 + 7)	5 (1 - 5D.)
<i>Daption capensis</i> ,	15	7	11	7	40	8 (1 + 7)	6 (1 - 6D.)
<i>Acipetes antarcticus</i> ,	15	7	11	7	40	8 (1 + 7)	6 (1 - 6D.)
<i>Thalassæca glacialis</i> ,	15	7	11	8	41	8 (1 + 7)	5 (1 - 5D.)
<i>Fulmarus glacialis</i> ,	15	7	11	8	41	8 (1 + 7)	5 (1 - 5D.)
<i>Ossifraga gigantea</i> ,	15	7	11	7	40	8 (1 + 7)	5 (1 - 5D.)
<i>Prion desolatus</i> ,	15	7	10	7	39	9 (2 + 7)	6 (15C. 1 - 5D.)
<i>Pelecanoïdes urinatrix</i> ,	15	7	10	9	41	8 (1 + 7)	6 (1 - 6D.)
<i>Diomedea exulans</i> ,	15	7	12	6	40	8 (1 + 7)	5 (1 - 5D.)
" <i>brachyura</i> ,	15	7	12	7	41	8 (1 + 7)	5 (1 - 5D.)
<i>Thalassiarche melanophrys</i> ,	15	7	12	7	41	8 (1 + 7)	5 (1 - 5D.)

Pectoral arch.—The sternum (Pl. VII.) is usually rather broad and short, much longer in *Pelecanoïdes* than in any other genus, with a well-developed keel, and a short, but distinct manubrium—obsolete in *Pelecanoïdes*. The costal processes are triangular in shape, directed outwards, or in the *Oceanitidæ* and *Pelecanoïdes*, forwards and outwards. The anterior margin of the keel is more or less excavated, with its lower angle produced forwards, most so in *Puffinus anglorum*. In *Pelecanoïdes* (Pl. VII. figs. 3, 4) this part articulates with the clavicular symphysis, instead of being merely connected to it by ligament, as in the other forms. The coracoidal grooves are oblique backwards, and present two distinct articular areas for the articulation of the coracoid bone. The sides of the sternum usually converge towards the lower end of the costal process, and then diverge again to their posterior extremities. As may be seen from the figures of Plate VII.

the posterior end of the sternum varies a great deal in its outline in different members of the group.

In most of the larger forms of Procellariidæ, the visceral aspect of the sternum presents, towards its anterior extremity, more or fewer pneumatic apertures, which are best developed in the Albatrosses, where the whole bone is much permeated with air. In *Fulmarus*, and all the smaller forms of Procellariidæ, as well as in the Oceanitidæ, the sternum has no pneumatic apertures at all, and does not contain air.

In the genera *Cymochorea* (fig. 5), *Procellaria*, and *Halocyptena*, as also in *Fregetta* (fig. 7) and *Garrodia*, the posterior margin of the sternum is entire, with only a very slight concavity in the outline of each side. In the Oceanitine genera *Oceanites* and *Pelagodroma* it is very nearly the same in shape, though each side has a small excavation, the margin between the excavations being convex. In *Pelecanoïdes* (fig. 3) also the sternum is nearly straight posteriorly. In the Diomedeinæ (e.g., *Thalassiarche melanophrys*, fig. 1) the posterior angles of the sternum are produced backwards and outwards considerably, and its posterior border is broadly excavated by a sinuous curve, convex externally, concave mesially. In *Diomedea exulans* the inner concave part is divided into two smaller concavities on each side by a process of bone, so that the posterior margin presents four slight notches, the inner pair being the bigger.

In the remaining genera of the group, the posterior border of the sternum is always more or less four-notched posteriorly, the notches being generally best developed and deepest in the genera allied to *Puffinus* and *Majaqueus* (figs. 9-13), whilst in the Fulmarine forms the notches are smaller and tend to be irregular. *Bulweria* (fig. 16) departs widely from any of the so-called Storm-Petrels in the form of its sternum, and approaches closely *Æstrelata*, &c. The exact forms of this notching, which is inclined to vary in different specimens, may be best understood from an inspection of the figures. The outer notch may, as in the specimen of *Adamastor* figured (fig. 18), be converted into a foramen by the partial ossification of the membrane filling it.

The coracoid bones in the smaller genera (*vide* Pl. VII. figs. 5-8) are well-developed, with nearly cylindrical shafts, dilated internally at their distal ends to meet the acromial process of the scapula, whilst proximally they are broad and expanded, and produced externally into a pointed, or slightly hooked process. In *Pelecanoïdes* (figs. 3, 4) these bones diverge at a smaller angle from each other than in the other forms; their shafts are less cylindrical, and the proximal ends comparatively little dilated. In the larger forms, on the other hand, the coracoids become very divergent, and the shaft and both extremities, but particularly the proximal one, are much dilated, so as to assume the extraordinary form seen in *Diomedea* (figs. 1 and 2) and its allies, where the greatest transverse diameter of the bone at its base is nearly as great as its entire length. The external outline of the bone is deeply concave, owing to the great development of its external costal process.

The scapula is a slender, slightly curved bone, presenting no special peculiarities. Its acromial process is prolonged inwards and forwards to nearly, or quite, meet the posterior end of the clavicle. The angle it forms with the coracoid varies very much in different genera, being most acute in *Pelecanoïdes*, whilst in the *Oceanitidæ* it is hardly, if at all, less than a right angle (*vide* Pl. VII. fig. 8, *Fregetta*). *Procellaria* and *Cymochorea* resemble the other *Procellariidæ*, the coraco-scapular angle being in them obviously (*t.c.*, fig. 6) acute.

The clavicles are always well-developed, strongly convex forwards as seen from the side, and forming a more or less widely-open U when seen from in front. Their posterior ends are produced backwards to unite, by ligament, with the acromial process of the scapula. The symphysis is usually somewhat dilated and thickened and closely apposed to the antero-inferior angle of the sternum, to which it is connected by ligament. In *Pelecanoïdes* the clavicular arch is more V-shaped, its limbs diverging but little, and the symphysis develops a firm articulation with the *carina sterni* (*vide* Pl. VII. figs. 3, 4) as in *Phalacrocorax*, *Sula*, *Plotus*, and *Phaëthon* of the *Steganopodes*. In the *Oceanitidæ* (*vide* Pl. VII. fig. 8) the *symphysis furculæ* has a strong, curved hypocleidial process, directed downwards and backwards, very much more developed than the corresponding part in any *Procellarian* genus, even *Cymochorea* or *Procellaria* (*t.c.*, fig. 6).

Anterior Extremity.—The *humerus* (Pl. VI. figs. 9–11, where that of *Majaqueus æquinoctialis* is figured) is long, with a cylindrical shaft, often much compressed distally in such a way that the outer margin of the bone with its condyle is anterior and the inner one with its condyle posterior. The head is but little elevated above the general level of the proximal end of the bone. The pectoral ridge is prominent and triangular, but short, and the deltoid impression extends only as low as its distal termination. Behind the deltoid impression is a linear one for the *latissimus dorsi*. The bicipital surface is well developed, the lesser trochanter strong and re-curved; it is excavated behind and below by a deep infra-capitular fossa, bounded above by the strong interfossal ridge, the supra-capitular fossa being a more shallow concavity. The tubercle for the insertion of the *pectoralis secundus* is strong, and is situated at the commencement of the pectoral crest, just anterior to the articular head. Below and anterior to it is an oval depression, often large, for the *pectoralis tertius*. The external condyle is prolonged obliquely upwards and inwards on the anterior surface of the bone; the capitellum is distinct, and separated by a slight notch from the internal condyle. The olecranal fossa is shallow and prolonged upwards into a smooth, slightly excavated triangular area. The impression for the *brachialis anticus* is deep and oval.

Above the external condyle there is a very strong, forwardly-directed epicondylar process, from which arises the more superficial of the bellies of the *extensor*

metacarpi radialis longior muscle. This is least developed in *Pelecanoïdes* and *Thalassæca*.

The pectoral crest, on its inferior aspect, presents an elongated surface for the attachment of the great pectoral, coextensive with the lower moiety of its border. This surface develops a roughness at each extremity, particularly below, where the main part of the more superficial layer of the muscle is attached by its strong tendon. The double nature of the pectoral muscle is indicated by a distinct muscular ridge dividing the general area of insertion into two.

In the Oceanitidæ the humerus is conspicuously a stouter and shorter bone, with its shaft evidently curved, instead of being almost straight. The epicondylar process projects much less forwards, and is continued down by an elevated ridge to the surface of the condyle itself.

In the Albatrosses the humerus is distinctly concave forwards, with its shaft considerably compressed throughout. The pectoral crest is sharply pointed, the bicipital surface very prominent and convex, the internal trochanter less developed, and the infra-capitular fossa very shallow, with its apex occupied by a large pneumatic foramen, and the *brachialis* impression long and very shallow.

In *Pelecanoïdes*, as might have been expected from its diving habits, the humerus is somewhat modified from the ordinary Procellarian type. The shaft of the bone is comparatively short and much compressed, especially below, where it has sharp anterior (external) and posterior (internal) margins. The pectoral crest is little developed. The internal condyle descends considerably lower than the external one, and the capitellar surface is well-developed and compressed. Behind it and the external condylar trochlea is a strongly-marked deep pit, into which fits, like a peg, a sharp conical process developed at the proximal end of the ulna. The epicondylar process is very short, and the depression for the *brachialis anticus* very shallow.

The *radius* is a slender, straight and cylindrical bone, with its distal end depressed and grooved superiorly.

The *ulna* is much stouter, with its posterior edge sharply keeled, with only slight impressions for the secondary remiges. The olecranon process is short and bluntly triangular. In *Pelecanoïdes* the radius and ulna are considerably compressed from before backwards. The ulna is stout, and develops at its proximal end a slightly curved triangular process, directed upwards, which, as already described, fits into a corresponding socket on the humerus, and so firmly unites the bones together.

The *manus* is very long. The second and third metacarpals are nearly parallel and straight, the third metacarpal being much more slender than its fellows. The pollex has but one phalanx, which is strong and long, about equalling one-half of the second metacarpal. The two phalanges of the index are well-developed, the basal one, which does not articulate with the third digit, being much dilated posteriorly.

In the Oceanitidæ the radius and ulna are generally stouter and stronger bones they are in the Procellariidæ; the former is considerably expanded at its distal extremity.

As may be seen by the table at the end of this section (p. 54) the three chief segments of the fore-limb are, as a rule, nearly equal in length, this being especially true as regards the arm and forearm.

Pelecanoïdes alone has the latter much shorter than the arm, the proportions here being three to four. In all the others the humerus and ulna are nearly equal in length.

In most of the genera the manus (excluding the carpus) is the longest of the three segments, but this is not the case in the larger forms (*Adamastor*, *Majaqueus*, and *Ossifraga*) of the Procellariinæ, whilst in the Diomedeinæ the manus is very much shorter, as may be seen by the measurements, than either the humerus or ulna.

Pelvic arch.—The pelvis (*cf.* Pl. VI. fig. 12, pelvis, &c., of *Majaqueus æquinoctialis*) may be described as generally elongated and narrow. The præ-acetabular is about equal to the post-acetabular axis, though in *Cymochorea*, *Procellaria*, *Pelecanoïdes* and the Oceanitidæ it is considerably longer. In *Puffinus*, on the other hand, the reverse is the case.

The ilia are long and narrow; anterior to the acetabula they are slightly concave plates, with their anterior extremities somewhat rounded off, separated mesially by the sacral vertebræ, the neural spines of which coalesce into a strong median ridge. The antitrochanteric eminences are strong, and stand out conspicuously, the iliac bones attaining here their greatest transverse extent, though each bone is narrow and separated by a wide space, occupied by the bodies and transverse processes of the more posterior sacral vertebræ, from its fellow of the other side. A strongly marked post-acetabular ridge runs from here inwards and backwards to the prominent posterior iliac angle, which lies between the transverse processes of the second and third caudal vertebræ. External to the ridge, the iliac surface is nearly vertical.

The ischia are narrow and compressed plates of bone, usually strongly curved downwards posteriorly to articulate with the dilated posterior ends of the nearly straight, slender, pubic bones, each of which has at the level of the anterior angle of the acetabulum, a slight prepubic spine. The posterior ilio-sciatic margin is first strongly concave backwards, and then convex.

Seen from below, the pelvis preserves its generally narrow shape, the pubes being only slightly inturned at their posterior, cartilaginous extremities. The renal fossæ are narrow, fairly deep and confluent. In front they are limited by the transverse processes of the 3rd or 4th sacral vertebræ, which, like those of their predecessors, are short and slender, the 7th, 8th, 9th and 10th of those bones developing transverse processes, which abut against the ilia, and in the larger forms become strong and more or less double.

There is not very much divergence from the general form of pelvis described here amongst the various forms of Petrels. In the Albatrosses it becomes very narrow, especially anteriorly, the renal fossæ being correspondingly narrow and deep. The bones entering into its composition, and supporting it become extensively pneumatic. Anteriorly the ilia unite, or nearly so, over the neural crest, whilst posteriorly the foramina between the transverse processes of the sacral vertebræ become reduced to small holes, owing to the increased amount of ossification. A tendency to similar increased ossification in these parts is discernible in the larger forms of Petrels.

In *Pelecanoïdes* the ischia are nearly straight along their posterior margin.

In *Cymochorea* and *Procellaria*, as well as in the Oceanitidæ, the pelvis generally is weaker, with its posterior region more deflexed. But that of the two former genera may be distinguished from that of the Oceanitidæ by the obsolete condition of the posterior iliac spine, the weakness of the post-acetabular ridge, and the smaller size of the ilio-sciatic and obturator foramina.

Posterior Extremity.—The *femur* is short, and more or less curved, most so in *Puffinus*. The head is a little elevated, and set on nearly at right angles to the long axis of the bone. The external condyle descends lower than the internal, and has a well-marked posterior trochlear surface. The femur of the Oceanitidæ is a stronger and better developed bone, particularly at the two extremities, than it is in the Procellariidæ of corresponding size. The *tibia* is long, especially in the Oceanitidæ, where it is at least twice as long as the humerus. It has a very large and strong cnemial process, best developed in the genus *Puffinus*, for the attachment of muscles, rising high above the articular faces of the femur (*vide* Pl. VI. fig. 13). Its distal end is more or less antero-posteriorly compressed, and has an osseous bridge for the *extensor communis digitorum*. The ridge for the fibula extends for about one-quarter the total length of the shaft of the bone, beginning a little below the external condylar facet.

The *fibula* is a delicate, styliform bone, which may be two-thirds as long as the shaft of the tibia.

The *tarso-metatarsus* has a smooth, rounded, interarticular prominence proximally, and a calcaneal eminence, with two deep grooves, which may become converted into canals, for the passage of the flexor tendons. In the Diomedeinæ this calcaneal process is feebly developed, with but a single groove internally, and a broad trochlear surface, with two shallow furrows, externally. The antero-external margin of the bone is sharply keeled. In such forms as *Puffinus* this keel becomes very sharp and prominent, owing to the greatly compressed form of the leg. Internal to it the bone is distinctly grooved.

Of the articular trochleæ at its distal end, the inner is the shortest and most oblique. Those for the third and fourth digits are more nearly equal, that for the

third however being slightly the longer. There is a small foramen between it and the fourth.

In *Puffinus* there is a distinct osseous bridge, developed on the anterior and distal surface of this bone, external to the impression for the *tibialis anticus*, which I have also seen present (on one side only) in *Diomedea exulans*. Usually the bridge remains tendinous.

The three anterior digits are strong and well developed, the third and fourth being nearly equal in length. They have the normal number of phalanges, of which the basal one is always much the longest. In the Oceanitidæ the phalanx of the middle digit always exceeds the two succeeding ones, taken together, in length, whereas in the Procellariidæ it is always shorter, considerably, than these two.

The hallux is altogether absent in *Pelecanoïdes*, and is present only in the most rudimentary form, as already described (*supra*, p. 13) in the Diomedeinæ. In the Oceanitidæ and remaining Procellariinæ it is always present, though small, but is peculiar in consisting of only a single phalanx, which bears the claw (*vide* Pl. VI. fig. 14). It articulates, proximally, with a small metatarsal, which lies in its usual relationship to the cannon-bone formed by the conjoined metatarsals.

In the ordinary Petrels the only pneumatic bones of the skeleton are the skull, lower jaw (around its angle), sternum (very slightly), and the cervical, dorsal, and some of the more anterior sacral vertebræ. The limb bones are all filled with marrow. In the smaller forms indeed of both families only the skull, lower jaw, and a few of the most posterior cervical vertebræ seem to be pneumatic. As a rule there seems to be a gradual increase in the amount of pneumaticity of the bones correlated with the increase of size in the bird generally.

In the Albatrosses the whole of the axial skeleton (excepting some of the ribs, the scapula, furcula, caudal vertebræ, and uncinæ processes) becomes extensively pneumatic, the sternum being especially so. The humerus, moreover, becomes hollowed and filled by air, which enters through the pneumatic foramina developed at the bottom of the infra-capitular fossa.

The proportion of the hind, as compared with the fore, extremity, as well as those between different segments of those limbs, are very different, as may be seen from the appended table of measurements (in millimetres), in the Oceanitidæ and the Procellariidæ respectively. In the former the leg, as measured by the combined lengths of the femur, tibia, and metatarsus, and therefore excluding the toes, is longer than the wing (humerus + ulna + manus (omitting the carpals). The tarsus is longer than the mid-toe or ulna, and at least twice as long as the femur. The tibia is at least twice as long as the humerus, and much longer than the manus.

In the Procellariidæ (including the Diomedeinæ and *Pelecanoïdes*) the leg, measured in the same way, is shorter than the wing. The tarsus is not longer than the mid-toe

(except in *Procellaria* where it is just) but shorter, and the same is always the case when it is compared to the ulna. It is never twice as long as the femur. The tibia is only a little, or not at all, longer than the humerus or manus.

Name.	Humerus.	Ulna.	Manus.	Femur.	Tibia.	Tarso- Metatarsus.	Middle Toe.
<i>Oceanites oceanicus</i> , . . .	23	21	34	15	50	35	28
<i>Garrodia nereis</i> , . . .	20	17	26(?) ¹	14	51	34	25
<i>Pelagodroma marina</i> , . . .	27	24	37	18	60	41	35
<i>Fregetta melanogastra</i> , . . .	27	23	36	19	56	38	26
<i>Cymochorea leucorrhoa</i> , . . .	35	35	42	16	37	24	26
<i>Procellaria pelagica</i> , . . .	26	24	33	13	33	22	20
<i>Bulweria columbina</i> , . . .	62	62	63	20	42	28	28
" <i>Æstrelata grisea</i> ," . . .	81	83	84	31	61	36	43
<i>Majaqueus æquinoctialis</i> , . . .	151	154	143	51	116	67	81
<i>Adamastor cinereus</i> , . . .	134	132	127	50	108	62	78
<i>Puffinus anglorum</i> , . . .	79	72	86	31	79	46	51
" <i>obscurus</i> ," . . .	66	63	71	25	66	40	44
<i>Daption capensis</i> , . . .	86	84	91	38	80	46	56
<i>Aeipetes antarcticus</i> , . . .	98	93	100	44	88	44	56
<i>Thalassœca glacialis</i> , . . .	115	113	118	48	96	57	68
<i>Fulmarus glacialis</i> , . . .	118	116	117	50	113	54	67
<i>Ossifraga gigantea</i> , . . .	243	236	212	88	184	94	130
<i>Prion desolatus</i> , . . .	57	56	56	23	53	32	35
<i>Pelecanoides urinatrix</i> , . . .	43	33	44	23	46	24	27
<i>Diomedea exulans</i> , . . .	428	417	290	110	246	124	168
" <i>brachyura</i> ," . . .	281	285	222	76	175	96	122
<i>Thalassiarche melanophrys</i> , . . .	259	262	202	80	161	83	118

IV. THE CLASSIFICATION OF THE TUBINARES.

The propriety of the division of the entire order Tubinares into two main families, which must be termed the Oceanitidæ and Procellariidæ,² first proposed by Professor Garrod in 1873 (*vide supra*, p. 9), has been fully borne out by my further investigations into the structure of these forms. To the differences in their myological formulæ, and in the presence or absence of cæca, may now be added numerous other points, both external and internal.

The Oceanitidæ agree together in having the following peculiarities which are not shared in—with one or two exceptions marked by an*—by any of the Procellariidæ:—

The number of secondary remiges is never more than ten. The tarsi are not uniformly reticulate, but are either ocreate, or covered by large transversely-oblique

¹ Imperfect in the specimen measured. This length is estimated.

² Cf. Proc. Zool. Soc., 1881, p. 737.

scutes anteriorly. The claws are very flat, depressed, and lamellar. There are no colic cæca.* (Absent in *Halocyptena* only of the Procellariidæ.) There is a peculiar *expansor secundariorum* muscle. The tendon of the *tensor patagii brevis* is quite simple throughout. The *semi-tendinosus* muscle has a well-developed accessory head. The *ambiens* muscle, when present, does not pass over the knee, but is lost on the cnemial process of the tibia. The number of cervico-dorsal vertebræ is twenty-one. The clavicles have a long, curved, symphyseal process. The leg bones are longer than the wing bones. The tarsus is longer than the mid-toe* and ulna, and at least twice as long as the femur. The tibia is at least twice as long as the humerus, and much longer than the manus. The basal phalanx of the middle toe is as long as, or longer than, the next two taken together.

The Oceanitidæ also agree together in having no basipterygoid processes, no uncinatæ bone, a peculiarly short and stout humerus, radius, and ulna, a single circular nasal aperture, a sternum with its posterior margin quite or nearly entire, a larger *gluteus primus*, as well as in numerous other smaller details already noticed. All these characters never coexist together in any Procellarian form, and, if my observations are correct, the Oceanitidæ further differ from the Procellariidæ by having a *biceps brachii* muscle of the normal form, with no patagial slip.

The Procellariidæ on the other hand, have the following characters :—

The number of secondary remiges is never less than thirteen, and is usually much greater. The tarsi are pretty uniformly covered with small hexagonal scutellæ. The claws are sharp, curved, compressed. Short colic cæca are present.¹ There is no *expansor secundariorum* muscle. The termination of the tendon of the *tensor patagii brevis* is never quite simple, and may become very complicated. There is no accessory head to the *semi-tendinosus*. The *ambiens* muscle (only absent in *Pelcanoïdes*) always crosses the knee. The number of cervico-dorsal vertebræ is not less than twenty-two. The clavicles have only a very small symphyseal process. The leg is shorter than the wing. The tarsus is not larger than the mid-toe (except in *Procellaria*), and is shorter than the ulna. It is never twice as long as the femur. The tibia is only a little, or not at all, longer than the humerus or manus. The basal phalanx of the middle toe is shorter than the two next joints. Basipterygoid facets may or may not be present, and the same is true of the uncinatæ bone. The humerus, radius, and ulna have a shape different from that of the Oceanitidæ. The form of the nostrils, and of the posterior margin of the sternum, varies extensively. The *gluteus primus* is always very small, and there is a peculiarly formed patagial slip derived from the *biceps* muscle.

¹ *Halocyptena* is apparently an exception to this rule, but as *Cymochorea* has only one cæcum, there is nothing surprising in the reduction being carried a step further. As therefore all the congeners of *Halocyptena* have cæca, it may be safely assumed that their disappearance in it has been very recent, and has occurred since it acquired the rest of its Procellarian characters. This loss of cæca therefore by it does not in any way really approximate it to the Oceanitidæ.

Thus in spite of the general superficial resemblance of the Oceanitidæ to the smaller forms of Procellariidæ, with which all ornithologists previous to Garrod had confounded them, the differences between the two families are, it will be seen, numerous and important. The special points of resemblance which the Oceanitidæ have with such Procellarian genera as *Procellaria* and *Cymochorea*—such as the general small size, style of coloration, form of skull, comparative simplicity of the *tensor patagii* arrangement, simple sternum and syrinx (the last three peculiarities being also common to *Pelecanoides*)—may best be explained by supposing that these small Procellarian forms are on the whole less specialised than the larger ones (Fulmars, Albatrosses, Shearwaters, &c.), and so retain more of the characters possessed by the primitive and now extinct common form from which both the Procellariidæ and Oceanitidæ must have been derived.

The Oceanitidæ are a small and, on the whole, compact group, with but few differences of importance between the four genera contained in it. Of such differences the most important are the loss of the *ambiens*, and the very flattened nails and feet of *Fregetta*; the lengthening of the foot in *Pelagodroma*; and the acquisition of an ocreate tarsus by *Fregetta* and *Oceanites*. *Garrodia* is, therefore, on the whole, the least modified form of the group. The four genera may be distinguished as follows:—

Garrodia. *Ambiens* present; tarsus scutellated anteriorly; sternum posteriorly entire.

Oceanites. *Ambiens* present; tarsus ocreate; sternum posteriorly slightly excavated; interdigital webs yellow.¹

Pelagodroma. *Ambiens* present; tarsus scutellated; sternum and webs as in *Oceanites*; feet very long.

Fregetta. *Ambiens* absent; tarsus ocreate; sternum entire; feet very short, and nails peculiarly broad and blunt.²

The Procellariidæ, comprising as they do by far the greater number of species and genera of the group, show much more divergence *inter se* than is the case with the Oceanitidæ. The Albatrosses are by far the most aberrant forms of this group, with which, however, they have all the characters above noted in common, though in themselves specialised in several points. The discovery of a rudimentary hallux, and of an aftershaft in these birds, disposes of two of the characters which have hitherto been available for their separation from the other Tubinares, as do the gradations of form that exist in the amount of separation of the two parts of the dorsal tract of another. As peculiarities of the Diomedeinæ may be included:—

¹ To the genus *Oceanites* belong *Thalassidroma gracilis* (Elliott, Ibis, 1859, p. 391—the type (!) of which, now in the Smithsonian Institution, I have examined) and *Thalassidroma lineata* (Peale, Orn. U.S. Expl. Exped., pl. xxxix. p. 403). *Thalassidroma segethi* (Philippi and Landbeck, Wieg. Arch., 1860, p. 282) may be the former bird, or, as suggested by Mr. Salvin (Proc. Zool. Soc., 1878, p. 736), *Fregetta grallaria*.

² Besides *Fregetta grallaria* and *melanogastra* there seem to be two other species to be referred here, viz., *Procellaria albobularis*, Finsch, (Proc. Zool. Soc., 1877, p. 722), and *Fregetta moerstissima*, Salvin (Proc. Zool. Soc., 1879, p. 130).

The lateral position of the nostrils.¹ The presence of a distinct *gluteus quintus* muscle. The formation of the *biceps humeri* muscle, which gives off a patagial slip from its coracoidal head. The characteristic sternum. The absence of hæmapophyses on the dorsal vertebræ. The pneumatic *os humeri*. The generally pneumatic condition of the skeleton. The proportion of the manus to the humerus and ulna.

The tongue and palate are also more or less peculiar, and in all the genera there are uncinæ bones, no basipterygoid facets, and two large distinct accessory wing-ossicles; the right liver-lobe is also distinctly the larger of the two.

There are apparently three good genera of Albatrosses which may be distinguished, independently of external characters, as follows:—

Diomedea. Tongue very short; uncinæ bones more or less styliform. (*Diomedea exulans* and *brachyura*.)

Thalassiarche. Tongue intermediate; uncinæ bones styliform. (*Thalassiarche culminata*.)

Phæbetria. Tongue much longer; uncinæ bones flattened; hallux better developed than in the other genera, and with an external claw. (*Phæbetria fuliginosa*.)

Neglecting for the present the peculiar diving *Pelecanoïdes*, the remainder of the Procellariidæ forms a natural group distinguished by the following characters from the Albatrosses (Diomedeinæ):—

The more or less dorsal position of the nostrils, the form of which however varies, as has already been described, though they are never lateral. The absence of a *gluteus quintus*. The peculiar form of the *biceps brachii* muscle, which is in two separate parts, the humeral head forming a patagial slip. The presence of hæmapophyses on the dorsal vertebræ, the centre of which are marked by more or less developed pneumatic depressions. The non-pneumatic humerus. The different pterylosis, and the nearly equal size of the lobes of the liver. The greater size of the hallux, which always has a distinct nail externally. (Quite absent in *Pelecanoïdes*.)

Pelecanoïdes is, in some respects, as much specialised as the Albatrosses, though many of its modifications are distinctly traceable to its diving habits, as, *e.g.*, the compressed form of the wing bones, the great development of the hypapophyses of the dorsal vertebræ, the elongated sternum and pectoral muscles, the peculiar ribs. But it stands alone (amongst the Procellariidæ) in the absence of the *ambiens* muscle; the peculiar disposition of the femoral vein; the absence of a hallux; and the single interclavicular air-cell. Moreover, as in *Bulweria* only of other Tubinares, its myological formula is A.X., there being no accessory head to the femoro-caudal muscle.

¹ This feature, in which the Albatrosses are apparently more primitive than are either the Oceanitidæ or the other Procellariidæ, can hardly, if my views about the relationships of these groups to each other be correct, be considered to have been a character of the common Petrel-ancestor. It may be more probably explained as due to arrested development during embryonic life, as a study of the development of the nostrils of other Petrels would probably show that these are actually, at some time, lateral, and subsequently coalesce.

But *Pelecanoïdes* shows marks of being in some respects an early form in the simple condition of the *tensor patagii* muscle, in its very simple syrinx, and in the general shape of its sternum. It has the characteristic form of *biceps* muscle found in all the Procellariidæ, except the Albatrosses, and like all those forms, except the *Procellaria*-group, has basipterygoid facets.

Pelecanoïdes is thus, as will be seen, a very well-marked form, though it is somewhat difficult to decide as to whether its peculiarities are such as to entitle it to form a separate sub-family by itself. The presence of basipterygoid facets would seem to indicate that it probably diverged from the general stock of the Procellariinæ at a point when the latter had already developed that feature, and therefore at a period after the ancestor of the *Procellaria*-group—in many ways the least specialised, and therefore presumably more ancient, of the sub-family, and in which there are no such facets—had already acquired its main characters.

According to modern ideas, the object of a classification is not so much to represent morphological facts as to indicate the phylogenetic relations of the different forms concerned. According to the first view, *Pelecanoïdes* might well be placed, as many authors have done, in a special group of its own; but if we admit, as seems on the whole most probable, that it has been derived from the same stock as the *Procellaria*-group after the special ancestor of the latter was developed, I prefer considering it as simply a highly-specialised form of the Procellariinæ.

The Procellariinæ so defined fall into a number of smaller groups, distinguishable by good characters.

The "Stormy-Petrels" of the genera *Procellaria*, *Cymochorea*, and *Halocyptena*¹ form one such minor group, distinguished by their general small size and coloration, comparatively long tarsi, nearly single nasal aperture, simple triangular tongue, simple *tensor patagii*, peculiar skull with no basipterygoid facets or distinct uncinate bone, entire posterior sternal margin, and little specialised syrinx. *Procellaria* has two cæca, *Cymochorea* one only, and *Halocyptena*, as already mentioned, has them quite absent.

The position of *Pelecanoïdes* has already been fully discussed; it stands quite *per se*, though presumably derived from a stem common to it and the remaining Procellariinæ, which must have diverged from the less specialised one now represented by the *Procellaria*-group.

Prion (with which *Halobæna* is probably to be associated) represents a third minor group, much specialised as regards its peculiarly broad beak with its fringe of lamellæ, whilst in its *tensor patagii* arrangement and syrinx it is not highly developed.

The two genera *Pagodroma* and *Daption* seem very central as regards their relationships, which seem to be with *Prion* (as indicated chiefly by the rudimentary lamellæ of

¹ *Oceanodroma* also, I have little doubt, belongs to this group.

Daption) on the one hand, and with the Fulmars on the other, *Aeipetes*¹ being the less specialised of these, both as regards its imperfect tracheal septum, and the number of rectrices. The type of syrinx so characteristic of the Fulmars is foreshadowed, as it were, as has been already pointed out (*supra*, p. 35) in that of *Pagodroma*, and all four genera (*Fulmarus*, *Thalassæca*, *Ossifraga*, and *Aeipetes*) agree in the general disposition of the *tensor patagii*, which has no ossicles, in the more or less rudimentary *os uncinatum* in the tendency to ankylosis of the lachrymal and frontal, in the shape of the tongue and of more or less well-developed lamellæ on the bill, and in having four more or less complete, but never deep, sternal emarginations.

Aeipetes is, on the whole, the least specialised of the Fulmarine group in the most limited sense. This includes besides *Thalassæca*, *Fulmarus*, and *Ossifraga*, which last,

FIG. 31.—Beak of *Thalassæca glacialis*. a. The aperture of the nasal tubes, from in front. Natural size.

FIG. 32.—The same parts of *Aeipetes antarcticus*.

on account of its great size, peculiar syrinx, and sixteen rectrices, may be considered the culminating point in this direction of the Procellariidæ.

The remaining genera, *Æstrelata*, *Puffinus*, *Adamastor*, *Majaqueus*, and *Bulweria* are also apparently closely related to each other, the first and last named being perhaps

¹ I propose to make a genus under this name, for the reception of the *Procellaria antarctica* of Gmelin (Syst. Nat., 1788, vol. i. p. 565), which has usually been considered congeneric with *Thalassæca*, the type (and only representative) of which is *Thalassæca glacialis*. For the latter bird also was instituted Hombon and Jacquinot's genus *Priocella* (s.c., vol. iii. p. 148). *Aeipetes* is easily distinguishable from *Thalassæca* by the much shorter and stouter bill, and differently shaped nasal tubes, as will be best understood from the accompanying figures (figs. 31, 32). The number of rectrices is also different (twelve as compared to fourteen); the tracheal septum is incomplete, and the structure of the syrinx also quite different (*vide supra*, p. 37). The coloration of the two forms is quite unlike.

least so. All agree in having a deeply four-notched sternum, in having well developed uncinate bones, in the possession of one or two accessory wing-ossicles developed in the termination of the *tensor patagii* tendons, in the spiny tongue (? *Adamastor*), and the palatal armature of spines (? *Adamastor*), and in there never being even indications of lateral lamellæ on the beak.

Æstrelata differs from its allies in having only a single ulnar ossicle, there being two in all the others.

Puffinus and *Adamastor* are more closely connected together than they are with *Majaqueus*, easily distinguishable by its more normal nostrils, less compressed tarsi, and specialised (? *Adamastor*) syrinx. *Bulweria* is a peculiar form, with no very close ally, and must be regarded as a highly specialised form, as shown in its myological formula being reduced to A.X, and its peculiar cuneate tail. It has no close relationship at all to the Stormy-Petrels, as already pointed out by Dr. Coues,¹ and Garrod.²

These views on the classification of the Tubinares may be represented in the annexed diagram (p. 61).

V. THE AFFINITIES OF THE TUBINARES.

The Tubinares as a group may be shortly defined as follows:—

Holorhinal schizognathous birds with a large, broad, depressed, pointed vomer, and truncated mandible; with the anterior toes fully webbed, and the hallux either very small and reduced to one phalanx, or absent; with a tufted oil gland and large supra-orbital glands furrowing the skull; with the external nostrils produced into tubes, usually more or less united together dorsally; with an enormous glandular proventriculus and small gizzard of unusual shape and position, and with the commencing duodenum ascending; with a completely double great pectoral muscle, and a well-developed *pectoralis tertius*; with the femoro-caudal and *semi-tendinosus* muscles always present, and the *ambiens* and accessory femoro-caudal only exceptionally absent.

Some, at least of these characters—the structure of the hallux, the formation of the nostrils³ and the form of the stomach are quite peculiar to the Tubinares, not being found in any other birds, though of universal presence in these. These features alone would at once suffice to distinguish them from any other Avian order, whilst the combination of other characters is as unique. It is therefore a difficult task to assign to this group a satisfactory position in any arrangement of the class Aves, owing to its much isolated position.

¹ *S.c.*, 1866, p. 139.

² *Coll. Papers*, p. 221.

³ The Caprimulgine genus *Siphonorhis* (Sclater, *Proc. Zool. Soc.*, 1861, p. 78) perhaps approaches the Tubinares more nearly in this point than any other bird known to me.

OCEANITIDÆ

PROCELLARIDÆ

PROCELLARIINÆ

DIOMEDEINÆ

Most previous writers have considered the Petrels as more or less closely connected with the Gulls (Laridæ), but the grounds for any such collocation are very slight, in my judgment, now that the structure of the two groups is better known.

The Gulls exhibit no trace of any of the characteristic peculiarities of the Petrels,¹ and differ widely from them in the important feature of being schizorhinal.² The peculiar disposition in two quite separate layers of the great pectoral muscle in the Tubinares is quite unlike anything seen in the Gulls or their allies, whilst the large *pectoralis tertius* of the Petrels is altogether unrepresented in the Laridæ. The character of the cæca in the two groups is also quite different, and there are no special osteological resemblances between the two groups so far as I can see, for the mere schizognathous character of the palate is, we now know, not necessarily a mark of affinity. The character of the young plumage, the condition of the young birds, and the number, shape, and coloration of the eggs—points on which some stress may be laid in questions of this kind—are totally dissimilar in the two groups, as indeed are the habits of the adult birds themselves, though no doubt both are “web-footed” and more or less pelagic in habit. Such resemblances, however, can hardly be seriously considered as indicating any real affinities.³

L’herminier, A. Milne-Edwards, and Huxley have all, in describing various points in the osteology of the Tubinares, pointed out similarities of various kinds between their osseous structure and that of various forms of the Steganopodes, though they still kept them close to the Laridæ. Eyton, on the other hand, places the various Petrels he describes in the family “Pelecanidæ,” the Gulls forming a separate family by themselves.

But no one will be prepared, I think, to dispute that the Steganopodes are allied to the Herodiones, including under that name the Storks and Herons, with *Scopus*, only. Thus, on osteological grounds alone, there is sufficient ground for placing the Tubinares in the vicinity of the Steganopodes and Herodiones. And, in fact, neglecting the desmognathous structure of the palate—the taxonomic value of which *per se* is becoming more and more dubious as our knowledge of the structure of birds increases—there is little in the characters assigned to the groups Pelargomorphæ and Dysporomorphæ by Professor Huxley (*l. c.*, p. 461) that is not applicable to the general Petrel type.

The completely double great pectoral muscle is a characteristic only found, as already observed, in the Ciconiidae, Cathartidae, the Steganopodes (except *Phalacrocorax*), and

¹ I cannot understand Professor Huxley’s remark (Proc. Zool. Soc., 1867, p. 455) that “the Gulls grade insensibly into the Procellariidae.”

² Cf. Garrod, Coll. Papers, p. 128.

³ No views regarding the affinities of the Petrels other than that to the Laridæ already discussed, and that to the Ciconiiform birds have, so far as I know, been seriously advanced by ornithological writers, Professor Garrod having abandoned his early idea that the Tubinares were probably related remotely to the Anseres and their allies, (cf. Coll. Papers, pp. 220 and 521).

the Tubinares, and in all these forms it is associated with short colic cæca of peculiar shape (absent altogether in the Cathartidæ, as in some of the Tubinares), more or less completely webbed feet, tufted oil-gland (except in the Cathartidæ), holorhinal nostrils, a tendency of the palatine bones to unite behind the posterior nares, truncated mandible, broad, strong, well-developed sternum, and strongly curved, well-developed clavicles. These birds also agree together in being "Altrices," the young birds being quite helpless after birth, and requiring to be fed for a long time by their parents—and in generally laying eggs of a white, or nearly white, colour.

The group so constituted, of which the Ardeidæ and Falconidæ must also be considered as aberrant members,—the first family being closely related to the Ciconiidæ through *Scopus*, whilst the Falconidæ are probably, though much more remotely, connected with the Steganopods,—corresponds to the Ciconiiformes of Garrod,¹ with the addition, as he had already himself suggested,² of the Tubinares.

But his earlier definition of that group, in so far as it relates to the absence in it of the accessory femoro-caudal muscle (B), will have to be modified; inasmuch as this muscle is, as shown above, generally present in the Tubinares. These too, differ markedly from the other Ciconiiformes in the well-developed *pectoralis tertius* (very small or absent in the others), in the large size of the vomer, and the non-desmognathism of the palate, though as regards this latter character it has already been pointed out that the Albatrosses are nearly desmognathous, whilst the desmognathism of the Cathartidæ is of a different kind to that prevalent in the other forms concerned.

The two existing groups of Petrels are clearly related to each other so much more nearly than to any other group of birds that it is evident that they must have had a common ancestor that possessed the peculiar features characterising the Tubinares as an order. Such a form may therefore be safely assumed to have had—

1. The characteristic nostrils of the group.
2. The equally characteristic stomach and duodenum.
3. Webbed feet, with a small hallux of a single phalanx.
4. A double great pectoral muscle, and large *pectoralis tertius*.
5. A formula AB.XY, a *gluteus primus* and an *ambiens* muscle.
6. Short colic cæca of characteristic shape.
7. A tufted oil gland, and the pterylosis characteristic of the group.
8. A holorhinal schizognathous skull, with large depressed vomer, great supra-orbital glandular depressions, no basipterygoid facets, and a truncated mandible.
9. A short, broad, deeply-keeled sternum, more or less entire behind, with strong clavicles.
10. A peculiar humerus, and tibia with large cnemial crest.

¹ Collected Papers, p. 218.

² *Loc. cit.*, p. 521.

No living Petrel has this combination of characters ; the Oceanitidæ having lost their colic cæca, the Procellariidæ the accessory semi-tendinosus (Y) muscle, and both groups having become specialised in other ways.

Such an ancestral form as here indicated may be supposed to be an early, and in some respects—as shown by the large vomer, schizognathous palate, large third pectoral muscle and formula AB. XY—more primitive form, that diverged from the common stock of the Ciconiiform birds very early, when the latter had only acquired the most prevalent of the characters now existing in the various groups of that sub-order. One branch of this stock has since become greatly modified in the Tubinarial direction, whilst the other branch, loosing “B” and the large vomer, and becoming desmognathous, split up and gave origin, at different times and in different ways, to the remaining families of the group. The definiteness of the characters of these, and the amount of specialisation they show, indicate not only a great antiquity for the whole group, but also the great amount of extinction that has gone on amongst its members in the past, in the process of which nearly all the intermediate and less specialised forms have disappeared.

PLATE I.

Fig. 1. Head of *Oceanites oceanicus*. 1*a* leg and 1*b* foot (from before) of same.

Fig. 2, 2*a*, 2*b*. The same of *Garrodia nereis*.

Fig. 3, 3*a*, 3*b*. The same of *Pelagodroma marina*.

Fig. 4, 4*a*, 4*b*. The same of *Fregetta grallaria*.

Fig. 5, 5*a*, 5*b*. The same of *Procellaria pelagica*.

Fig. 6. Bill of *Bulweria columbina*.

Fig. 7. View of external nares of same, from before, to show their two distinct openings.

Fig. 8. Nostrils of *Oceanites oceanicus*, from before.

Fig. 9. The same of *Procellaria pelagica*.

Figs. 7-9 enlarged. The others are of the natural size.

EXTERNAL CHARACTERS OF PETRELS.
(Oceanitidae, &c.)

PLATE II.

Fig. 1. Liver, stomach, and duodenal loop of *Majaqueus æquinoctialis*, viewed from in front. L. Liver. *pr.* Proventriculus (the letters are placed on its fundus). *g.* Gizzard. *p.* Pancreas. *g.b.* Gall-bladder. *r.h.d.*, *l.h.d.* Right and left hepatic ducts. *v.p.* Vena portæ. *h.a.* Hepatic artery.

Fig. 2. Outline of stomach, &c., of *Fregetta grallaria*.

Fig. 3. Colic cæca of *Majaqueus æquinoctialis*, enlarged slightly.

Fig. 4. Gizzard of *Fulmarus glacialis* laid open, to show the character of its epithelium.

Fig. 5. Tongue of *Oceanites oceanicus*.

Fig. 6. Tongue of *Pelecanoïdes urinatrix*.

Fig. 7. Tongue of *Diomedea brachyura*.

Fig. 8. Tongue of *Phaethria fuliginosa*.

Fig. 9. Tongue of *Cymochorea leucorrhœa*.

Fig. 10. Tongue of *Ossifraga gigantea*.

Fig. 11. Tongue of *Aeipetes antarcticus*.

Fig. 12. Tongue of *Daption capensis*.

Fig. 13. Tongue of *Prion banksi*.

Fig. 14. Tongue of *Pagodroma nivea*.

Fig. 15. Tongue of *Æstrelata lessoni*.

Fig. 16. Tongue of *Larus* sp. ?

Fig. 17. Tongue of *Majaqueus æquinoctialis*.

Fig. 18. Tongue of *Puffinus brevicauda*.

Fig. 19. Palate of *Oceanites oceanicus*, enlarged. (The line shows the natural size.)

Fig. 20. Palate of *Pelecanoïdes urinatrix*.

Fig. 21. Palate of *Æstrelata lessoni*.

Fig. 22. Palate of *Fulmarus glacialis*.

Fig. 23. Palate of *Prion banksi*.

All the figures, except figs. 3 and 19, are of the natural size.

PLATE III.

Fig. 1. Left pectoral region of *Majaqueus æquinoctialis*, to show the double *pectoralis major* (*seu primus*) muscle. Its superficial layer (*p. 1a*) has been for the most part removed, its cut origin from the sternal crest and furcula (*F.*) being reflected: *p. 1a'*, its insertion into the humerus, also cut and reflected. *p. 1b*. The deep layer. *p. 2*. Fascia covering the *pectoralis secundus* muscle. *t.p.* Belly of *tensor patagii* muscles. *t.p.l.* Their tendon, joined by *b.s.* (*biceps-slip*) formed by the humeral head of the *biceps humeri* muscle. *b.* Main belly of *biceps* muscle, formed by the coracoidal head. *S.* Body of sternum, bare of muscular fibres.

Fig. 2. Dissection of left pectoral region of *Diomedea brachyura* to show the two layers of the *pectoralis primus* muscle (*p. 1a*, *p. 1b*), which have been cut and removed in large part, and the compound *pectoralis secundus*. *p. 2*. Its sternal origin; *p. 2'*, its coracoid origin; *p. 2''*, its furcular origin; *p. 2'''*, origin from coraco-furcular membrane (*c.f.m.*). *p. 3*. *Pectoralis tertius*. *C.* Coracoid bone. *F.* Furcula, at symphysis. *S.* Sternum. (The line above it shows the limit of origin of the deep layer of the *pectoralis primus*.)

Fig. 3. Dissection of right wing of *Oceanites oceanicus*, to show the peculiar *expansor secundariorum* muscle. *e.s.* Tendinous portion arising from the last remiges (*S.*). *e.s'*. The other moiety, arising from the last scapular feathers (*Sc.*). *p. 1*. *Pectoralis primus* muscle, to which the *expansor secundariorum* is attached. *H.* Humerus. *Pat.* Patagial membrane. *v.n.* Vessels and nerves to wing.

Fig. 4. Left shoulder joint, inner side, of *Ossifraga gigantea*, to show the peculiar *biceps* muscle. *c.* Its coracoid head, continuous below with the belly of the muscle (*b*). *h.* Its humeral head, which forms a *biceps-slip*, joining the tendon of the *tensor patagii* (*t.p.*). *p. 1*. Insertions (cut) of the two layers of the *pectoralis primus* muscle. *e.* *Extensor*. *t.* *Teres*. *c.b.l.* *Coraco-brachialis longus*. *c.b.b.* *Coraco-brachialis brevis*.

Fig. 5. Same parts in *Thalassiarche culminata*. *c., h.* Coracoid and humeral heads of *biceps*, here uniting below into the common tendon of that muscle (*b.*) *b.s.* *Biceps* slip, largely tendinous and joining the *tensor patagii* near the elbow, derived from the coracoid head of the *biceps*.

PLATE IV.

Fig. 1. Dissection of right elbow of *Prion desolatus*, to show the disposition of the *tensor patagii* muscles, as seen from above.

Fig. 2. The same in *Æstrelata brevirostris*.

Fig. 3. The same in *Diomedea exulans*. An arrow is passed between the twin tendons of origin of the superficial part of the *extensor metacarpi radialis longior*.

Fig. 4. The same in *Æstrelata lessoni*.

Fig. 5. The same in *Ossifraga gigantea*.

Fig. 6. The same in *Pelecanoïdes urinatrix*. *H.* Humerus. *R.* Radius. *b.* *Biceps* muscle. *t.p.l.* *Tensor patagii longus*. *t.p.b.* *Tensor patagia brevis*. *e.m., e.m'.* Superficial and deep bellies of *extensor metacarpi radialis longior*. *e.m.** Inner of twin tendons of origin of its superficial belly. *b.s.* (in fig. 3). *Biceps* slip. *f.* Fasciculus of patagial tendons continued on to ulnar fascia. *a, a'.* Ossicles developed at origin of the *extensor metacarpi radialis longior*. *t.p.' (in fig. 5).* Special slip from patagial tendons to deep belly of *extensor metacarpi radialis longior*.

Fig. 7. Dissection of right wing of *Majaqueus æquinotialis*, to show origin and general disposition of the *tensor patagii* muscles. Lettering as above; also *t.p.* Common belly of *tensor patagii longus* and *brevis*. *t.p.l'.* Cushion of elastic tissue, developed in the tendon of the *tensor patagii longus (t.p.l.)* at its origin from the humerus. *e.* Elastic pad, developed in the marginal tendon of *tensor patagii longus*, opposite the elbow. *d.* Deltoid muscle. *l.d.* *Latissimusdorsi* (insertion). *n.* Circumflex nerve.

PLATE V.

Fig. 1. View of superficial muscles of right thigh of *Majaqueus æquinoctialis*. *P.* Pelvis. *s.* *Sartorius*. *gl. 1.* *Gluteus primus*. *g.* *Gastrocnemius*. *b.* *Biceps*. *s.t.* *Semi-tendinosus*. *s.m.* *Semi-membranosus*.

Fig. 2. View of deeper thigh muscles of the same bird; the *gluteus primus*, *biceps*, and *gastrocnemius* (*g'*.) muscles cut and reflected to show the deeper parts. Lettering as above; also *b'*, cut end of *biceps* passing through the tendinous loop formed by the origin of the *gastrocnemius*. *f.c.* Femoro-caudal muscle. *a.f.c.* Its accessory head. *o.e.* *Obturator externus*. *add.* Adductor muscles. *f.v.* Femoral vein. *sc.* Sciatic nerve and artery. *o.g.* Oil gland.

Fig. 3. The same parts in *Oceanites oceanicus*. *a.s.t.* Accessory semi-tendinosus muscle. *Pb.* Pubis. *R.* Rectrices.

Fig. 4. Dissection of thigh of *Pelecanoïdes*, to show the absence of the accessory femoro-caudal muscle, and the abnormal course of the femoral vein, this passing over, instead of under, the femoro-caudal muscle. *o.i.* *Obturator internus*. *gl.* Glutei.

PLATE VI.

Fig. 1. Skull of *Æstrelata lessoni*, viewed from the side. All the figures are of the natural size.

Fig. 2. The same, from below.

Fig. 3. The same, from above.

Fig. 4. Skull of *Prion vittatus*, from below.

Fig. 5. Vomer,—with the ascending plate, anchylosed to it, of the palatine bones,—of *Diomedea exulans*, from the side.

Fig. 6. The same, from above.

Fig. 7. Left uncinat bone (“os crochu” of Reinhardt) from behind, of *Thalassiarche culminata*.

Fig. 8. The same of *Phæbetria fuliginosa*.

Fig. 9. Left humerus of *Majaqueus æquinoctialis*, from above.

Fig. 10. Proximal, and fig. 11, distal extremities of the same bone, inferior surface.

Fig. 12. Pelvis, seen from the side, of *Majaqueus æquinoctialis*.

Fig. 13. Proximal end of right tibia of *Ossifraga gigantea*, to show the cnemial crest.

Fig. 14. Hallux of *Ossifraga*, with its metatarsal. The single phalanx of which it consists is vertically bisected, to show the hollow interior.

OSTEOLOGY OF PETRELS
Skull, Pelvis and Limb-bones

PLATE VII.

Fig. 1. Sternum, with coracoids and furcula, of *Thalassiarche melanophrys*, from in front. Reduced.

Fig. 2. The same, from the side.

Fig. 3. Sternum and pectoral arch of *Pelecanoïdes urinatrix*, from in front.

Fig. 4. The same, from the side.

Fig. 5. The same, of *Cymochorea leucorrhœa*, from in front.

Fig. 6. The same, from the side.

Fig. 7. The same of *Fregetta melanogastra*, from in front.

Fig. 8. The same, from the side.

Fig. 9. Outline of posterior margin (right side) of sternum of *Ossifraga gigantea*. Reduced.

Fig. 10. The same of *Daption capensis*.

Fig. 11. The same of *Fulmarus glacialis*.

Fig. 12. The same of *Aeipetes antarcticus*.

Fig. 13. The same of *Thalassœca glacialisoides*.

Fig. 14. The same of *Prion desolatus*.

Fig. 15. The same of *Pagodroma nivea*.

Fig. 16. The same of *Bulweria columbina*.

Fig. 17. The same of *Æstrelata lessoni*.

Fig. 18. The same of *Adamastor cinereus*.

Fig. 19. The same of *Majaqueus æquinoctialis*.

Fig. 20. The same of *Puffinus anglorum*.

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